DOCKETED

Docket Number:	20-MISC-01
Project Title:	2020 Miscellaneous Proceedings.
TN #:	232959
Document Title:	AB 2514 - Alameda Municipal Power 2017 Updated Staff Report
Description:	N/A
Filer:	Courtney Wagner
Organization:	Alameda Municipal Power
Submitter Role:	Public Agency
Submission Date:	5/8/2020 4:18:30 PM
Docketed Date:	5/8/2020

ALAMEDA MUNICIPAL POWER
A Department of the City of Alameda

AGENDA ITEM NO.: 5.C.1
MEETING DATE: 11/13/2017
ADMINISTRATIVE REPORT NO.: 2018-23

To: Honorable Public Utilities Board

Submitted by: [signature] for
Rebecca Irwin
AGM – Customer Resources

From: Sarah Liuba
Energy Resource Analyst

Approved by: [signature]
Nicolas Procos
General Manager

Subject: By Motion, Accept Report Findings Pursuant to the Requirements of Assembly Bill 2514 that Energy Storage Procurement Targets are neither viable nor cost Effective for Alameda Municipal Power at this Time

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RECOMMENDATION

By *Motion*, accept report findings pursuant to the requirements of Assembly Bill 2514 that energy storage procurement targets are neither viable nor Cost Effective for Alameda Municipal Power at this time.

BACKGROUND

California Assembly Bill (AB) 2514, signed in 2010, requires publicly owned utilities to "determine appropriate targets, if any, for the utility to procure viable and cost-effective energy storage systems." Energy storage systems are defined in the legislation to be "commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy." To be viable, they must "be cost-effective and either reduce emissions of greenhouse gases (GHG), reduce demand for peak electrical generation, defer or substitute for an investment in generation, transmission, or distribution assets, or improve the reliable operation of the electrical transmission or distribution grid."

On March 19, 2012, AMP's Public Utilities Board (Board) responded to the requirements of AB 2514 by directing AMP's general manager to initiate a process to decide appropriate targets, if any, for procuring viable, cost-effective storage systems by December 31, 2016, and December 31, 2020. On August 18, 2014, the Board accepted staff's evaluation indicating that storage was not projected to be cost-effective by 2016, resulting in a decision to not adopt storage targets for this timeframe. Consistent with the legislation, the Board directed staff to return in three years with an updated analysis on establishing an energy storage target.

Table 1: Benefits, Constraints and Average Prices of Storage Options

Devices	Benefits	Constraints	$ / MWh Range*
Pumped Hydro	• Mature technology • High power capacity	• Geographic limitations • Low energy density	$152 - $198
Compressed Air	• Low cost, modular adaptability • Mature technology • Leverages existing gas turbines	• Geographic limitation • Difficult to modularize • Subject to natural gas price fluctuations	$116 - $140
Mechanical Flywheels	• High power density with scalability • High depth of discharge capability • Integrated AC motor	• Cost-prohibitive • Emerging technology risk • High-heat generation • Sensitive to vibrations • Low energy capacity	$601 - $983**
Thermal Storage	• Low cost, flexible sizing options • Power and energy ratings are independently scalable • Mature technology	• Lack A/C load in AMP territory • Geographic limitations • Emerging technology • Difficulty with modularity	$227 - $280
Lead-Acid Batteries	• Mature technology • Established recycling infrastructure	• Operates poorly in a partially charged state • Short lifespan	$425 - $933
Redox Flow Batteries	• Independently scalable in power and energy (other than zinc-bromine) • Modular blocks for system design	• Cost-prohibitive • Power & energy rating (for zinc-bromine) • Reduced efficiency (rapid degradation)	(Zinc – Bromine) $434 - $549
Zinc Batteries	• Currently most affordable battery • Deep discharge • Can be recycled	• Unproven for commercial deployment • Low efficiency	$262 - $438
Lithium-Ion Batteries	• Multiple chemistries available • Highly manufactured • Efficient power • High energy density	• Cost-prohibitive • Safety: combustion, leakage, & overheating • Advanced manufacturing for higher output • Lithium refinement average capital cost: $15,000/ton	$267 - $561
Sodium Batteries	• Low-temperature: residential/small use; low-cost potential & safer • High power & energy density • High temperature/liquid-electrolyte flow for large-scale capacity	• Relatively high cost for utility-scale • Low-temperature: less efficient & expensive • Possible safety concern: flammability for high-temperature batteries	$301 - $748

(*) Costs depict unsubsidized levelized cost of storage by *transmission system* applications
(**) Costs were evaluated under *distribution feeder* end-use application through a levelized cost approach

After reviewing these options staff determined that battery storage technology with *lithium-ion* or *flow* applied chemistries could be a potential candidate for future adoption due to their market penetration and performance. Attributes of the two technologies are provided on the following page.

- Lithium-ion batteries are a type of rechargeable battery in which lithium ions move between negative and positive electrodes (depending on discharge and charge cycles). They include a variety of advanced chemistry components and capacitors (allowing batteries to store energy on an electric field) and continue to be widely researched. These battery types are the most promising of all the battery technologies under review. Several utilities have deployed these applications under varied end-use scenarios, including in combination with utility-scale solar photovoltaics (PV) power plants.

- Redox flow batteries provide quicker response times and longer dispatch cycles by storing energy on an electrode cell with an electrolyte solution of two dissolved chemical components. While not as power-dense as lithium-ion, flow batteries operate via electrochemical reactions providing safer energy dispatch. Still, the technology is cost-prohibitive for most current applications at this time.

Based on current pricing information and deployment array, lithium-ion batteries would likely surface as a primary candidate if an opportunity to employ storage arises.

Market Conditions for Economic Viability

Determining financial feasibility for storage investment must take into account not only capital or financing costs, but also the energy market costs to initially charge the device, and available incentives and disincentives specific to the geographic area. For example, California investor-owned utilities, businesses, and residents can take advantage of the state's Self-Generation Incentive Program to help finance generation and small and large-scale storage initiatives. Federal investment tax credits can similarly cover a percentage of expenditures, as well.

Although the costs of some storage technologies are expected to decline according to LLCOS and DNV GL, the lifetime levelized cost of delivered energy from conventional generation technologies is currently substantially lower than those of storage technologies, leading staff to conclude that storage systems remain cost-prohibitive.

Alameda's Load Characteristics and Resource Mix

Electricity use in Alameda is fairly flat and consistent primarily due to influences like energy efficiency, limited air conditioning, and the temperate climate. Monthly averages for hourly energy demand range from 52 MW in the summer to 63 MW in the winter, with generally minimized load swings. Peak hours, which exist in the evening (6 p.m. to 10 p.m.) reflect increased demand and yet coincide with reduced output form customer-sited PV systems.

Further, AMP's existing resource mix currently does not require storage for operational enhancements, or smoothing/shaping generation, as much of AMP's renewable or carbon-neutral resources are baseload power, i.e., (they run around the clock). Serving as an intermediate and peaking resource, hydroelectric power has adjustable output and historically is used to meet peaks and provide other services to the market. Intermittent generation for AMP consists of its wind contract, which varies in its output and generates two-thirds of its power in the summer, the opposite of Alameda's winter needs. As AMP renewables contracts begin to expire as early as 2019, future power procurement will necessitate reevaluation of storage cost structures.

Behind the Meter Storage in Alameda

Behind-the-Meter (BTM) refers to generation systems, such as solar PV, interconnected at the customer's facility and intended for personal use as they are sized to match annual consumption. Of AMP's 28 commercial and 349 residential customers with onsite distributed generation, the average system size is around 86.5 kW and 4 kW, respectively.

AMP presently has two residents interested in adding battery storage to their existing solar PV systems. In response, staff reached out to popular battery storage vendors to gain insight on residential storage trends and benefits in the Bay Area. Cost-savings, distributed generation flexibility, natural disaster response, and grid-islanding (fully-independent of the grid) have, in part, motivated recent growing interest. As cited in the *Q4 2016 U.S. Energy Storage Monitor* report, BTM installments accounted for 86 percent of deployed storage (in MW). Of these, lithium-ion batteries dominated the energy storage market, representing 96.2 percent.[1] A recent third quarter of 2017 report from this research team revealed that non-residential BTM deployments (commercial, industrial, religious, military, and nonprofit) rose by 27.3 MWh of capacity dispatched in the first half of 2017.

Local Generation plus Storage Investigations

On October 16, 2017, staff presented to the Board preliminary information on a potential local generation investment in the form of 7 MW of utility-scale solar PV. The analysis stated that battery storage could potentially add 3 MW/12 MWh (capacity/energy dispatch), though storage dramatically increases the cost of the project. The addition of energy storage could allow the utility to shift a portion of unused daytime solar output for peak hour demand. Based on Board direction at the October meeting, staff will fine-tune the preliminary analysis and continue the evaluation of the use of energy storage paired with the solar PV system.

Conclusion

Pursuant to AB 2514, staff recommends not adopting storage procurement targets achievable by December 31, 2020, as it is not cost-effective. However, future adoption will be considered as resource contracts expire or there is a need to pursue additional renewable electricity or transmission grid optimization.

<u>FINANCIAL IMPACT</u>

N/A

<u>NEXT STEPS</u>

Pursuant to the evaluation process required by AB 2514, staff will:

- Submit this report to the California Energy Commission (CEC)
- Bring to the Board storage updates as circumstances warrant

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[1] GreenTech Media Research (gtmresearch) and the Energy Storage Association provide quarterly and annual updates on nationally-deployed energy storage statistics

- Present the Board with a BTM storage interconnection agreement to allow those customers who wish to install onsite energy storage systems a mechanism to do so

- Provide the CEC with a summary report reflecting any storage research, development, and demonstration by January 1, 2021

LINKS TO STRATEGIC PLAN AND METRICS

KRA 5, Goal 5.1:	Develop alternative energy opportunities
KRA 5, Goal 5.2:	Define power procurement plan for 2025
KRA 5, Goal 5.4:	Achieve sustainable level of carbon neutral

EXHIBITS

A. PowerPoint Presentation
B. LLCOS 2.0

AB 2514 Energy Storage System Procurement Viability

Update to Staff's 2014 Study

November 13, 2017

ALAMEDA MUNICIPAL POWER
A Department of the City of Alameda

Overview

- Assembly Bill (AB) 2514 Compliance
  - Board activities and past evaluation
- Energy Storage Technologies
- AMP's Load & Generation Resource Mix
- Storage Activities & Research in Alameda
- Recommendation
- Next Steps

AB 2514 Legislation

- **Assembly Bill (AB) 2514:** Determine energy storage procurement targets achievable by December 31, 2016 & December 31, 2020
- **Energy Storage:** commercially available technology, capable of absorbing and storing energy for a period of time, thereafter, dispatching the energy.
  - Reduce greenhouse gas emissions
  - Reduce demand for peak electrical generation
  - Defer investment or provide alternatives for generation, transmission, or distribution assets

Energy Storage Technologies

Technology	Description
Pumped Storage Hydro	Stores potential energy of water by pumping and storing it at a higher elevation and using it later to generate electricity
Compressed Air Storage	Power is stored for long durations by compressing air in containers for later dispatch
Mechanical Flywheels	Utilize rotating mechanism to store rotational energy with rapid charge and discharge features, ideal for quick release
Thermal Energy Storage	Allows temporarily reserving energy produced (heating or cooling) to use as later times

Unviable: Both cost-prohibitive and technologically unfit

- Echo findings from 2014

Battery Storage Technologies

Technology	Benefits	Constraints	$ / MWh Range*
Lithium –Ion Batteries	• Multiple chemistries available • Highly manufactured • Efficient power • High energy density • Most widely-deployed	• Cost-prohibitive • Safety: combustion, leakage, & overheating • Advanced manufacturing required for higher output • Lithium refinement can constitute 25 percent of overall costs	$267 - $561
Redox Flow Batteries	• Independently scalable in power and energy (other than zinc-bromine) • Modular blocks for system design	• Cost-prohibitive • Power & energy rating (for zinc-bromine) • Reduced efficiency (rapid degradation) • Not yet penetrated the battery market	$434 - $549 (Zinc-Bromine chemistry)

(*) Costs depict unsubsidized levelized cost of storage by *transmission system* applications

AMP's Load & Generation Mix

- Monthly averages for hourly demand
  - 52 megawatts (MW) in the summer months
  - 63 MW in the winter months
  - Peak hours occur: *6 p.m. to 10 p.m.*
- Present resource mix meets customer demand
  - Base resources: Geothermal & Landfill
  - Intermediate & Peaking: Hydropower
  - Intermittent: Wind
  - Peaking: Combustion Turbine (Natural Gas)

Behind & Front of the Meter

Customer-Sited Storage Applications & Advantages

- Behind-the-Meter (BTM) generation + storage
  - Onsite, reliably delivered power
  - Cost-savings on electricity bills
  - Flexible and modular generation
  - Disaster response
  - Grid-islanding and outage mitigation
  - Electric vehicle charging optimization

Behind & Front of the Meter

Utility-Sited Storage Applications & Advantages

- Front of the meter storage provides services such as:
  - Energy price arbitrage
  - Time-shifting energy
  - Capacity value for resource adequacy requirements
  - Transmission-cost savings
  - Reduction for distribution and transmission grid congestion as well as asset/upgrade deferral
  - Peak shaving

AMP Customer Storage Interest

- BTM energy generation customers:
  - 349 residential with average system size: 4 kilowatts (kW)
  - 28 commercial with average system size: 86.5 kW
- Customer-sited storage interest in Alameda is expected to increase
  - Two customers inquired when storage interconnection pathways are to occur
- Electric vehicle purchases on the rise

Local Generation Discovery: Solar + Storage

- On October 16, 2017, staff presented findings for potential local solar generation
  - Investigate opportunities to replace expiring contacts
  - Uncover pathways for renewable generation adoption
  - 7 MW system sizing potential
- Battery storage could optimize usage
  - Greater capacity / energy dispatch (up to 3 MW / 12 MWh)

Recommendation

- Staff recommends not setting targets for energy storage system procurement achievable by December 31, 2020
  - May be revised if economics become favorable
- Does not preclude action to investigate storage opportunities within this window

Next Steps

- Submit the report to the California Energy Commission
- Interconnection agreement for BTM storage
- Provide periodic updates to the Board
- Submit a summary of any research, development, and demonstration of storage in Alameda by January 1, 2021

Questions?

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DECEMBER 2016

AGENDA ITEM NO,: 5.C.
MEETING DATE: 11/13/2017
EXHIBIT B

LAZARD'S LEVELIZED COST OF STORAGE—VERSION 2.0

LAZARD

I Introduction and Executive Summary

Introduction

Lazard's Levelized Cost of Storage Analysis ("LCOS") addresses the following topics:

- **Definition of a cost-oriented approach to energy storage technologies and applications**
- **Description of ten defined Use Cases for energy storage**
- **Description of selected energy storage technologies**
- **Analysis of LCOS for a number of use case and technology combinations**
- **Decomposition of the levelized cost of storage for various use case and technology combinations by total capital cost, operations and maintenance expense, charging cost, tax and other factors, as applicable**
- **Comparison and analysis of capital costs for various use case and technology combinations, including in respect of projected/expected capital cost declines for specific technologies**
- **Identification of a number of geographically distinct merchant, behind-the-meter illustrative energy storage systems and their related value propositions in a mixed-use case context**
- **Summary assumptions for the various use case and technology combinations examined, including detailed assumptions on charging costs**

Energy storage systems are rated in terms of both instantaneous power capacity and potential energy output (or "usable energy"). The instantaneous power capacity of an energy storage system is defined as the maximum output of the invertor (in MW, kW, etc.) under specific operational and physical conditions. The potential energy output of an energy storage system is defined as the maximum amount of energy (in MWh, kWh, etc.) the system can store at one point in time. Both capital cost divided by instantaneous power capacity and capital cost divided by potential energy output are common Industry conventions for cost quoting. This study principally describes capital costs in terms of potential energy output to capture the duration of the relevant energy storage system, as well as its capacity.

Throughout this study, use cases require fixed potential energy output values. Due to physical and operating conditions, some energy storage systems may need to be "oversized" on a usable energy basis to achieve these values. This oversizing results in depth of discharge over a single cycle that is less than 100% (i.e., some technologies must maintain a constant charge).

Other factors not covered in this report would also have a potentially significant effect on the results presented herein, but have not been examined in the scope of this current analysis. The analysis also does not address potential social and environmental externalities, including, for example, the long-term residual and societal consequences of various conventional generation technologies (for which energy storage is a partial substitute) that are difficult to measure (e.g., nuclear waste disposal, environmental impacts, etc.).

While energy storage is a beneficiary of and sensitive to various tax subsidies, this report presents the LCOS on an unsubsidized basis to isolate and compare the technological and operational components of energy storage systems and use cases, as well as to present results that are applicable to a global energy storage market.

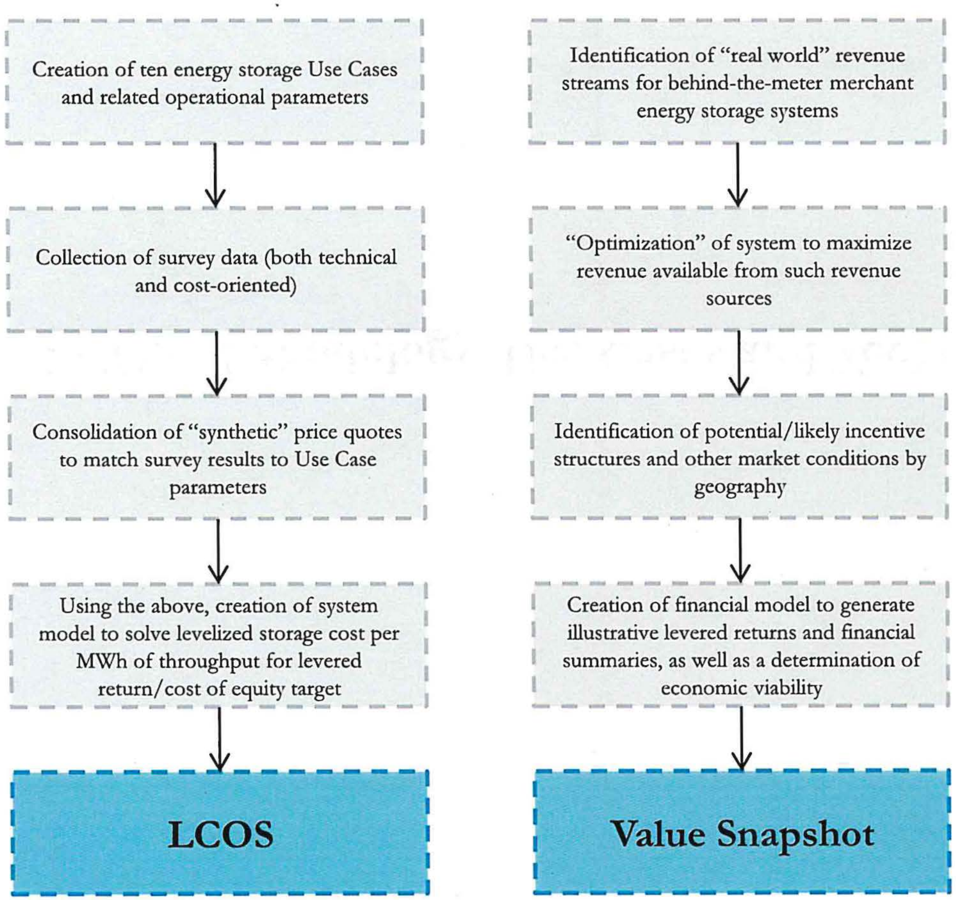
The inputs contained in the LCOS were developed by Lazard in consultation and partnership with Enovation Partners, a leading consultant to the Power & Energy Industry.

Executive Summary and Overview

GENERAL ARCHITECTURE AND PROCESS

LCOS

VALUE SNAPSHOTS



SELECTED COMMENTARY

- **In Version 1.0 of Lazard's LCOS study, we articulated a levelized cost framework to identify minimum costs per unit (MWh) of energy throughput to achieve illustrative equity returns, given levelized cost structures, capital structures and costs of capital**
- **Lazard has refined its LCOS methodology and report for Version 2.0**
  - Narrower LCOS ranges, reflecting revised technology/Use Case combinations (e.g., eliminating unfavorable technologies)
  - Revised Use Cases, better reflecting the current state of the energy storage market
  - Presentation of power-oriented Use Cases on both $/MW and $/MWh bases
- **In addition, Lazard notes that the LCOS construct and related results may differ materially from the "value" of storage (see page 4 for additional detail)**
- **To that end, we have included in this report a number of illustrative "Value Snapshots," presenting illustrative "real world" behind-the-meter, merchant energy storage systems operating in selected geographical markets**

II LCOS Methodology, Use Cases and Technology Overview

What is Lazard's Levelized Cost of Storage Analysis?

Lazard's Levelized Cost of Storage study analyzes the levelized costs associated with the leading energy storage technologies given a single assumed capital structure and cost of capital, and appropriate operational and cost assumptions derived from a robust survey of Industry participants

- **The LCOS does not purport to measure the value associated with energy storage to Industry participants, as such value is necessarily situation-, market- and owner-dependent and belies this cost-oriented and "levelized" analysis**

WHAT THE LCOS DOES

- Defines operational parameters associated with systems designed for each of the most prevalent use cases of storage
- Aggregates cost and operational survey data from original equipment manufacturers and energy storage developers, after validation from additional Industry participants/energy storage users
- Identifies an illustrative "base case" conventional alternative to each use case for energy storage, while acknowledging that in some use cases there is no conventional alternative (or such comparison may be only partially apt)
- Generates estimates of the installed cost over the indicated project life required to achieve certain levelized returns for various technologies, designed for a series of identified use cases
- Provides an "apples-to-apples" basis of comparison among various technologies within use cases
- Identifies a potential framework for evaluating energy storage against certain "base case" conventional alternatives within use cases
- Aggregates robust survey data to define range of future/expected capital cost decreases by technology

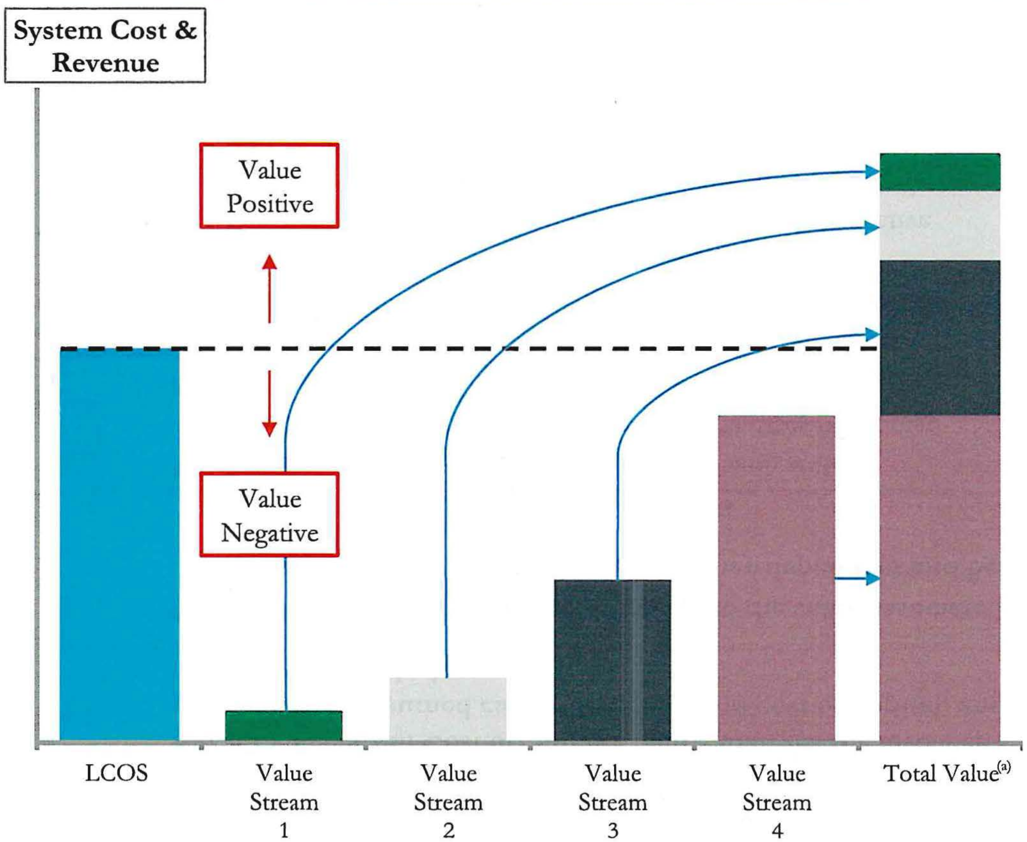
WHAT THE LCOS DOES NOT DO

- Identify the full range of use cases for energy storage, including "stacked" use cases (i.e., those in which multiple value streams are obtainable from a single storage installation)
- Authoritatively establish or predict prices for energy storage projects/products
- Propose that energy storage technologies be compared solely against a single conventional alternative
- Analyze the "value" of storage in any particular market context or to specific individuals/entities
- Purport to provide an "apples-to-apples" comparison to conventional or renewable electric generation
- Provide parameter values which by themselves are applicable to detailed project evaluation or resource planning

The Energy Storage Value Proposition—A Cost Approach

Understanding the economics of energy storage is challenging due to the highly tailored nature of potential value streams associated with an energy storage installation. Rather than focusing on the value available to energy storage installations, this study analyzes the levelized cost of energy storage technologies operationalized across a variety of use cases; the levelized cost of storage may then be compared to the more specific value streams available to particular installations

ENERGY STORAGE VALUE PROPOSITION



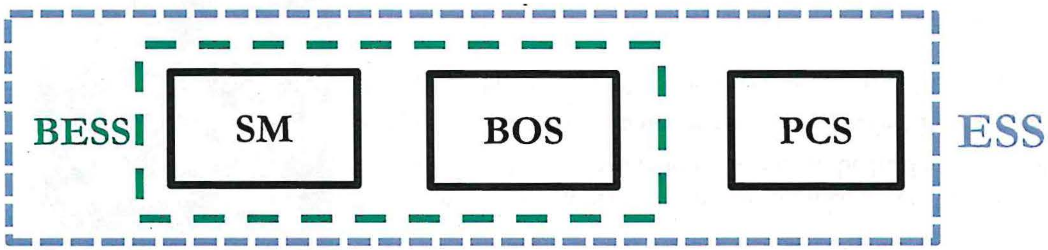
SELECTED OBSERVATIONS

- While an energy storage system may be optimized for a particular use case requiring specified operating parameters (e.g., power rating, duration, etc.), other sources of revenue may also be available for a given system
  - For example, a single energy storage system could theoretically be designed to capture value through both providing frequency regulation for a wholesale market and enabling deferral of an investment in a substation upgrade
- Energy storage systems are sized and developed to solve for one or more specific revenue streams, as the operating requirements of one use case may preclude efficient/economic operations in another use case for the same system (e.g., frequency regulation vs. PV integration)
- The total of all potential value streams available for a given system thus defines the maximum, economically viable cost for that system
- Importantly, incremental sources of revenue may only become available as costs (or elements of levelized cost) decrease below a certain value

(a) Presented here as the simple sum of all available value streams. Due to operational and other factors, such "stacked" value would likely differ from the simple sum of all value streams in practice.

Components of Energy Storage System Capital Costs

Lazard's LCOS study incorporates capital costs for the entirety of the energy storage system ("ESS"), which is composed of the storage module ("SM"), balance of system ("BOS"), power conversion system ("PCS") and related EPC costs



KEY

SM	**Storage Module** Rack Level System (DC)
BESS	**Battery Energy Storage System** Containerized System (DC)
ESS	**Energy Storage System** Complete System

Storage Module ("SM")	Balance of System ("BOS")	Power Conversion System ("PCS")	Engineering Procurement & Construction ("EPC")	Other (Not Included in Analysis)
Racking Frame/Cabinet	Container	Inverter	Project Management	SCADA Software
Local Protection (i.e., Breakers)	Electrical Distribution & Control	Electrical Protection	Engineering Studies/Permitting	Shipping
Rack Management System	Communication	Energy Management System ("EMS")	Site Preparation/Construction	Grid Integration Equipment
Battery Management System	HVAC/Thermal Management		Foundation/Mounting	Metering
Battery Module	Fire Suppression		Commissioning	Land

Use Case Overview—Grid-Scale

Lazard's Levelized Cost of Storage ("LCOS") study examines the cost of energy storage in the context of its specific applications on the grid and behind the meter; each Use Case specified herein represents an application of energy storage that market participants are utilizing now or in the near future

	USE CASE DESCRIPTION
TRANSMISSION SYSTEM	■ Large-scale energy storage system to improve transmission grid performance and assist in the integration of large-scale variable energy resource generation (e.g., utility-scale wind, solar, etc.) ■ Specific operational uses: provide voltage support and grid stabilization; decrease transmission losses; diminish congestion; increase system reliability; defer transmission investment; optimize renewable-related transmission; provide system capacity and resources adequacy; and shift renewable generation output
PEAKER REPLACEMENT	■ Large-scale energy storage system designed to replace peaking gas turbine facilities ■ Specific operational uses include: capacity, energy sales (e.g., time-shift/arbitrage, etc.), spinning reserve and non-spinning reserve ■ Brought online quickly to meet the rapidly increasing demand for power at peak; can be quickly taken offline as power demand diminishes ■ Results shown in $/kW-year as well as standard LCOS ($/MWh)
FREQUENCY REGULATION	■ Energy storage system designed to balance power by raising or lowering output to follow the moment-by-moment changes in load to maintain frequency to be held within a tolerance bound ■ Specific Use Case parameters modeled to reflect PJM Interconnection requirements ■ Results shown in $/kW-year as well as standard LCOS ($/MWh)
DISTRIBUTION SUBSTATION	■ Energy storage systems placed at substations controlled by utilities to provide flexible peaking capacity while also mitigating stability problems ■ Typically integrated into utility distribution management systems
DISTRIBUTION FEEDER	■ Energy storage systems placed along distribution feeders controlled by utilities to mitigate stability problems and enhance system reliability and resiliency ■ Typically integrated into utility distribution management systems

Use Case Overview—Behind-the-Meter

Lazard's Levelized Cost of Storage ("LCOS") study examines the cost of energy storage in the context of its specific applications on the grid and behind the meter; each Use Case specified herein represents an application of energy storage that market participants are utilizing now or in the near future

	USE CASE DESCRIPTION
MICROGRID	■ Energy storage systems that support small power systems that can "island" or otherwise disconnect from the broader power grid (e.g., military bases, universities, etc.) ■ Provides ramping support to enhance system stability and increase reliability of service; emphasis is on short-term power output (vs. load shifting, etc.)
ISLAND GRID	■ Energy storage system that supports physically isolated electricity system (e.g., islands, etc.) by supporting stability and reliability, in addition to integrating renewable/intermittent resources; may also provide balancing service for isolated power grids that integrate multiple distributed resources (i.e., fast ramping) ■ Relative emphasis on discharge endurance vs. simply short-term power output (as in Microgrid Use Case) ■ Scale may vary widely across variations on Use Case (e.g., island nations vs. relatively smaller off-grid, energy-intensive commercial operations, etc.)
COMMERCIAL & INDUSTRIAL	■ Energy storage system that provides behind-the-meter peak shaving and demand charge reduction services for commercial and industrial energy users ■ Units typically sized to have sufficient power and energy to support multiple C&I energy management strategies, and provide option of system providing grid services to utility or wholesale market
COMMERCIAL APPLIANCE	■ Energy storage system that provides behind-the-meter demand charge reduction services for commercial and industrial energy users ■ Unit contains limited energy and power vs. Commercial & Industrial Use Case—geared toward more modest "peak clipping" to reduce demand charges
RESIDENTIAL	■ Energy storage system for behind-the-meter residential home use—provides backup power, power quality improvements and extends usefulness of self-generation (e.g., "solar plus storage") ■ Regulates the power supply and smooths the quantity of electricity sold back to the grid from distributed PV applications

Energy Storage Use Cases—Operational Parameters

For comparison purposes, this study assumes and quantitatively operationalizes ten Use Cases for energy storage; while there may be alternative or combined/"stacked" use cases available to energy storage systems, the ten Use Cases below represent illustrative current and contemplated energy storage applications and are derived from Industry survey data

	PROJECT LIFE (YEARS)	MW[(a)]	MWh OF CAPACITY[(b)]	100% DOD CYCLES/ DAY[(c)]	DAYS / YEAR[(d)]	ANNUAL MWh	PROJECT MWh
TRANSMISSION SYSTEM	20	100	800	1	350	280,000	5,600,000
PEAKER REPLACEMENT	20	100	400	1	350	140,000	2,800,000
FREQUENCY REGULATION	10	10	5	4.8	350	8,400	84,000
DISTRIBUTION SUBSTATION	20	4	16	1	300	4,800	96,000
DISTRIBUTION FEEDER	20	0.5	1.5	1	200	300	6,000
MICROGRID	20	2	2	2	350	1,400	28,000
ISLAND GRID	20	1	8	1	350	2,800	56,000
COMMERCIAL & INDUSTRIAL	10	0.5	2	1	250	500	5,000
COMMERCIAL APPLIANCE	10	0.1	0.2	1	250	50	500
RESIDENTIAL	10	0.005	0.01	1	250	2.5	25

[dashed box] = "Usable Energy"[(e)]

(a) Indicates power rating of system (i.e., system size).
(b) Indicates total battery energy content on a single, 100% charge, or "usable energy." Usable energy divided by power rating (in MW) reflects hourly duration of system.
(c) "DOD" denotes depth of battery discharge (i.e., the percent of the battery's energy content that is discharged). Depth of discharge of 100% indicates that a fully charged battery discharges all of its energy. For example, a battery that cycles 48 times per day with a 10% depth of discharge would be rated at 4.8 100% DOD Cycles per Day.
(d) Indicates number of days of system operation per calendar year.
(e) Usable energy indicates energy stored and able to be dispatched from system.

Overview of Selected Energy Storage Technologies

There are a wide variety of energy storage technologies currently available and in development; some technologies are better suited to particular Use Cases or other operational requirements (e.g., geological considerations for compressed air, heat considerations for lithium-ion and sodium, etc.) than are competing technologies

	DESCRIPTION	EXPECTED USEFUL LIFE[(a)]
COMPRESSED AIR	■ Compressed Air Energy Storage ("CAES") uses electricity to compress air into confined spaces (e.g., underground mines, salt caverns, etc.) where the pressurized air is stored. When required, this pressurized air is released to drive the compressor of a natural gas turbine	20 years
FLOW BATTERY‡	■ Flow batteries contain two electrolyte solutions in two separate tanks, circulated through two independent loops; when connected to a load, the migration of electrons from the negative to positive electrolyte solution creates a current ■ The subcategories of flow batteries are defined by the chemical composition of the electrolyte solution; the most prevalent of such solutions are vanadium and zinc-bromine. Other solutions include zinc-chloride, ferrochrome and zinc chromate	10 – 20 years
FLYWHEEL	■ Flywheels are mechanical devices that spin at high speeds, storing electricity as rotational energy, which is released by decelerating the flywheel's rotor, releasing quick bursts of energy (i.e., high power and short duration) or releasing energy slowly (i.e., low power and long duration), depending on short duration or long duration flywheel technology, respectively ■ Typically, maintenance is minimal and lifespans are greater than most battery technologies	20+ years
LEAD-ACID‡	■ Lead-acid batteries were invented in the 19th century and are the oldest and most common batteries; they are low-cost and adaptable to numerous uses (e.g., electric vehicles, off-grid power systems, uninterruptible power supplies, etc.) ■ "Advanced" lead-acid battery technology combines standard lead-acid battery technology with ultra-capacitors; these technologies increase efficiency and lifetimes and improve partial state-of-charge operability[(b)]	5 – 10 years
LITHIUM-ION‡	■ Lithium-ion batteries are relatively established and have historically been used in the electronics and advanced transportation industries; they are increasingly replacing lead-acid batteries in many applications, and have relatively high energy density, low self-discharge and high charging efficiency ■ Lithium-ion systems designed for energy applications are designed to have a higher efficiency and longer life at slower discharges, while systems designed for power applications are designed to support faster charging and discharging rates, requiring extra capital equipment	5 – 10 years
PUMPED HYDRO	■ Pumped hydro storage makes use of two vertically separated water reservoirs, using low cost electricity to pump water from the lower to the higher reservoir and running as a conventional hydro power plant during high electricity cost periods	20+ years
SODIUM‡	■ "High temperature"/"liquid-electrolyte-flow" sodium batteries have high power and energy density and are designed for large commercial and utility scale projects; "low temperature" batteries are designed for residential and small commercial applications	10 years
THERMAL	■ Thermal energy storage uses conventional cryogenic technology, compressing and storing air into a liquid form (charging) then releasing it at a later time (discharge). Best suited for large-scale applications; the technology is still emerging, but has a number of units in early development and operation	20+ years
ZINC‡	■ Zinc batteries cover a wide range of possible technology variations, including metal-air derivatives; they are non-toxic, non-combustible and potentially low-cost due to the abundance of the primary metal; however, this technology remains unproven in widespread commercial deployment	10 years

‡ Denotes battery technology.
(a) Indicates general ranges of useful economic life for a given family of technology. Useful life will vary in practice depending on sub-technology, intensity of use/cycling, engineering factors, etc.
(b) Advanced lead-acid is an emerging technology with wider potential applications and greater cost than traditional lead-acid batteries.

Overview of Selected Energy Storage Technologies (cont'd)

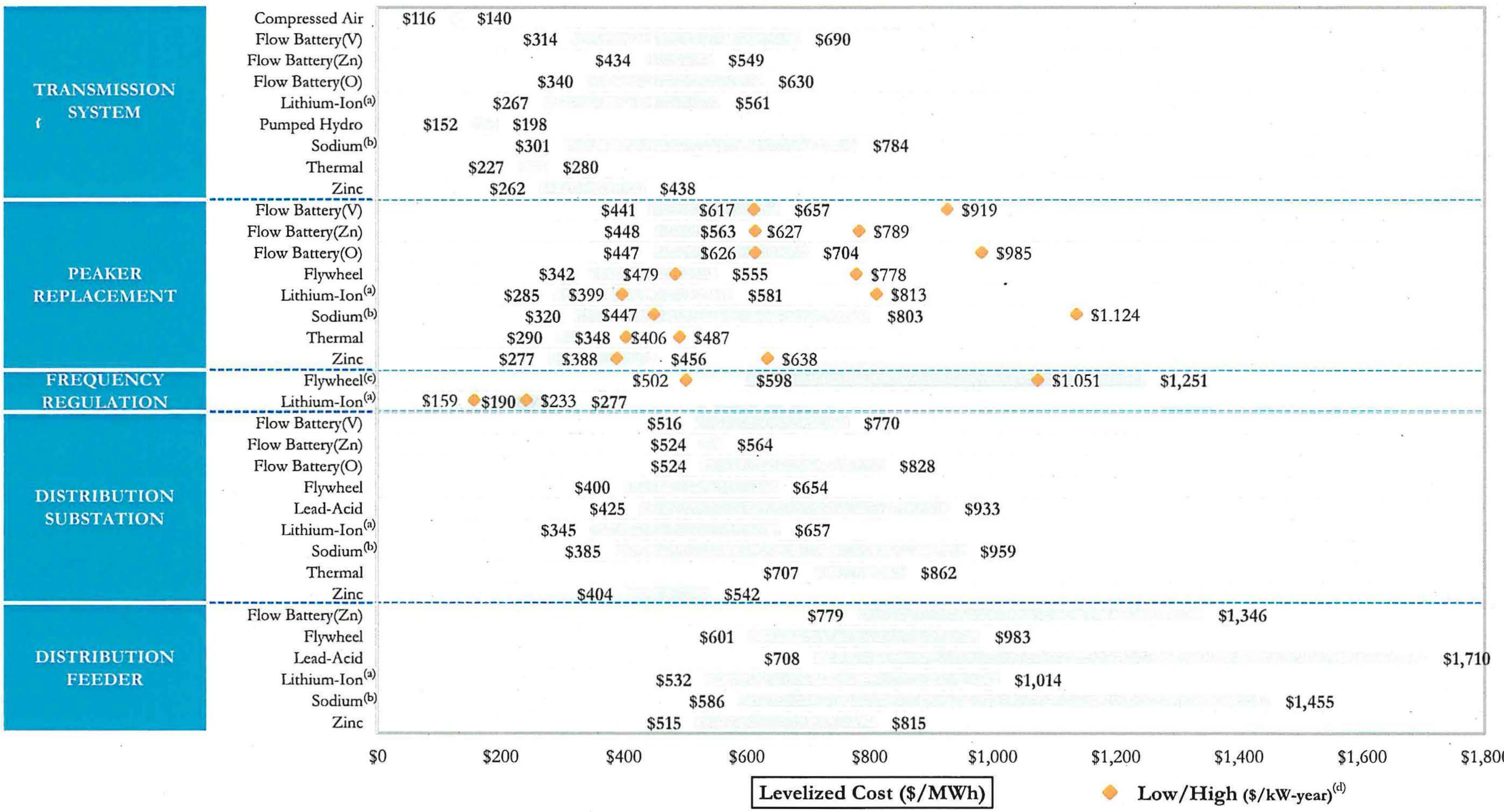
There is a wide variety of energy storage technologies currently available and in development; some technologies are better suited to particular use cases or other operational requirements (e.g., geological considerations for compressed air, heat considerations for lithium-ion and sodium, etc.) than competing technologies

	SELECTED COMPARATIVE ADVANTAGES	SELECTED COMPARATIVE DISADVANTAGES
COMPRESSED AIR	▪ Low cost, flexible sizing, relatively large-scale ▪ Mature technology and well-developed design ▪ Leverages existing gas turbine technologies	▪ Requires suitable geology ▪ Relatively difficult to modularize for smaller installations ▪ Exposure to natural gas price changes
FLOW BATTERY‡	▪ Power and energy profiles highly and independently scalable (for technologies other than zinc-bromine) ▪ Designed in fixed modular blocks for system design (for zinc-bromine technology) ▪ No degradation in "energy storage capacity"	▪ Power and energy rating scaled in a fixed manner for zinc-bromine technology ▪ Relatively high balance of system costs ▪ Reduced efficiency due to rapid charge/discharge
FLYWHEEL	▪ High power density and scalability for short duration technology; low power, higher energy for long-duration technology ▪ High depth of discharge capability ▪ Compact design with integrated AC motor	▪ Relatively low energy capacity ▪ High heat generation ▪ Sensitive to vibrations
LEAD-ACID‡	▪ Mature technology with established recycling infrastructure ▪ Advanced lead-acid technologies leverage existing technologies	▪ Poor ability to operate in a partially charged state ▪ Relatively poor depth of discharge and short lifespan
LITHIUM-ION‡	▪ Multiple chemistries available ▪ Rapidly expanding manufacturing base leading to cost reductions ▪ Efficient power and energy density	▪ Remains relatively high cost ▪ Safety issues from overheating ▪ Requires advanced manufacturing capabilities to achieve high performance
PUMPED HYDRO	▪ Mature technology (commercially available; leverages existing hydropower technology) ▪ High power capacity solution	▪ Relatively low energy density ▪ Limited available sites (i.e., water availability required)
SODIUM‡	▪ High temperature technology: Relatively mature technology (commercially available); high energy capacity and long duration ▪ Low temperature technology: Smaller scale design; emerging technology and low cost potential; safer	▪ Although mature, inherently higher costs—low temperature batteries currently have a higher cost with lower efficiency ▪ Potential flammability issues for high-temperature batteries
THERMAL	▪ Low cost, flexible sizing, relatively large-scale ▪ Power and energy ratings independently scalable ▪ Leverages mature industrial cryogenic technology base; can utilize waste industrial heat to improve efficiency	▪ Technology is pre-commercial ▪ Difficult to modularize for smaller installations
ZINC‡	▪ Currently quoted as low cost ▪ Deep discharge capability	▪ Currently unproven commercially ▪ Lower efficiency

Source: *DOE Energy Storage Database.*
‡ Denotes battery technology.

III Levelized Cost of Storage Analysis

Unsubsidized Levelized Cost of Storage Comparison



Source: Lazard and Enovation Partners estimates.

Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery.

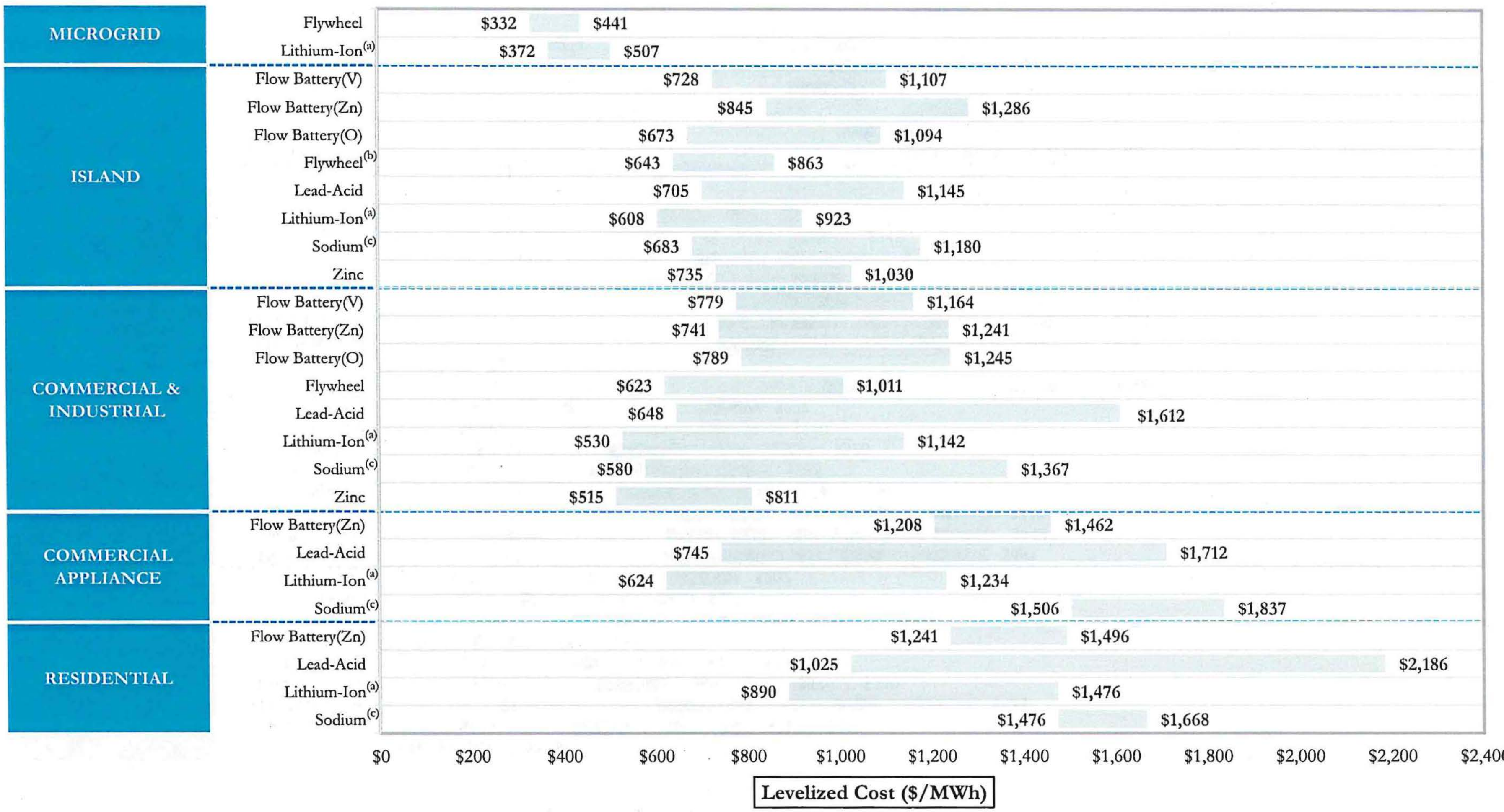
(a) Lithium-Ion-Power technology used in the Frequency Regulation and Microgrid Use Cases due to low duration/high power requirements. Lithium-Ion-Energy systems are used in all other Use Cases that include Lithium-Ion technology.

(b) Sodium-Low Temperature systems are used in Commercial Appliance and Residential Use Cases. Sodium-High Temperature systems are used in all other Use Cases that utilize Sodium technology.

(c) Flywheel storage in the Frequency Regulation Use Case represents short-duration storage. Flywheel storage in all other Use Cases represents long-duration storage.

(d) Reflects conversion of LCOS figure ($/MWh) by multiplying by total annual energy throughput (MWh) and dividing by capacity (kW).

Unsubsidized Levelized Cost of Storage Comparison (cont'd)



Source: Lazard and Enovation Partners estimates.

Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery.

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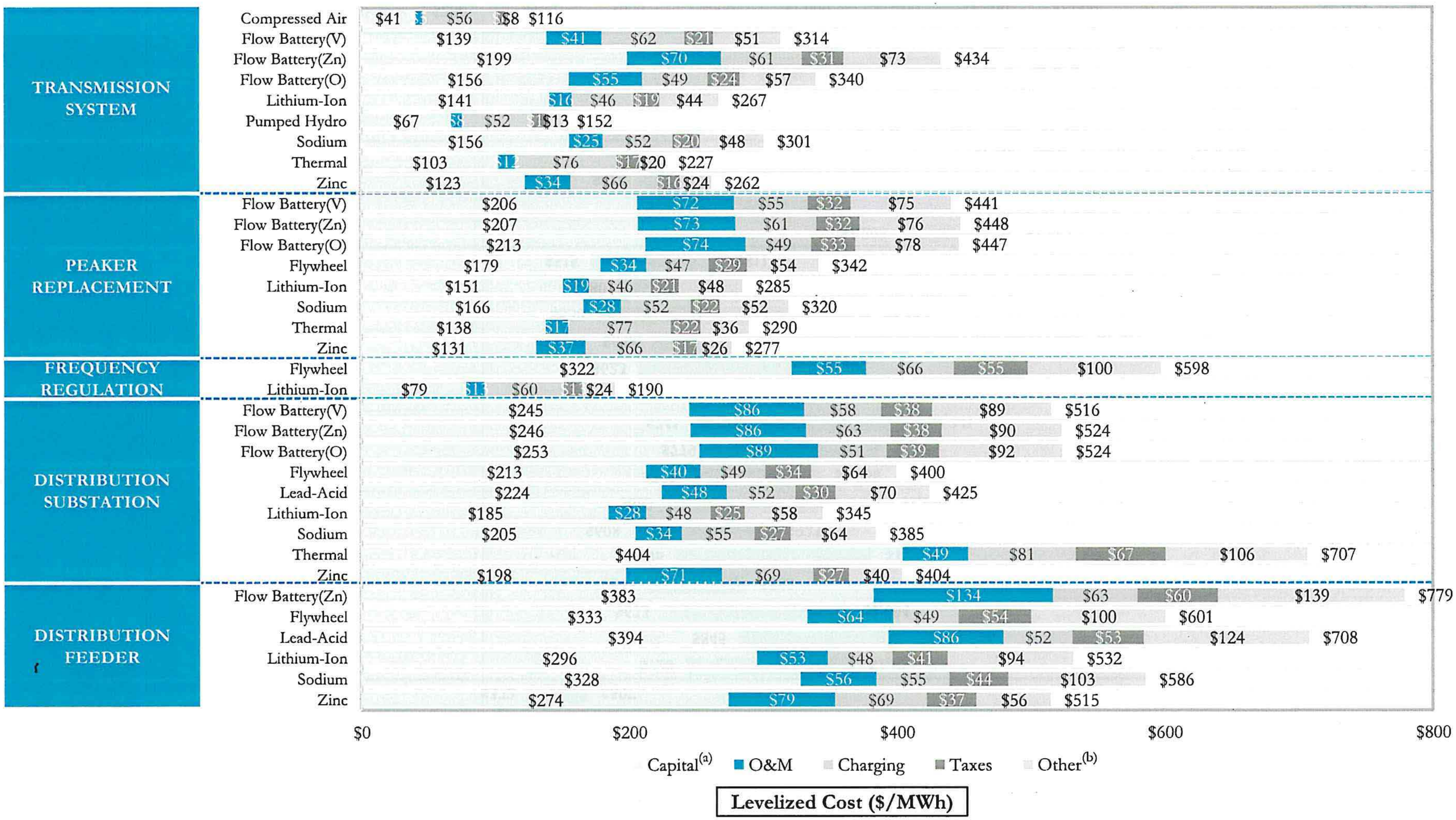
(c) Sodium-Low Temperature systems are used in Commercial Appliance and Residential Use Cases. Sodium-High Temperature systems are used in all other Use Cases that utilize Sodium technology.

Levelized Cost of Storage Components—Low End



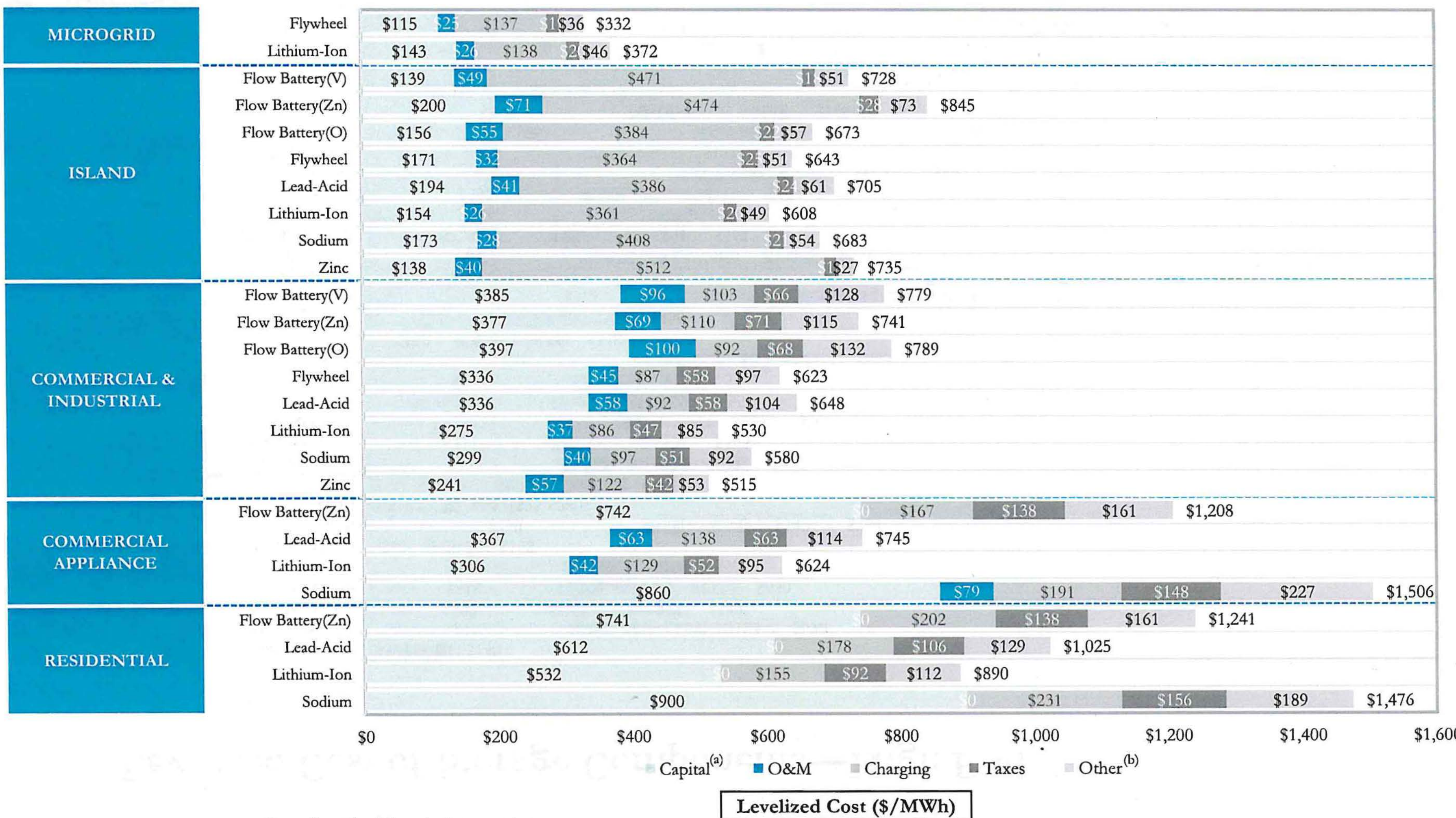
Source: Lazard and Enovation Partners estimates.

Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery. Analysis on this page does not decompose capacity-oriented cost figures presented elsewhere in this presentation (i.e., $/kW).

(a) Consists of the equity portion of all capital expenditures (i.e., both initial and replacement capex).

(b) Consists of costs related to the extended warranty and total debt service (i.e., both interest and principal payments over the economic life of the system, inclusive of debt associated with replacement capex, if any).

Levelized Cost of Storage Components—Low End (cont'd)



Source: Lazard and Enovation Partners estimates.

Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery. Analysis on this page does not decompose capacity-oriented cost figures presented elsewhere in this presentation (i.e., $/kW).

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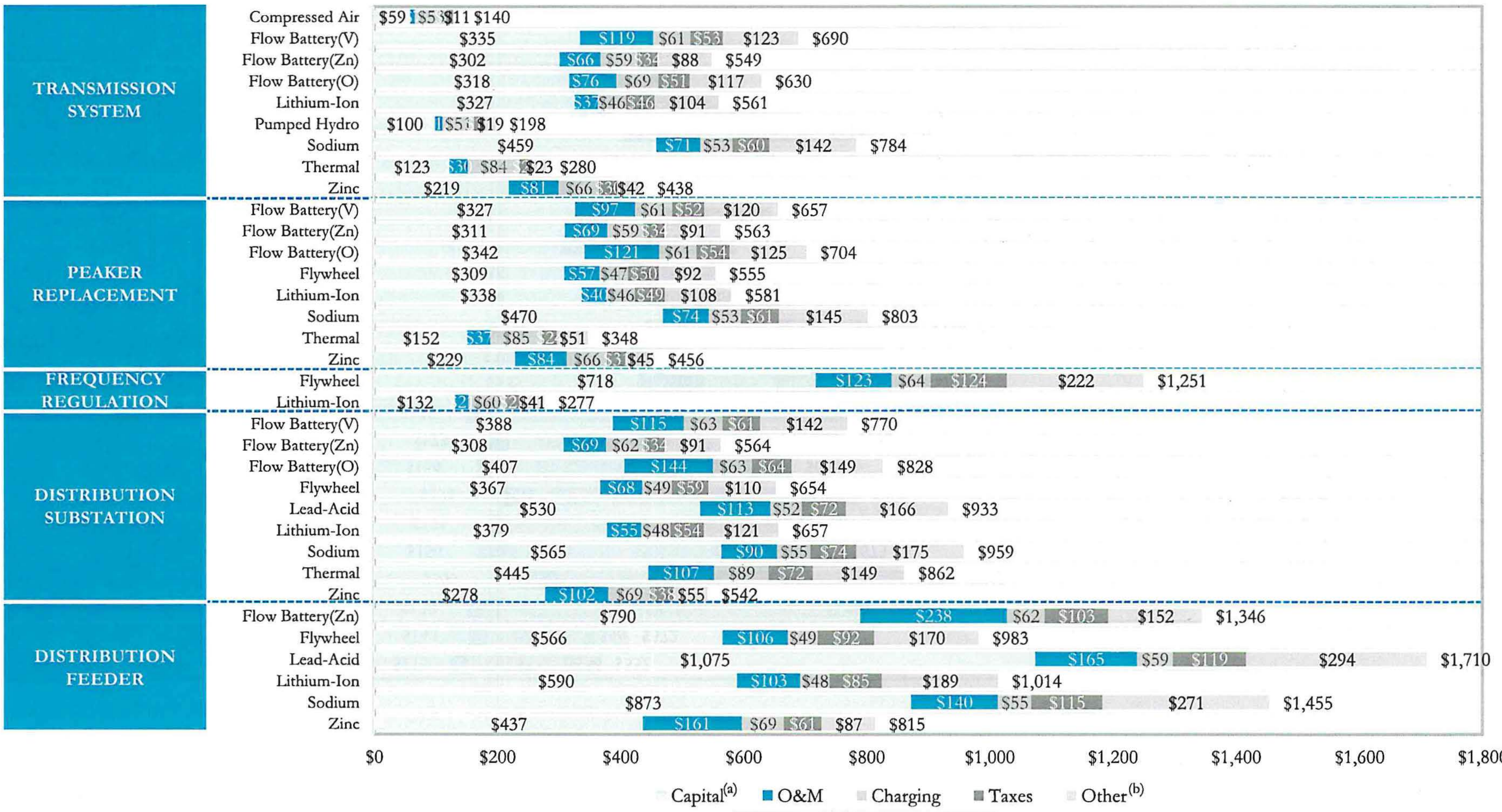
(b) Consists of costs related to the extended warranty and total debt service (i.e., both interest and principal payments over the economic life of the system, inclusive of debt associated with replacement capex, if any).

Levelized Cost of Storage Components—High End



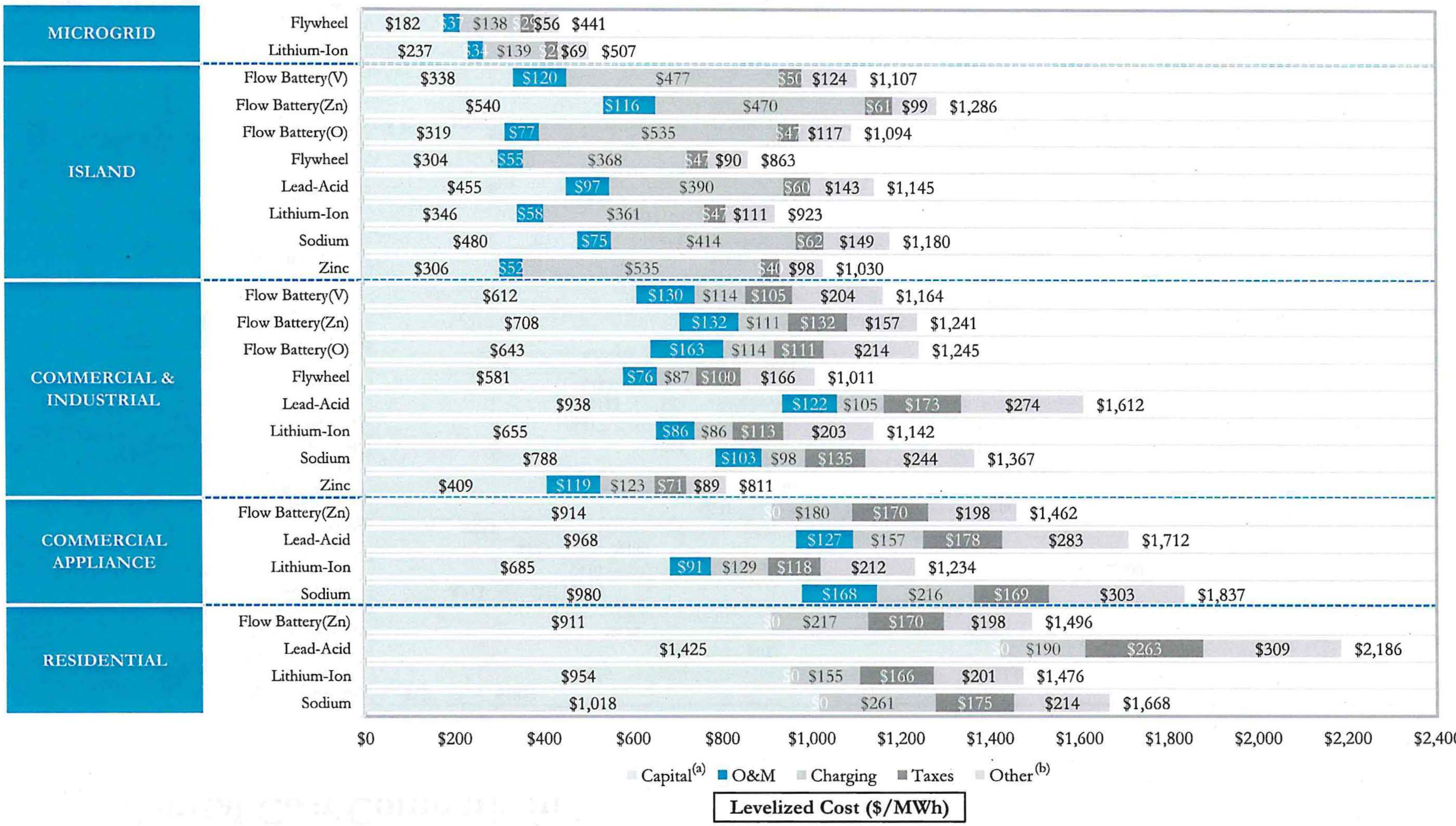
Source: Lazard and Enovation Partners estimates.

Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery. Analysis on this page does not decompose capacity-oriented cost figures presented elsewhere in this presentation (i.e., $/kW).

(a) Consists of the equity portion of all capital expenditures (i.e., both initial and replacement capex).

(b) Consists of costs related to the extended warranty and total debt service (i.e., both interest and principal payments over the economic life of the system, inclusive of debt associated with replacement capex, if any).

Levelized Cost of Storage Components—High End (cont'd)



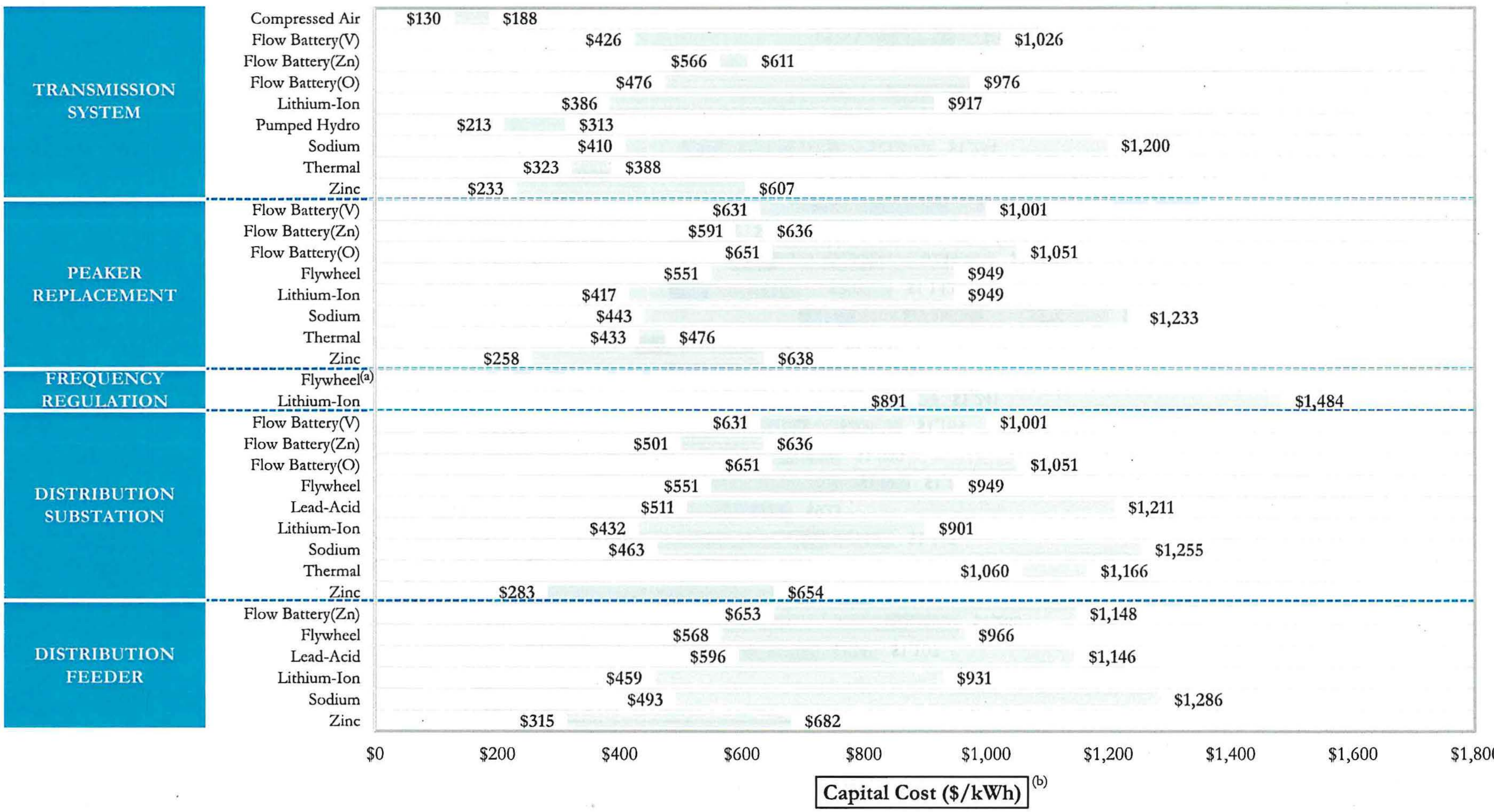
Source: Lazard and Enovation Partners estimates.

Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery. Analysis on this page does not decompose capacity-oriented cost figures presented elsewhere in this presentation (i.e., $/kW).

(a) Consists of the equity portion of all capital expenditures (i.e., both initial and replacement capex).

(b) Consists of costs related to the extended warranty and total debt service (i.e., both interest and principal payments over the economic life of the system, inclusive of debt associated with replacement capex, if any).

Capital Cost Comparison



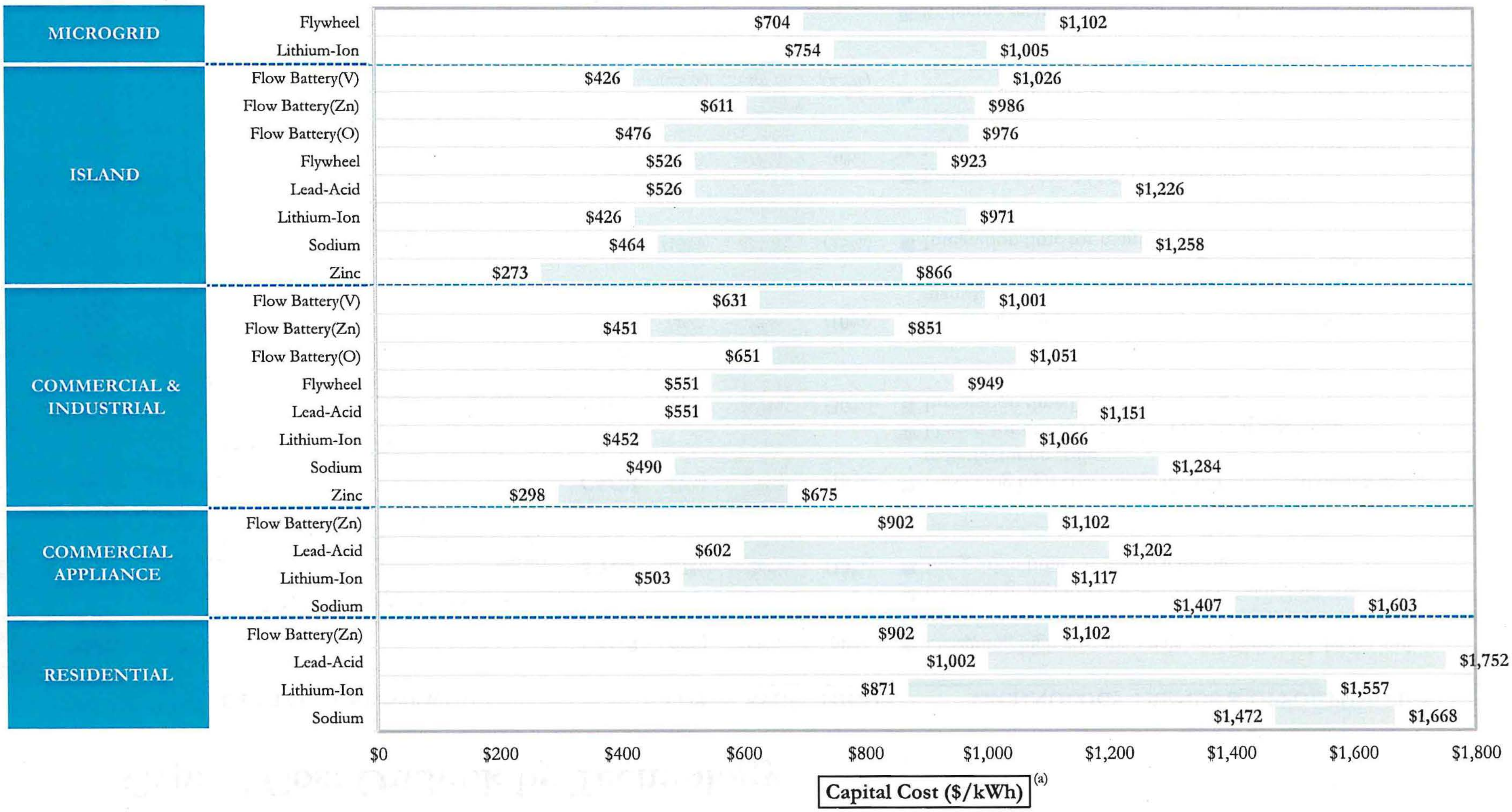
Source: Lazard and Enovation Partners estimates.

Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery.

(a) Capital cost range for Flywheel storage in Frequency Regulation Use Case is $3,600 – $8,000/kWh.

(b) Denotes $/kWh of "usable energy" (i.e., capacity multiplied by duration and expressed in kWh) vs. energy production. Only overnight capital is reflected in the numerator (excludes capital charge, plus operating expenses), and rated discharge capacity is in the denominator (typically much greater than what is actually employed in most use cases).

Capital Cost Comparison (cont'd)



Source: Lazard and Enovation Partners estimates.

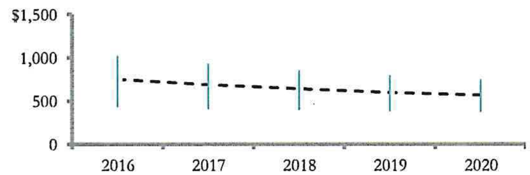
Note: Flow Battery(V) represents Vanadium Flow Batteries; Flow Battery(Zn) represents Zinc-Bromine Flow Batteries; Flow Battery(O) represents Other Flow Batteries. Lazard's LCOS v1.0 study did not separately analyze each of these distinct technologies within Flow Battery.

(a) Denotes $/kWh of "usable energy" (i.e., capacity multiplied by duration and expressed in kWh) vs. energy production. Only overnight capital is reflected in the numerator (excludes capital charge, plus operating expenses), and rated discharge capacity is in the denominator (typically much greater than what is actually employed in most use cases).

Capital Cost Outlook by Technology

CAPITAL COST ($/KWH) | **LOW[a] AVG[b] HIGH[a]** | **TECHNOLOGY TRENDS & OPPORTUNITIES**

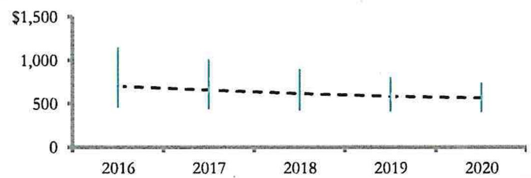
FLOW BATTERY-VANADIUM



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(7%)	(7%)	(4%)
5 Year	(27%)	(24%)	(13%)

- Designing high cost materials, and improved design and manufacturing scale
- Extending operating range to eight-hour discharge
- Integration time for manufacturing

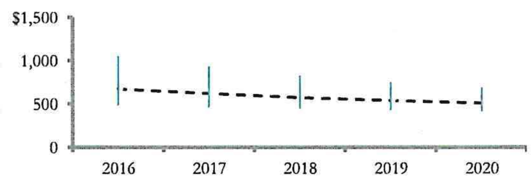
FLOW BATTERY-ZINC-BROMINE



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(3%)	(5%)	(10%)
5 Year	(11%)	(19%)	(36%)

- Designing high cost materials, and improved design and manufacturing scale
- Design for efficient two- or four-hour operation
- Integration time for manufacturing

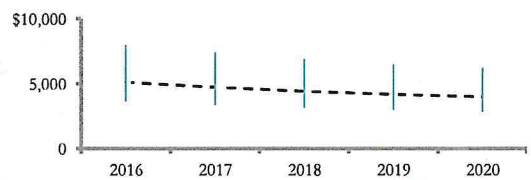
FLOW BATTERY-OTHER



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(4%)	(7%)	(10%)
5 Year	(13%)	(24%)	(35%)

- Designing high cost materials, and improved design and manufacturing scale
- Extending operating range to eight-hour discharge
- Integration time for manufacturing

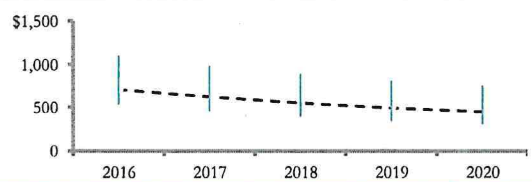
FLYWHEEL-SHORT DURATION



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(6%)	(6%)	(6%)
5 Year	(23%)	(23%)	(23%)

- Reducing required high cost materials
- Improving control and response time to increase usable range of operation
- Improvements in operation sustainability—ability to remove heat; higher efficiency motor/generator

FLYWHEEL-LONG DURATION



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(13%)	(11%)	(9%)
5 Year	(43%)	(37%)	(31%)

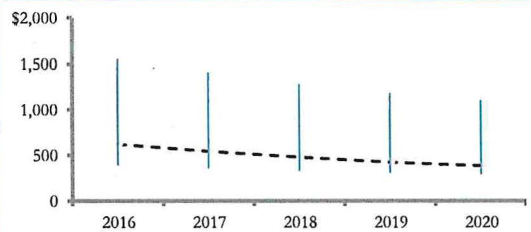
- Reducing required high cost materials
- Improving control and response time to increase usable range of operation
- Improvements in operation sustainability—ability to remove heat; higher efficiency motor/generator

Note: Capital Costs reported are based on year 1 costs for systems designed for all LCOS Use Cases.
(a) "Low"/"High" represents the lower and upper bounds for the outlook on capital cost offerings of the lowest and highest cost manufacturer or provider of each technology.
(b) The average capital cost outlook is weighted based on Lazard's and Enovation's assessment of the relative commercial maturity of different offerings. More mature offerings receive a higher rating.

Capital Cost Outlook by Technology (cont'd)

CAPITAL COST ($/KWH)

LITHIUM-ENERGY

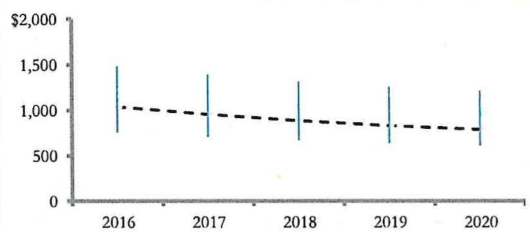


	LOW[a]	AVG[b]	HIGH[a]
CAGR	(7%)	(11%)	(8%)
5 Year	(26%)	(38%)	(29%)

TECHNOLOGY TRENDS & OPPORTUNITIES

- Scale manufacturing lowering cost
- Design improvements lower high cost component input requirements
- Chemistry improvements increasing capability of battery, increases usable energy

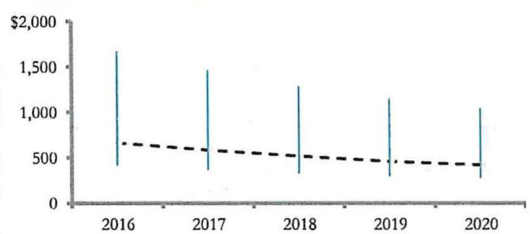
LITHIUM-POWER



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(5%)	(7%)	(5%)
5 Year	(20%)	(24%)	(18%)

- Scale manufacturing lowering cost
- Design improvements lower high cost component input requirements
- Chemistry improvements increasing capability of battery, increases ability to charge and discharge quickly

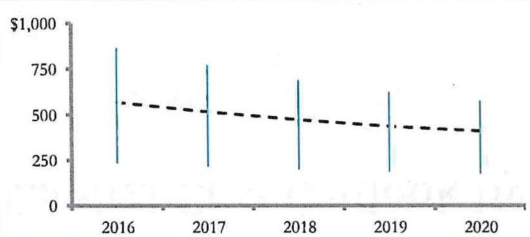
SODIUM



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(10%)	(11%)	(11%)
5 Year	(34%)	(37%)	(37%)

- High-temperature: improve manufacturing scale, and redesign of system to reduce material
- Low-temperature: early stage commercialization, benefitting from rapid technology maturity

ZINC



	LOW[a]	AVG[b]	HIGH[a]
CAGR	(7%)	(8%)	(10%)
5 Year	(26%)	(28%)	(33%)

- Early commercial status and improvement in manufacturing scale
- Redesign of system to reduce material

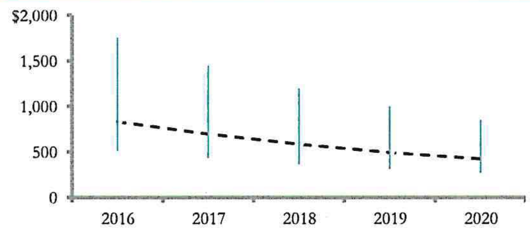
Note: Capital Costs reported are based on year 1 costs for systems designed for all LCOS Use Cases.
(a) "Low"/"High" represents the lower and upper bounds for the outlook on capital cost offerings of the lowest and highest cost manufacturer or provider of each technology.
(b) The average capital cost outlook is weighted based on Lazard's and Enovation's assessment of the relative commercial maturity of different offerings. More mature offerings receive a higher rating.

Capital Cost Outlook by Technology (cont'd)

CAPITAL COST ($/KWH)

		LOW[(a)]	AVG[(b)]	HIGH[(a)]
LEAD	CAGR	(15%)	(15%)	(17%)
	5 Year	(48%)	(49%)	(52%)
COMPRESSED AIR	CAGR	(1%)	(1%)	(1%)
	5 Year	(5%)	(5%)	(5%)
PUMPED HYDRO	CAGR	(1%)	(1%)	(1%)
	5 Year	(5%)	(5%)	(5%)
THERMAL	CAGR	(1%)	(1%)	(1%)
	5 Year	(5%)	(4%)	(5%)

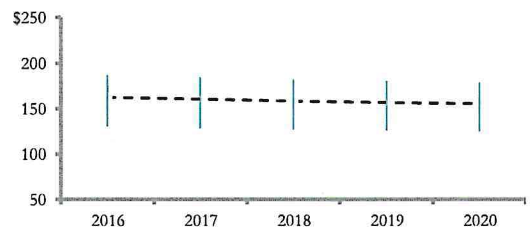
LEAD



TECHNOLOGY TRENDS & OPPORTUNITIES

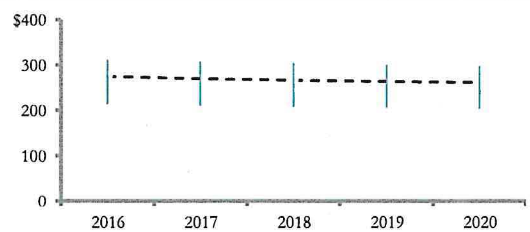
- High rate of decline based, in large part, on improving lead carbon technology
- Carbon will be integrated into new and existing products
- Improvements increase lifespan and range of operation

COMPRESSED AIR



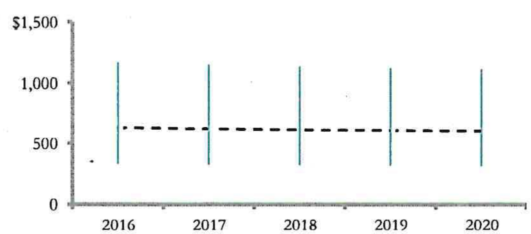
- Improvement in thermal management
- Benefits from improved thermodynamics of recuperator and gas turbine

PUMPED HYDRO



- Improvements in impeller blade design
- Improvement in generator winding to improve efficiency

THERMAL



- Early-stage commercial deployment based on existing cryogenic equipment
- Operational experience expected to prove out current design and showcase avenues for improvement

Note: Capital Costs reported are based on year 1 costs for systems designed for all LCOS Use Cases.
(a) "Low"/"High" represents the lower and upper bounds for the outlook on capital cost offerings of the lowest and highest cost manufacturer or provider of each technology.
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IV Illustrative Energy Storage Value Snapshots

Illustrative Value Snapshots—Introduction

While the LCOS methodology allows for "apples-to-apples" comparisons within Use Cases, it is narrowly focused on costs, based on an extensive survey of suppliers and market participants. To supplement this LCOS analysis, we have included in this report several "Illustrative Value Snapshots" that show typical economics associated with merchant behind-the-meter storage projects in a variety of geographies

- **Based on illustrative storage systems configured to capture value streams available in a number of ISOs/RTOs**
  - Includes revenue from serving RTO markets and delivering customer cost savings, assuming relevant market and contractual rules
  - Load profiles applied based on U.S. DOE's standard medium/large-sized commercial building profile load, adjusted for regional differences
  - Specific tariff rates reflect medium or large commercial power with peak load floors and caps of 10kW and 100kW, respectively; assumes demand charges ranging from $4 to $53 per peak kW, depending on jurisdiction
  - Assumes state-level, non-tax-oriented incentive payments (e.g., SGIP in California and DMP in New York) are treated as taxable income for federal income tax purposes[a]
- **Cost estimates[b] based on LCOS framework (i.e., assumptions regarding O&M, warranties, etc.), but sized to reflect the system configuration described above**
  - System size and performance adjusted to capture multiple value streams and to reflect estimated regional differences in system installation costs, based on survey data and proprietary Enovation Partners case experience
  - System costs based on individual component (lithium-ion battery, inverter, etc.) sizing based on the needs determined in the analysis
  - Operational performance specifications required to serve various modeled revenue streams, based on lithium-ion system in LCOS v2.0 (cycling life, Depth of Discharge, etc.)
- **System economic viability described by Illustrative Value Snapshot-levered IRR[c]**

(a) Based on discussions with developers of merchant storage projects in New York and California.
(b) "Costs" for Illustrative Value Snapshots denote actual cost-oriented line items, not "LCOS" costs (i.e., $/MWh required to satisfy assumed equity cost of capital).
(c) This report does not attempt to determine "base" or "typical" IRRs associated with a given market or region. Results and viability are purely illustrative and may differ from actual project results.

Illustrative Value Snapshots—Summary Results and Assumptions

	1	2	3	4	5
	Frequency Regulation + Demand Response	Demand Charge Management + Demand Response + Frequency Regulation	Frequency Regulation + Demand Response	Demand Charge Management + Demand Response + Frequency Regulation	Demand Response + Demand Charge Management
Region	PJM	ISO-NE	CAISO	ERCOT	NYISO[f]
Value Sources[a]					
Demand Charge Savings[b]	0%	10%	0%	10%	26%
Demand Response Revenue	14%	54%	86%	58%	74%
Frequency Regulation	86%	36%	14%	32%	0%
Energy Storage Configuration					
Battery Size (kWh)	1,000	2,000	2,000	4,000	4,000
Inverter Size (kW)	2,000	1,000	1,000	1,000	1,000
C-rating	2C	C/2	C/2	C/4	C/4
Cycles per year (full DoD)	1,459	215	80	99	74
IRR	**11.6%**	**N/A**	**9.6%**[c]	**N/A**	**14.8%**[d]
Economic Viability[e]	**Viable**	**Not Viable**	**Potentially Viable**	**Not Viable**	**Viable**

Source: DOE, Lazard and Enovation Partners estimates.

(a) Percentages reflect share of total project revenue and cost savings associated with each source of such revenue/cost savings. Spinning reserve payments excluded from analysis, as such payments, though theoretically available, would account for less than 1% of total revenues.
(b) Modeled percentages do not include Peak Load Contribution ("PLC") benefits, which were added in after storage use case optimization.
(c) Includes 60% Self-Generation Incentive Program ("SGIP") incentive. See subsequent pages for additional detail.
(d) Includes 50% Demand Management Program ("DMP") incentive. See subsequent pages for additional detail.
(e) Systems are considered economically viable if they generate levered returns over 10%, potentially viable if they generate levered returns over 8% and not viable if they fail to achieve 8% levered returns. Required returns/hurdle rates may vary in practice by market participant.
(f) Assumes NYISO Zone J. Assumes FDNY will, at some point in the future, authorize the use of Lithium-Ion batteries for commercial purposes.

1 Illustrative Value Snapshot—PJM

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total Revenue[a]	**$0**	**$290,454**	**$297,716**	**$305,158**	**$312,787**	**$320,607**	**$328,622**	**$336,838**	**$345,259**	**$353,890**	**$362,738**
Memo:											
Demand Charge Savings[b]	*$0*	*$16,656*	*$17,073*	*$17,499*	*$17,937*	*$18,385*	*$18,845*	*$19,316*	*$19,799*	*$20,294*	*$20,801*
Demand Response	*0*	*7,232*	*7,413*	*7,599*	*7,789*	*7,983*	*8,183*	*8,387*	*8,597*	*8,812*	*9,032*
Frequency Regulation	*0*	*266,566*	*273,230*	*280,060*	*287,062*	*294,239*	*301,595*	*309,134*	*316,863*	*324,784*	*332,904*
Incentive Payments	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total Operating Costs	**$0**	**($101,480)**	**($103,949)**	**($127,497)**	**($130,087)**	**($132,741)**	**($135,459)**	**($138,243)**	**($141,095)**	**($144,017)**	**($147,010)**
Memo:											
O&M	*$0*	*($20,931)*	*($21,402)*	*($21,884)*	*($22,376)*	*($22,880)*	*($23,395)*	*($23,921)*	*($24,459)*	*($25,010)*	*($25,572)*
Warranty[c]	*0*	*0*	*0*	*(21,019)*	*(21,019)*	*(21,019)*	*(21,019)*	*(21,019)*	*(21,019)*	*(21,019)*	*(21,019)*
Charging[d]	*0*	*(80,549)*	*(82,546)*	*(84,594)*	*(86,692)*	*(88,841)*	*(91,045)*	*(93,303)*	*(95,617)*	*(97,988)*	*(100,418)*
EBITDA	**$0**	**$188,974**	**$193,767**	**$177,662**	**$182,700**	**$187,866**	**$193,164**	**$198,595**	**$204,164**	**$209,873**	**$215,728**
Less: MACRS D&A[e]	0	(150,184)	(257,383)	(183,815)	(131,266)	(93,852)	(93,747)	(93,852)	(46,873)	0	0
EBIT	**$0**	**$38,790**	**($63,616)**	**($6,153)**	**$51,434**	**$94,015**	**$99,417**	**$104,743**	**$157,290**	**$209,873**	**$215,728**
Less: Interest Expense	0	(16,816)	(15,655)	(14,401)	(13,047)	(11,585)	(10,006)	(8,300)	(6,458)	(4,469)	(2,320)
Less: Cash Taxes	0	(8,570)	0	0	0	(8,187)	(34,870)	(37,613)	(58,825)	(80,108)	(83,229)
Tax Net Income	**$0**	**$13,405**	**($79,271)**	**($20,554)**	**$38,387**	**$74,243**	**$54,541**	**$58,830**	**$92,008**	**$125,297**	**$130,179**
MACRS D&A	0	150,184	257,383	183,815	131,266	93,852	93,747	93,852	46,873	0	0
Construction Capex	(840,777)	0	0	0	0	0	0	0	0	0	0
Principal	0	(14,510)	(15,670)	(16,924)	(18,278)	(19,740)	(21,319)	(23,025)	(24,867)	(26,856)	(29,005)
After Tax Levered Cash Flow	**($840,777)**	**$149,079**	**$162,442**	**$146,336**	**$151,375**	**$148,355**	**$126,968**	**$129,657**	**$114,014**	**$98,441**	**$101,174**

Levered Project IRR	**11.6%**

Model Assumptions:

Size (MW)	2.0	Extended Warranty (%)[c)(h]	2%	Regional Power Equipment Cost Scalar[k]	1.00
Capacity (MWh)	1.0[f]	EPC Cost (%)[i]	13%	Regional BOS Cost Scalar[k]	0.95
Cycles Per Year	1,459[g]	O&M Cost (%)[j]	1.9%	Regional EPC Cost Scalar[k]	1.09
Depth of Discharge (%)	8%	Useful Life (years)	10		
Efficiency (%)	89%				

Source: DOE, Lazard and Enovation Partners estimates.

(a) Assumes 2.5% revenue escalation.
(b) Includes PLC benefits.
(c) Represents extended warranty costs that provide coverage beyond the initial two-year product warranty (included in equipment capital costs).
(d) Assumes 2.5% charging cost escalation.
(e) Assumes 7-year MACRS depreciation.
(f) Indicates "usable energy" capacity.
(g) Reflects full depth of discharge cycles per year.
(h) Sized as a percentage of total installed capex, annually, after expiration of initial two-year product warranty.
(i) Assumes EPC costs as a percentage of AC and DC raw capital costs.
(j) Sized as a portion of total installed capital cost. Assumes O&M escalation of 2.25%.
(k) Scalars are adjustment factors for the national averages, determined by Bloomberg estimates and Labor Departments statistics.

2 Illustrative Value Snapshot—ISO-NE

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total Revenue[a]	**$0**	**$177,083**	**$181,510**	**$186,048**	**$190,699**	**$195,466**	**$200,353**	**$205,362**	**$210,496**	**$215,758**	**$221,152**
Memo:											
Demand Charge Savings[b]	*$0*	*$46,098*	*$47,250*	*$48,432*	*$49,643*	*$50,884*	*$52,156*	*$53,460*	*$54,796*	*$56,166*	*$57,570*
Demand Response	*0*	*50,922*	*52,195*	*53,500*	*54,837*	*56,208*	*57,614*	*59,054*	*60,530*	*62,044*	*63,595*
Frequency Regulation	*0*	*80,063*	*82,064*	*84,116*	*86,219*	*88,374*	*90,584*	*92,848*	*95,169*	*97,549*	*99,987*
Incentive Payments	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total Operating Costs	**$0**	**($74,524)**	**($76,318)**	**($107,944)**	**($109,826)**	**($111,752)**	**($113,725)**	**($115,746)**	**($117,815)**	**($119,935)**	**($122,105)**
Memo:											
O&M	*$0*	*($23,706)*	*($24,240)*	*($24,785)*	*($25,343)*	*($25,913)*	*($26,496)*	*($27,092)*	*($27,702)*	*($28,325)*	*($28,962)*
Warranty[c]	*0*	*0*	*0*	*(29,790)*	*(29,790)*	*(29,790)*	*(29,790)*	*(29,790)*	*(29,790)*	*(29,790)*	*(29,790)*
Charging[d]	*0*	*(50,818)*	*(52,078)*	*(53,369)*	*(54,693)*	*(56,049)*	*(57,439)*	*(58,864)*	*(60,324)*	*(61,820)*	*(63,353)*
EBITDA	**$0**	**$102,559**	**$105,192**	**$78,103**	**$80,873**	**$83,714**	**$86,628**	**$89,616**	**$92,680**	**$95,824**	**$99,047**
Less: MACRS D&A[e]	0	(212,849)	(364,777)	(260,512)	(186,038)	(133,012)	(132,863)	(133,012)	(66,431)	0	0
EBIT	**$0**	**($110,290)**	**($259,585)**	**($182,409)**	**($105,164)**	**($49,298)**	**($46,235)**	**($43,396)**	**$26,249**	**$95,824**	**$99,047**
Less: Interest Expense	0	(23,832)	(22,187)	(20,410)	(18,491)	(16,419)	(14,181)	(11,764)	(9,153)	(6,334)	(3,289)
Less: Cash Taxes	0	0	0	0	0	0	0	0	0	0	0
Tax Net Income	**$0**	**($134,122)**	**($281,771)**	**($202,819)**	**($123,656)**	**($65,717)**	**($60,416)**	**($55,159)**	**$17,096**	**$89,490**	**$95,758**
MACRS D&A	0	212,849	364,777	260,512	186,038	133,012	132,863	133,012	66,431	0	0
Construction Capex	(1,191,594)	0	0	0	0	0	0	0	0	0	0
Principal	0	(20,564)	(22,209)	(23,986)	(25,904)	(27,977)	(30,215)	(32,632)	(35,243)	(38,062)	(41,107)
After Tax Levered Cash Flow	**($1,191,594)**	**$58,163**	**$60,797**	**$33,708**	**$36,478**	**$39,318**	**$42,232**	**$45,220**	**$48,285**	**$51,428**	**$54,651**

Levered Project IRR	**N/A**

Model Assumptions:

Size (MW)	1.0	Extended Warranty (%)[c][h]	2%	Regional Power Equipment Cost Scalar[k]	1.00
Capacity (MWh)	2.0[f]	EPC Cost (%)[i]	18%	Regional BOS Cost Scalar[k]	1.14
Cycles Per Year	215[g]	O&M Cost (%)[j]	1.6%	Regional EPC Cost Scalar[k]	1.23
Depth of Discharge (%)	100%	Useful Life (years)	10		
Efficiency (%)	92%				

Source: DOE, Lazard and Enovation Partners estimates.

(a) Assumes 2.5% revenue escalation.
(b) Includes PLC benefits.
(c) Represents extended warranty costs that provide coverage beyond the initial two-year product warranty (included in equipment capital costs).
(d) Assumes 2.5% charging cost escalation.
(e) Assumes 7-year MACRS depreciation.
(f) Indicates "usable energy" capacity.
(g) Reflects full depth of discharge cycles per year.
(h) Sized as a percentage of total installed capex, annually, after expiration of initial two-year product warranty.
(i) Assumes EPC costs as a percentage of AC and DC raw capital costs.
(j) Sized as a portion of total installed capital cost. Assumes O&M escalation of 2.25%.
(k) Scalars are adjustment factors for the national averages, determined by Bloomberg estimates and Labor Departments statistics.

3 Illustrative Value Snapshot—CAISO

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total Revenue(a)	**$393,919**	**$235,290**	**$239,202**	**$243,213**	**$247,323**	**$251,537**	**$177,072**	**$181,499**	**$186,036**	**$190,687**	**$195,454**
Memo:											
Demand Charge Savings	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
Demand Response	*0*	*154,774*	*158,644*	*162,610*	*166,675*	*170,842*	*175,113*	*179,491*	*183,978*	*188,578*	*193,292*
Frequency Regulation	*0*	*1,731*	*1,775*	*1,819*	*1,865*	*1,911*	*1,959*	*2,008*	*2,058*	*2,110*	*2,162*
Incentive Payments(b)	*393,919*	*78,784*	*78,784*	*78,784*	*78,784*	*78,784*	*0*	*0*	*0*	*0*	*0*
Total Operating Costs	**$0**	**($31,878)**	**($32,621)**	**($59,642)**	**($60,419)**	**($61,215)**	**($62,030)**	**($62,863)**	**($63,716)**	**($64,588)**	**($65,481)**
Memo:											
O&M	*$0*	*($20,898)*	*($21,369)*	*($21,849)*	*($22,341)*	*($22,844)*	*($23,358)*	*($23,883)*	*($24,421)*	*($24,970)*	*($25,532)*
Warranty(c)	*0*	*0*	*0*	*(26,261)*	*(26,261)*	*(26,261)*	*(26,261)*	*(26,261)*	*(26,261)*	*(26,261)*	*(26,261)*
Charging(d)	*0*	*(10,980)*	*(11,252)*	*(11,531)*	*(11,817)*	*(12,110)*	*(12,411)*	*(12,718)*	*(13,034)*	*(13,357)*	*(13,688)*
EBITDA	**$393,919**	**$203,411**	**$206,582**	**$183,571**	**$186,904**	**$190,322**	**$115,042**	**$118,636**	**$122,321**	**$126,099**	**$129,973**
Less: MACRS D&A(e)	0	(187,637)	(321,569)	(229,655)	(164,002)	(117,257)	(117,125)	(117,257)	(58,563)	0	0
EBIT	**$393,919**	**$15,775**	**($114,988)**	**($46,084)**	**$22,902**	**$73,065**	**($2,083)**	**$1,379**	**$63,758**	**$126,099**	**$129,973**
Less: Interest Expense	0	(21,009)	(19,559)	(17,993)	(16,301)	(14,474)	(12,501)	(10,370)	(8,069)	(5,583)	(2,899)
Less: Cash Taxes	(153,628)	0	0	0	0	0	0	0	0	(5,447)	(49,559)
Tax Net Income	**$240,291**	**($5,234)**	**($134,546)**	**($64,076)**	**$6,601**	**$58,591**	**($14,584)**	**($8,991)**	**$55,689**	**$115,069**	**$77,515**
MACRS D&A	0	187,637	321,569	229,655	164,002	117,257	117,125	117,257	58,563	0	0
Construction Capex	(1,050,451)	0	0	0	0	0	0	0	0	0	0
Principal	0	(18,128)	(19,578)	(21,145)	(22,836)	(24,663)	(26,636)	(28,767)	(31,068)	(33,554)	(36,238)
After Tax Levered Cash Flow	**($810,160)**	**$164,274**	**$167,444**	**$144,434**	**$147,767**	**$151,185**	**$75,905**	**$79,499**	**$83,184**	**$81,515**	**$41,277**

Levered Project IRR	9.6%

Model Assumptions:

Size (MW)	1.0	Extended Warranty (%)(c)(h)	2%	Regional Power Equipment Cost Scalar(k)	1.00
Capacity (MWh)	2.0(f)	EPC Cost (%)(i)	16%	Regional BOS Cost Scalar(k)	0.95
Cycles Per Year	80(g)	O&M Cost (%)(j)	1.6%	Regional EPC Cost Scalar(k)	1.09
Depth of Discharge (%)	100%	Useful Life (years)	10		
Efficiency (%)	92%				

Source: DOE, Lazard and Enovation Partners estimates.

(a) Assumes 2.5% revenue escalation.
(b) Assumes the 60% Self-Generation Incentive Program ("SGIP") incentive, with 50% of the incentives paid out in construction year and 10% of the incentives paid out in each of the five subsequent years. Assumes incentive payment is taxable (based on discussions with California developers and accountants) and assumes incentive is paid subsequent to construction spend and is thus not a source of construction finance (i.e., capital structure is incentive agnostic).
(c) Represents extended warranty costs that provide coverage beyond the initial two-year product warranty (included in equipment capital costs).
(d) Assumes 2.5% charging cost escalation.
(e) Assumes 7-year MACRS depreciation.
(f) Indicates "usable energy" capacity.
(g) Reflects full depth of discharge cycles per year.
(h) Sized as a percentage of total installed capex, annually, after expiration of initial two-year product warranty.
(i) Assumes EPC costs as a percentage of AC and DC raw capital costs.
(j) Sized as a portion of total installed capital cost. Assumes O&M escalation of 2.25%.
(k) Scalars are adjustment factors for the national averages, determined by Bloomberg estimates and Labor Departments statistics.

4 Illustrative Value Snapshot—ERCOT

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total Revenue[(a)]	**$0**	**$80,127**	**$82,130**	**$84,184**	**$86,288**	**$88,445**	**$90,657**	**$92,923**	**$95,246**	**$97,627**	**$100,068**
Memo:											
Demand Charge Savings	*$0*	*$8,653*	*$8,869*	*$9,091*	*$9,318*	*$9,551*	*$9,790*	*$10,035*	*$10,285*	*$10,543*	*$10,806*
Demand Response	*0*	*46,609*	*47,774*	*48,968*	*50,193*	*51,447*	*52,734*	*54,052*	*55,403*	*56,788*	*58,208*
Frequency Regulation	*0*	*24,866*	*25,487*	*26,125*	*26,778*	*27,447*	*28,133*	*28,837*	*29,557*	*30,296*	*31,054*
Incentive Payments	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total Operating Costs	**$0**	**($46,741)**	**($47,807)**	**($98,748)**	**($99,863)**	**($101,004)**	**($102,170)**	**($103,363)**	**($104,584)**	**($105,832)**	**($107,108)**
Memo:											
O&M	*$0*	*($40,612)*	*($41,526)*	*($42,460)*	*($43,415)*	*($44,392)*	*($45,391)*	*($46,412)*	*($47,457)*	*($48,525)*	*($49,616)*
Warranty[(b)]	*0*	*0*	*0*	*(49,852)*	*(49,852)*	*(49,852)*	*(49,852)*	*(49,852)*	*(49,852)*	*(49,852)*	*(49,852)*
Charging[(c)]	*0*	*(6,129)*	*(6,281)*	*(6,437)*	*(6,596)*	*(6,760)*	*(6,927)*	*(7,099)*	*(7,275)*	*(7,456)*	*(7,641)*
EBITDA	**$0**	**$33,386**	**$34,324**	**($14,565)**	**($13,575)**	**($12,558)**	**($11,513)**	**($10,440)**	**($9,337)**	**($8,204)**	**($7,041)**
Less: MACRS D&A[(d)]	0	(356,189)	(610,432)	(435,952)	(311,323)	(222,587)	(222,338)	(222,587)	(111,169)	0	0
EBIT	**$0**	**($322,803)**	**($576,109)**	**($450,517)**	**($324,898)**	**($235,145)**	**($233,851)**	**($233,027)**	**($120,506)**	**($8,204)**	**($7,041)**
Less: Interest Expense	0	(39,881)	(37,128)	(34,155)	(30,944)	(27,476)	(23,731)	(19,686)	(15,317)	(10,599)	(5,503)
Less: Cash Taxes	0	0	0	0	0	0	0	0	0	0	0
Tax Net Income	**$0**	**($362,684)**	**($613,237)**	**($484,672)**	**($355,842)**	**($262,621)**	**($257,582)**	**($252,713)**	**($135,823)**	**($18,803)**	**($12,544)**
MACRS D&A	0	356,189	610,432	435,952	311,323	222,587	222,338	222,587	111,169	0	0
Construction Capex	(1,994,063)	0	0	0	0	0	0	0	0	0	0
Principal	0	(34,412)	(37,165)	(40,138)	(43,350)	(46,818)	(50,563)	(54,608)	(58,977)	(63,695)	(68,790)
After Tax Levered Cash Flow	**($1,994,063)**	**($40,907)**	**($39,970)**	**($88,858)**	**($87,868)**	**($86,852)**	**($85,807)**	**($84,734)**	**($83,631)**	**($82,498)**	**($81,334)**

Levered Project IRR	**N/A**

Model Assumptions:

Size (MW)	1.0	Extended Warranty (%)[(b)(g)]	2%	Regional Power Equipment Cost Scalar[(j)]	1.00
Capacity (MWh)	4.0[(e)]	EPC Cost (%)[(h)]	12%	Regional BOS Cost Scalar[(j)]	0.95
Cycles Per Year	99[(f)]	O&M Cost (%)[(i)]	1.6%	Regional EPC Cost Scalar[(j)]	0.82
Depth of Discharge (%)	100%	Useful Life (years)	10		
Efficiency (%)	93%				

Source: DOE, Lazard and Enovation Partners estimates.

(a) Assumes 2.5% revenue escalation.
(b) Represents extended warranty costs that provide coverage beyond the initial two-year product warranty (included in equipment capital costs).
(c) Assumes 2.5% charging cost escalation.
(d) Assumes 7-year MACRS depreciation.
(e) Indicates "usable energy" capacity.
(f) Reflects full depth of discharge cycles per year.
(g) Sized as a percentage of total installed capex, annually, after expiration of initial two-year product warranty.
(h) Assumes EPC costs as a percentage of AC and DC raw capital costs.
(i) Sized as a portion of total installed capital cost. Assumes O&M escalation of 2.25%.
(j) Scalars are adjustment factors for the national averages, determined by Bloomberg estimates and Labor Departments statistics.

5 Illustrative Value Snapshot—NYISO

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total Revenue[a]	**$1,218,697**	**$354,163**	**$363,017**	**$372,093**	**$381,395**	**$390,930**	**$400,703**	**$410,721**	**$420,989**	**$431,513**	**$442,301**
Memo:											
Demand Charge Savings[b]	*$0*	*$108,205*	*$110,910*	*$113,683*	*$116,525*	*$119,438*	*$122,424*	*$125,485*	*$128,622*	*$131,837*	*$135,133*
Demand Response	*0*	*245,958*	*252,107*	*258,410*	*264,870*	*271,492*	*278,279*	*285,236*	*292,367*	*299,676*	*307,168*
Frequency Regulation	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Incentive Payments[c]	*1,218,697*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total Operating Costs	**$0**	**($46,591)**	**($47,657)**	**($97,496)**	**($98,612)**	**($99,753)**	**($100,920)**	**($102,114)**	**($103,336)**	**($104,585)**	**($105,864)**
Memo:											
O&M	*$0*	*($38,793)*	*($39,666)*	*($40,558)*	*($41,471)*	*($42,404)*	*($43,358)*	*($44,333)*	*($45,331)*	*($46,351)*	*($47,394)*
Warranty[d]	*0*	*0*	*0*	*(48,748)*	*(48,748)*	*(48,748)*	*(48,748)*	*(48,748)*	*(48,748)*	*(48,748)*	*(48,748)*
Charging[e]	*0*	*(7,798)*	*(7,992)*	*(8,190)*	*(8,393)*	*(8,601)*	*(8,814)*	*(9,033)*	*(9,257)*	*(9,487)*	*(9,722)*
EBITDA	**$1,218,697**	**$307,572**	**$315,360**	**$274,597**	**$282,783**	**$291,177**	**$299,783**	**$308,606**	**$317,653**	**$326,928**	**$336,437**
Less: MACRS D&A[f]	0	(348,304)	(596,918)	(426,300)	(304,431)	(217,659)	(217,416)	(217,659)	(108,708)	0	0
EBIT	**$1,218,697**	**($40,732)**	**($281,558)**	**($151,704)**	**($21,647)**	**$73,518**	**$82,367**	**$90,947**	**$208,945**	**$326,928**	**$336,437**
Less: Interest Expense	0	(38,998)	(36,306)	(33,399)	(30,259)	(26,868)	(23,205)	(19,250)	(14,978)	(10,364)	(5,381)
Less: Cash Taxes	(475,292)	0	0	0	0	0	0	0	0	(20,840)	(129,112)
Tax Net Income	**$743,405**	**($79,730)**	**($317,864)**	**($185,103)**	**($51,906)**	**$46,650**	**$59,162**	**$71,697**	**$193,967**	**$295,724**	**$201,944**
MACRS D&A	0	348,304	596,918	426,300	304,431	217,659	217,416	217,659	108,708	0	0
Construction Capex	(1,949,915)	0	0	0	0	0	0	0	0	0	0
Principal	0	(33,650)	(36,342)	(39,250)	(42,390)	(45,781)	(49,443)	(53,399)	(57,671)	(62,285)	(67,267)
After Tax Levered Cash Flow	**($1,206,510)**	**$234,923**	**$242,711**	**$201,948**	**$210,134**	**$218,528**	**$227,134**	**$235,957**	**$245,004**	**$233,439**	**$134,677**

Levered Project IRR	14.8%

Model Assumptions:

Size (MW)	1.0	Extended Warranty (%)[d][i]	2%	Regional Power Equipment Cost Scalar[l]	1.00
Capacity (MWh)	4.0[g]	EPC Cost (%)[j]	19%	Regional BOS Cost Scalar[l]	0.95
Cycles Per Year	74[h]	O&M Cost (%)[k]	1.6%	Regional EPC Cost Scalar[l]	1.16
Depth of Discharge (%)	100%	Useful Life (years)	10		
Efficiency (%)	92%				

Source: DOE, Lazard and Enovation Partners estimates.

(a) Assumes 2.5% revenue escalation.
(b) Includes PLC benefits.
(c) Assumes the 50% Demand Management Program ("DMP") incentive, with 100% of the incentives paid out in construction year. Assumes incentive payment is taxable (based on discussions with developers and accountants) and assumes incentive is paid subsequent to construction spend and is thus not a source of construction finance (i.e., capital structure is incentive agnostic).
(d) Represents extended warranty costs that provide coverage beyond the initial two-year product warranty (included in equipment capital costs).
(e) Assumes 2.5% charging cost escalation.
(f) Assumes 7-year MACRS depreciation.
(g) Indicates "usable energy" capacity.
(h) Reflects full depth of discharge cycles per year.
(i) Sized as a percentage of total installed capex, annually, after expiration of initial two-year product warranty.
(j) Assumes EPC costs as a percentage of AC and DC raw capital costs.
(k) Sized as a portion of total installed capital cost. Assumes O&M escalation of 2.25%.
(l) Scalars are adjustment factors for the national averages, determined by Bloomberg estimates and Labor Departments statistics.

Illustrative Value Snapshots—Assumptions

		Demand Response	Frequency Regulation	Building Type	Cost Assumptions
1	PJM	■ Observed payments based on PLC ■ Modeled payment: $63k/MW-year (Capacity/PLC)	■ Regulation payment: $40.00/MWh[(a)] (Reg-D)	■ NREL Climate Zone: 5A ■ Function: Medium-sized commercial building	■ DC system: $520/kWh ■ AC system: $410/kWh ■ EPC: 13% ■ Efficiency: 89% ■ Charging costs: $48/MWh
2	ISO-NE	■ Observed payments based on ICAP tag ■ Modeled payment: $115k/MW-year (PLC)	■ Regulation payment: $25.83/MWh	■ NREL Climate Zone: 5A ■ Function: Medium-sized commercial building	■ DC system: $527/kWh ■ AC system: $102/kWh ■ EPC: 18% ■ Efficiency: 92% ■ Charging costs: $106/MWh
3	CAISO	■ Observed payments for program participation includes Capacity Bidding Program ("CBP")—$81/MW-year and Base Interruptible Program ("BIP")—$139/MW-year ■ Modeled payment: $220k/MW-year (CBP & BIP)	■ Reg-Up characteristics: $5.66/MWh (75% split) ■ Reg-Down characteristics: $3.13/MWh (25% split)	■ NREL Climate Zone: 3B:CA ■ Function: Medium-sized commercial building	■ DC system: $462/kWh (net of SGIP) ■ AC system: $102/kWh (net of SGIP) ■ EPC: 16% ■ Efficiency: 92% ■ Charging costs: $61/MWh
4	ERCOT	■ Observed payments based on Responsive Reserve Service ("RRS") ■ Modeled payment: $98k/MW-year (RRS)	■ Reg-Up characteristics: $10.25/MWh (75% split) ■ Reg-Down characteristics: $5.35/MWh (25% split)	■ NREL Climate Zone: 2A ■ Function: Medium-sized commercial building	■ DC system: $504/kWh ■ AC system: $51/kWh ■ EPC: 12% ■ Efficiency: 93% ■ Charging costs: $14/MWh
5	NYISO	■ Observed payments based on Distribution Load Relief Program ("DLRP")—$90/MW-year; Commercial System Relief Program ("CSRP")—$90/MW-year; Special Case Resource ("SCR")—$120/MW-year ■ Modeled payment: $300k/MW-year (DLRP+CSRP+SCR)	■ Regulation payment: $8.79/MWh	■ NREL Climate Zone: 4A ■ Function: Large-sized commercial building	■ DC system: $462/kWh (net of DMP) ■ AC system: $51/kWh (net of DMP) ■ EPC: 19% ■ Efficiency: 92% ■ Charging costs: $24/MWh

Source: *DOE, Lazard and Enovation Partners estimates.*

(a) Recent research estimates payments for participation of storage in the PJM Reg-D program are in the range of $19/MWh and $52/MWh (*A Comparison of Policies on the Participation of Storage in U.S. Frequency Regulation Markets; IEEE February 2016*).

Appendix

Charging Cost and Escalation Assumptions

	CHARGING COST ($/MWh)	CHARGING COST SOURCE	CHARGING COST ESCALATION (%)	CHARGING COST ESCALATION SOURCE
TRANSMISSION	$34.69	EIA 2015 Wholesale Price $/MWh—Weighted Average (Low)	2.5%	EIA Electricity Monthly Update—12 Markets Averaged and Annualized
PEAKER REPLACEMENT	$34.69	EIA 2015 Wholesale Price $/MWh—Weighted Average (Low)	2.5%	EIA Electricity Monthly Update—12 Markets Averaged and Annualized
FREQUENCY REGULATION	$46.92	EIA 2015 PJM-Wholesale Real Time—Weighted Average	2.5%	EIA Electricity Monthly Update—PJM Market Annualized
DISTRIBUTION SUBSTATION	$36.14	EIA 2015 Wholesale Price $/MWh—Weighted Average	2.5%	EIA Electricity Monthly Update—12 Markets Averaged and Annualized
DISTRIBUTION FEEDER	$36.14	EIA 2015 Wholesale Price $/MWh—Weighted Average	2.5%	EIA Electricity Monthly Update—12 Markets Averaged and Annualized
MICROGRID	$104.55	EIA Average Commercial Retail Price 2015	2.3%	AEO 2015 Reference Case—Electric Power Projections: Commercial
ISLAND GRID	$281.29	Lazard LCOE v10.0 Diesel (High)	2.3%	Lazard Analysis
COMMERCIAL & INDUSTRIAL	$69.18	EIA Average Industrial Retail Price 2015	2.5%	AEO 2015 Reference Case—Electric Power Projections: Industrial
COMMERCIAL APPLIANCE	$104.55	EIA Average Commercial Retail Price 2015	2.3%	AEO 2015 Reference Case—Electric Power Projections: Commercial
RESIDENTIAL	$123.92	EIA Average Residential Retail Price 2015	2.5%	AEO 2015 Reference Case—Electric Power Projections: Residential

Source: EIA and Lazard estimates.

Levelized Cost of Storage—Key Assumptions

Transmission

	Units	Pumped HS	Zinc	CAES	Flow Battery (Vanadium)	Flow Battery (Zinc-Bromine)	Flow Battery (Other)	Lithium	Sodium	Thermal
Power Rating	MW	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100
Duration	Hours	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8
Usable Energy	MWh	800 - 800	800 - 800	800 - 800	800 - 800	800 - 800	800 - 800	800 - 800	800 - 800	800 - 800
100% Depth of Discharge Cycles/Day		1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1
Operating Days/Year		350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350
Project Life	Years	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20
Memo: Annual Used Energy	MWh	280,000 - 280,000	280,000 - 280,000	280,000 - 280,000	280,000 - 280,000	280,000 - 280,000	280,000 - 280,000	280,000 - 280,000	280,000 - 280,000	280,000 - 280,000
Memo: Project Used Energy	MWh	5,600,000 - 5,600,000	5,600,000 - 5,600,000	5,600,000 - 5,600,000	5,600,000 - 5,600,000	5,600,000 - 5,600,000	5,600,000 - 5,600,000	5,600,000 - 5,600,000	5,600,000 - 5,600,000	5,600,000 - 5,600,000
Initial Capital Cost—DC	$/kWh	--	$207 - $581	--	$400 - $1,000	$585 - $540	$450 - $950	$361 - $891	$385 - $1,175	--
Initial Capital Cost—AC	$/kWh	--	$26 - $26	--	$26 - $26	$26 - $26	$26 - $26	$26 - $26	$26 - $26	--
Initial Other Owners Costs	$/kWh	$26 - $38	$28 - $73	$16 - $23	$62 - $149	$88 - $82	$69 - $141	$54 - $128	$57 - $168	$39 - $47
Total Initial Installed Cost	$/kWh	$238 - $350	$261 - $680	$146 - $210	$487 - $1,174	$699 - $647	$544 - $1,117	$440 - $1,045	$468 - $1,368	$362 - $434
Replacement Capital Cost—DC	$/kWh									
After Year 5		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $420	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$0 - $0	$200 - $293	$0 - $0	$32 - $63	$36 - $389	$36 - $36	$189 - $338	$270 - $792	$0 - $0
After Year 15		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $379	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Replacement Capital Cost—AC	$/kWh									
After Year 5		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 15		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
O&M Cost	$/kWh	$2 - $4	$7 - $24	$1 - $2	$12 - $35	$21 - $19	$16 - $22	$5 - $11	$7 - $21	$4 - $9
O&M % of Capex	%	1.0% - 1.0%	2.7% - 3.5%	1.0% - 1.0%	2.5% - 3.0%	3.0% - 3.0%	3.0% - 2.0%	1.1% - 1.0%	1.6% - 1.5%	1.0% - 2.0%
Investment Tax Credit	%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%
Production Tax Credit	$/MWh	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Charging Cost	$/MWh	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35
Charging Cost Escalator	%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%
Efficiency	%	80% - 82%	64% - 64%	75% - 79%	68% - 70%	70% - 73%	86% - 62%	92% - 93%	82% - 82%	55% - 50%
Levelized Cost of Storage	$/MWh	$152 - $198	$262 - $438	$116 - $140	$314 - $690	$434 - $549	$340 - $630	$267 - $561	$301 - $784	$227 - $280

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

		Peaker Replacement							
	Units	Zinc	Lithium	Flow Battery (Vanadium)	Flow Battery (Zinc-Bromine)	Flow Battery (Other)	Sodium	Flywheel	Thermal
Power Rating	MW	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100	100 - 100
Duration	Hours	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4
Usable Energy	MWh	400 - 400	400 - 400	400 - 400	400 - 400	400 - 400	400 - 400	400 - 400	400 - 400
100% Depth of Discharge Cycles/Day		1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1
Operating Days/Year		350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350
Project Life	Years	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20
Memo: Annual Used Energy	MWh	140,000 - 140,000	140,000 - 140,000	140,000 - 140,000	140,000 - 140,000	140,000 - 140,000	140,000 - 140,000	140,000 - 140,000	140,000 - 140,000
Memo: Project Used Energy	MWh	2,800,000 - 2,800,000	2,800,000 - 2,800,000	2,800,000 - 2,800,000	2,800,000 - 2,800,000	2,800,000 - 2,800,000	2,800,000 - 2,800,000	2,800,000 - 2,800,000	2,800,000 - 2,800,000
Initial Capital Cost—DC	$/kWh	$207 - $587	$366 - $898	$580 - $950	$585 - $540	$600 - $1,000	$392 - $1,182	$500 - $898	--
Initial Capital Cost—AC	$/kWh	$51 - $51	$51 - $51	$51 - $51	$51 - $51	$51 - $51	$51 - $51	$51 - $51	--
Initial Other Owners Costs	$/kWh	$32 - $78	$58 - $133	$91 - $145	$92 - $85	$94 - $152	$62 - $173	$75 - $128	$56 - $67
Total Initial Installed Cost	$/kWh	$290 - $715	$475 - $1,082	$722 - $1,146	$728 - $677	$745 - $1,203	$505 - $1,405	$626 - $1,077	$489 - $543
Replacement Capital Cost—DC	$/kWh								
After Year 5		$0 - $0	$0 - $0	$0 - $0	$0 - $420	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$200 - $293	$189 - $338	$45 - $53	$36 - $389	$42 - $52	$270 - $792	$24 - $40	$0 - $0
After Year 15		$0 - $0	$0 - $0	$0 - $0	$0 - $379	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Replacement Capital Cost—AC	$/kWh								
After Year 5		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 15		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
O&M Cost	$/kWh	$8 - $24	$6 - $12	$21 - $29	$22 - $20	$22 - $36	$8 - $22	$10 - $17	$5 - $11
O&M % of Capex	%	2.7% - 3.4%	1.2% - 1.1%	3.0% - 2.5%	3.0% - 3.0%	3.0% - 3.0%	1.6% - 1.5%	1.6% - 1.6%	1.0% - 2.0%
Investment Tax Credit	%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%
Production Tax Credit	$/MWh	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Charging Cost	$/MWh	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35	$35 - $35
Charging Cost Escalator	%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%
Efficiency	%	64% - 64%	92% - 93%	77% - 70%	70% - 73%	86% - 70%	82% - 82%	91% - 91%	55% - 50%
Levelized Cost of Storage	$/MWh	$277 - $456	$285 - $581	$441 - $657	$448 - $563	$447 - $704	$320 - $803	$342 - $555	$290 - $348

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

		Frequency Regulation			
	Units	Lithium		Flywheel	
Power Rating	MW	10	10	10	10
Duration	Hours	0.5	0.5	0.5	0.5
Usable Energy	MWh	5	5	5	5
100% Depth of Discharge Cycles/Day		4.8	4.8	4.8	4.8
Operating Days/Year		350	350	350	350
Project Life	Years	10	10	10	10
Memo: Annual Used Energy	MWh	8,400	8,400	8,400	8,400
Memo: Project Used Energy	MWh	84,000	84,000	84,000	84,000
Initial Capital Cost—DC	$/kWh	$482	$900	--	
Initial Capital Cost—AC	$/kWh	$409	$584	--	
Initial Other Owners Costs	$/kWh	$134	$223	$540	$1,200
Total Initial Installed Cost	$/kWh	$1,024	$1,706	$4,140	$9,200
Replacement Capital Cost—DC	$/kWh				
After Year 5		$0	$0	$0	$0
After Year 10		$0	$0	$0	$0
After Year 15		$0	$0	$0	$0
Replacement Capital Cost—AC	$/kWh				
After Year 5		$0	$0	$0	$0
After Year 10		$0	$0	$0	$0
After Year 15		$0	$0	$0	$0
O&M Cost	$/kWh	$20	$32	$83	$184
O&M % of Capex	%	2.0%	1.9%	2.0%	2.0%
Investment Tax Credit	%	0.0%	0.0%	0.0%	0.0%
Production Tax Credit	$/MWh	$0	$0	$0	$0
Charging Cost	$/MWh	$47	$47	$47	$47
Charging Cost Escalator	%	2.5%	2.5%	2.5%	2.5%
Efficiency	%	89%	89%	82%	85%
Levelized Cost of Storage	$/MWh	$190	$277	$598	$1,251

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

		Distribution Substation								
	Units	Zinc	Flow Battery (Vanadium)	Flow Battery (Zinc-Bromine)	Flow Battery (Other)	Lithium	Lead	Sodium	Flywheel	Thermal
Power Rating	MW	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4
Duration	Hours	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4	4 - 4
Usable Energy	MWh	16 - 16	16 - 16	16 - 16	16 - 16	16 - 16	16 - 16	16 - 16	16 - 16	16 - 16
100% Depth of Discharge Cycles/Day		1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1
Operating Days/Year		300 - 300	300 - 300	300 - 300	300 - 300	300 - 300	300 - 300	300 - 300	300 - 300	300 - 300
Project Life	Years	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20
Memo: Annual Used Energy	MWh	4,800 - 4,800	4,800 - 4,800	4,800 - 4,800	4,800 - 4,800	4,800 - 4,800	4,800 - 4,800	4,800 - 4,800	4,800 - 4,800	4,800 - 4,800
Memo: Project Used Energy	MWh	96,000 - 96,000	96,000 - 96,000	96,000 - 96,000	96,000 - 96,000	96,000 - 96,000	96,000 - 96,000	96,000 - 96,000	96,000 - 96,000	96,000 - 96,000
Initial Capital Cost—DC	$/kWh	$232 - $603	$580 - $950	$585 - $450	$600 - $1,000	$381 - $850	$460 - $1,160	$412 - $1,204	$500 - $898	--
Initial Capital Cost—AC	$/kWh	$51 - $51	$51 - $51	$51 - $51	$51 - $51	$51 - $51	$51 - $51	$51 - $51	$51 - $51	--
Initial Other Owners Costs	$/kWh	$40 - $93	$104 - $165	$105 - $82	$107 - $173	$69 - $144	$82 - $194	$74 - $201	$86 - $147	$159 - $187
Total Initial Installed Cost	$/kWh	$323 - $746	$735 - $1,166	$741 - $584	$758 - $1,224	$501 - $1,045	$593 - $1,405	$537 - $1,455	$637 - $1,096	$1,219 - $1,353
Replacement Capital Cost—DC	$/kWh									
After Year 5		$0 - $0	$0 - $0	$0 - $350	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$228 - $293	$45 - $53	$36 - $324	$42 - $52	$189 - $313	$280 - $630	$270 - $792	$24 - $40	$0 - $0
After Year 15		$0 - $0	$0 - $0	$0 - $316	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Replacement Capital Cost—AC	$/kWh									
After Year 5		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 15		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
O&M Cost	$/kWh	$11 - $26	$22 - $29	$22 - $17	$22 - $36	$7 - $14	$12 - $28	$9 - $22	$10 - $17	$12 - $27
O&M % of Capex	%	3.4% - 3.4%	3.0% - 2.5%	3.0% - 2.9%	3.0% - 3.0%	1.4% - 1.3%	2.0% - 2.0%	1.6% - 1.5%	1.6% - 1.6%	1.0% - 2.0%
Investment Tax Credit	%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%
Production Tax Credit	$/MWh	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Charging Cost	$/MWh	$36 - $36	$36 - $36	$36 - $36	$36 - $36	$36 - $36	$36 - $36	$36 - $36	$36 - $36	$36 - $36
Charging Cost Escalator	%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%	2.5% - 2.5%
Efficiency	%	64% - 64%	77% - 70%	70% - 73%	86% - 70%	92% - 93%	86% - 86%	82% - 82%	91% - 91%	55% - 50%
Levelized Cost of Storage	$/MWh	$404 - $542	$516 - $770	$524 - $564	$524 - $828	$345 - $657	$425 - $933	$385 - $959	$400 - $654	$707 - $862

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

		Distribution Feeder											
	Units	Zinc		Flow Battery (Zinc-Bromine)		Lithium		Flywheel		Lead		Sodium	
Power Rating	MW	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Duration	Hours	3	3	3	3	3	3	3	3	3	3	3	3
Usable Energy	MWh	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
100% Depth of Discharge Cycles/Day		1	1	1	1	1	1	1	1	1	1	1	1
Operating Days/Year		200	200	200	200	200	200	200	200	200	200	200	200
Project Life	Years	20	20	20	20	20	20	20	20	20	20	20	20
Memo: Annual Used Energy	MWh	300	300	300	300	300	300	300	300	300	300	300	300
Memo: Project Used Energy	MWh	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Initial Capital Cost—DC	$/kWh	$247	$613	$585	$1,080	$391	$863	$500	$898	$528	$1,078	$425	$1,218
Initial Capital Cost—AC	$/kWh	$68	$68	$68	$68	$68	$68	$68	$68	$68	$68	$68	$68
Initial Other Owners Costs	$/kWh	$48	$104	$114	$174	$78	$158	$94	$160	$101	$195	$84	$219
Total Initial Installed Cost	$/kWh	$363	$785	$767	$1,322	$537	$1,089	$662	$1,126	$697	$1,341	$577	$1,505
Replacement Capital Cost—DC	$/kWh												
After Year 5		$0	$0	$0	$0	$0	$0	$0	$0	$0	$792	$0	$0
After Year 10		$228	$293	$36	$823	$189	$313	$24	$40	$308	$766	$270	$792
After Year 15		$0	$0	$0	$0	$0	$0	$0	$0	$0	$753	$0	$0
Replacement Capital Cost—AC	$/kWh												
After Year 5		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
After Year 10		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
After Year 15		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost	$/kWh	$10	$27	$23	$39	$9	$17	$11	$18	$14	$27	$9	$23
O&M % of Capex	%	2.8%	3.4%	2.9%	3.0%	1.6%	1.6%	1.6%	1.6%	2.1%	2.0%	1.6%	1.6%
Investment Tax Credit	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Production Tax Credit	$/MWh	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Charging Cost	$/MWh	$36	$36	$36	$36	$36	$36	$36	$36	$36	$36	$36	$36
Charging Cost Escalator	%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Efficiency	%	64%	64%	70%	72%	92%	93%	91%	91%	86%	77%	82%	82%
Levelized Cost of Storage	$/MWh	$515	$815	$779	$1,346	$532	$1,014	$601	$983	$708	$1,710	$586	$1,455

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

		Microgrid					
	Units	Flywheel			Lithium		
Power Rating	MW	2	-	2	2	-	2
Duration	Hours	1	-	1	1	-	1
Usable Energy	MWh	2	-	2	2	-	2
100% Depth of Discharge Cycles/Day		2	-	2	2	-	2
Operating Days/Year		350	-	350	350	-	350
Project Life	Years	20	-	20	20	-	20
Memo: Annual Used Energy	MWh	1,400	-	1,400	1,400	-	1,400
Memo: Project Used Energy	MWh	28,000	-	28,000	28,000	-	28,000
Initial Capital Cost—DC	$/kWh	$500	-	$898	$550	-	$801
Initial Capital Cost—AC	$/kWh	$204	-	$204	$204	-	$204
Initial Other Owners Costs	$/kWh	$117	-	$183	$128	-	$171
Total Initial Installed Cost	$/kWh	$822	-	$1,285	$883	-	$1,176
Replacement Capital Cost—DC	$/kWh						
After Year 5		$0	-	$0	$0	-	$453
After Year 10		$24	-	$40	$275	-	$415
After Year 15		$0	-	$0	$0	-	$404
Replacement Capital Cost—AC	$/kWh						
After Year 5		$0	-	$0	$0	-	$0
After Year 10		$0	-	$0	$181	-	$181
After Year 15		$0	-	$0	$0	-	$0
O&M Cost	$/kWh	$15	-	$22	$16	-	$20
O&M % of Capex	%	1.8%	-	1.7%	1.8%	-	1.7%
Investment Tax Credit	%	0.0%	-	0.0%	0.0%	-	0.0%
Production Tax Credit	$/MWh	$0	-	$0	$0	-	$0
Charging Cost	$/MWh	$105	-	$105	$105	-	$105
Charging Cost Escalator	%	2.3%	-	2.3%	2.3%	-	2.3%
Efficiency	%	91%	-	91%	91%	-	91%
Levelized Cost of Storage	$/MWh	$332	-	$441	$372	-	$507

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

	Units	Island							
		Zinc	Lithium	Flow Battery (Vanadium)	Flow Battery (Zinc-Bromine)	Flow Battery (Other)	Sodium	Lead	Flywheel
Power Rating	MW	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1
Duration	Hours	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8
Usable Energy	MWh	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8	8 - 8
100% Depth of Discharge Cycles/Day		1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1	1 - 1
Operating Days/Year		350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350	350 - 350
Project Life	Years	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20	20 - 20
Memo: Annual Used Energy	MWh	2,800 - 2,800	2,800 - 2,800	2,800 - 2,800	2,800 - 2,800	2,800 - 2,800	2,800 - 2,800	2,800 - 2,800	2,800 - 2,800
Memo: Project Used Energy	MWh	56,000 - 56,000	56,000 - 56,000	56,000 - 56,000	56,000 - 56,000	56,000 - 56,000	56,000 - 56,000	56,000 - 56,000	56,000 - 56,000
Initial Capital Cost—DC	$/kWh	$247 - $840	$401 - $945	$400 - $1,000	$585 - $960	$450 - $950	$439 - $1,233	$500 - $1,200	$500 - $898
Initial Capital Cost—AC	$/kWh	$26 - $26	$26 - $26	$26 - $26	$26 - $26	$26 - $26	$26 - $26	$26 - $26	$26 - $26
Initial Other Owners Costs	$/kWh	$41 - $147	$72 - $165	$74 - $179	$107 - $148	$83 - $171	$79 - $214	$89 - $208	$87 - $152
Total Initial Installed Cost	$/kWh	$314 - $1,013	$499 - $1,136	$500 - $1,205	$717 - $1,134	$559 - $1,146	$543 - $1,472	$615 - $1,434	$612 - $1,076
Replacement Capital Cost—DC	$/kWh								
After Year 5		$0 - $0	$0 - $0	$0 - $0	$0 - $780	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$228 - $300	$189 - $338	$30 - $63	$36 - $731	$36 - $36	$270 - $792	$280 - $630	$24 - $40
After Year 15		$0 - $0	$0 - $0	$0 - $0	$0 - $716	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Replacement Capital Cost—AC	$/kWh								
After Year 5		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 10		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
After Year 15		$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
O&M Cost	$/kWh	$9 - $15	$8 - $17	$15 - $36	$21 - $34	$17 - $23	$8 - $22	$12 - $29	$9 - $16
O&M % of Capex	%	2.8% - 1.5%	1.6% - 1.5%	3.0% - 3.0%	3.0% - 3.0%	3.0% - 2.0%	1.6% - 1.5%	2.0% - 2.0%	1.5% - 1.5%
Investment Tax Credit	%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%	0.0% - 0.0%
Production Tax Credit	$/MWh	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0	$0 - $0
Charging Cost	$/MWh	$281 - $281	$281 - $281	$281 - $281	$281 - $281	$281 - $281	$281 - $281	$281 - $281	$281 - $281
Charging Cost Escalator	%	2.3% - 2.3%	2.3% - 2.3%	2.3% - 2.3%	2.3% - 2.3%	2.3% - 2.3%	2.3% - 2.3%	2.3% - 2.3%	2.3% - 2.3%
Efficiency	%	64% - 62%	92% - 93%	70% - 70%	70% - 72%	86% - 62%	82% - 82%	86% - 86%	91% - 91%
Levelized Cost of Storage	$/MWh	$735 - $1,030	$608 - $923	$728 - $1,107	$845 - $1,286	$673 - $1,094	$683 - $1,180	$705 - $1,145	$643 - $863

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

	Units	Commercial & Industrial: Zinc	Lithium	Flow Battery (Vanadium)	Flow Battery (Zinc-Bromine)	Flow Battery (Other)	Lead	Sodium	Flywheel
Power Rating	MW	0.5 – 0.5	0.5 – 0.5	0.5 – 0.5	0.5 – 0.5	0.5 – 0.5	0.5 – 0.5	0.5 – 0.5	0.5 – 0.5
Duration	Hours	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4
Usable Energy	MWh	2 – 2	2 – 2	2 – 2	2 – 2	2 – 2	2 – 2	2 – 2	2 – 2
100% Depth of Discharge Cycles/Day		1 – 1	1 – 1	1 – 1	1 – 1	1 – 1	1 – 1	1 – 1	1 – 1
Operating Days/Year		250 – 250	250 – 250	250 – 250	250 – 250	250 – 250	250 – 250	250 – 250	250 – 250
Project Life	Years	10 – 10	10 – 10	10 – 10	10 – 10	10 – 10	10 – 10	10 – 10	10 – 10
Memo: Annual Used Energy	MWh	500 – 500	500 – 500	500 – 500	500 – 500	500 – 500	500 – 500	500 – 500	500 – 500
Memo: Project Used Energy	MWh	5,000 – 5,000	5,000 – 5,000	5,000 – 5,000	5,000 – 5,000	5,000 – 5,000	5,000 – 5,000	5,000 – 5,000	5,000 – 5,000
Initial Capital Cost—DC	$/kWh	$247 – $624	$401 – $1,015	$580 – $950	$400 – $800	$600 – $1,000	$500 – $1,100	$439 – $1,233	$500 – $898
Initial Capital Cost—AC	$/kWh	$51 – $51	$51 – $51	$51 – $51	$51 – $51	$51 – $51	$51 – $51	$51 – $51	$51 – $51
Initial Other Owners Costs	$/kWh	$45 – $102	$77 – $181	$110 – $175	$79 – $129	$114 – $184	$94 – $196	$83 – $218	$91 – $157
Total Initial Installed Cost	$/kWh	$343 – $778	$529 – $1,247	$741 – $1,176	$530 – $980	$765 – $1,235	$645 – $1,347	$573 – $1,502	$642 – $1,106
Replacement Capital Cost—DC	$/kWh								
After Year 5		$0 – $0	$0 – $0	$0 – $0	$350 – $650	$0 – $0	$0 – $792	$0 – $0	$0 – $0
After Year 10		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
Replacement Capital Cost—AC	$/kWh								
After Year 5		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
After Year 10		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
O&M Cost	$/kWh	$9 – $26	$8 – $19	$22 – $29	$15 – $29	$22 – $36	$13 – $27	$9 – $23	$10 – $17
O&M % of Capex	%	2.8% – 3.4%	1.6% – 1.5%	2.9% – 2.5%	2.9% – 2.9%	2.9% – 3.0%	2.0% – 2.0%	1.5% – 1.5%	1.5% – 1.5%
Investment Tax Credit	%	0.0% – 0.0%	0.0% – 0.0%	0.0% – 0.0%	0.0% – 0.0%	0.0% – 0.0%	0.0% – 0.0%	0.0% – 0.0%	0.0% – 0.0%
Production Tax Credit	$/MWh	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
Charging Cost	$/MWh	$69 – $69	$69 – $69	$69 – $69	$69 – $69	$69 – $69	$69 – $69	$69 – $69	$69 – $69
Charging Cost Escalator	%	2.5% – 2.5%	2.5% – 2.5%	2.5% – 2.5%	2.5% – 2.5%	2.5% – 2.5%	2.5% – 2.5%	2.5% – 2.5%	2.5% – 2.5%
Efficiency	%	64% – 64%	92% – 93%	77% – 70%	73% – 72%	86% – 70%	86% – 77%	82% – 82%	91% – 91%
Levelized Cost of Storage	$/MWh	$515 – $811	$530 – $1,142	$779 – $1,164	$741 – $1,241	$789 – $1,245	$648 – $1,612	$580 – $1,367	$623 – $1,011

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

	Units	Commercial Appliance											
		Lithium			Lead			Flow Battery (Zinc-Bromine)			Sodium		
Power Rating	MW	0.1	-	0.1	0.1	-	0.1	0.1	-	0.1	0.1	-	0.1
Duration	Hours	2	-	2	2	-	2	2	-	2	2	-	2
Usable Energy	MWh	0.2	-	0.2	0.2	-	0.2	0.2	-	0.2	0.2	-	0.2
100% Depth of Discharge Cycles/Day		1	-	1	1	-	1	1	-	1	1	-	1
Operating Days/Year		250	-	250	250	-	250	250	-	250	250	-	250
Project Life	Years	10	-	10	10	-	10	10	-	10	10	-	10
Memo: Annual Used Energy	MWh	50	-	50	50	-	50	50	-	50	50	-	50
Memo: Project Used Energy	MWh	500	-	500	500	-	500	500	-	500	500	-	500
Initial Capital Cost—DC	$/kWh	$401	-	$1,015	$500	-	$1,100	$800	-	$1,000	$1,305	-	$1,501
Initial Capital Cost—AC	$/kWh	$102	-	$102	$102	-	$102	$102	-	$102	$102	-	$102
Initial Other Owners Costs	$/kWh	$85	-	$190	$102	-	$204	$135	-	$165	$226	-	$273
Total Initial Installed Cost	$/kWh	$588	-	$1,307	$705	-	$1,407	$1,038	-	$1,268	$1,633	-	$1,876
Replacement Capital Cost—DC	$/kWh												
After Year 5		$0	-	$0	$0	-	$792	$650	-	$813	$0	-	$0
After Year 10		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
After Year 15		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
Replacement Capital Cost—AC	$/kWh												
After Year 5		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
After Year 10		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
After Year 15		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
O&M Cost	$/kWh	$9	-	$20	$14	-	$28	$0	-	$0	$18	-	$38
O&M % of Capex	%	1.6%	-	1.5%	2.0%	-	2.0%	0.0%	-	0.0%	1.1%	-	2.0%
Investment Tax Credit	%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%
Production Tax Credit	$/MWh	$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
Charging Cost	$/MWh	$105	-	$105	$105	-	$105	$105	-	$105	$105	-	$105
Charging Cost Escalator	%	2.3%	-	2.3%	2.3%	-	2.3%	2.3%	-	2.3%	2.3%	-	2.3%
Efficiency	%	92%	-	93%	86%	-	77%	72%	-	67%	62%	-	55%
Levelized Cost of Storage	$/MWh	$624	-	$1,234	$745	-	$1,712	$1,208	-	$1,462	$1,506	-	$1,837

Source: Lazard and Enovation Partners estimates.

Levelized Cost of Storage—Key Assumptions (cont'd)

	Units	Residential											
		Lithium			Lead			Flow Battery (Zinc-Bromine)			Sodium		
Power Rating	MW	0.005	-	0.005	0.005	-	0.005	0.005	-	0.005	0.005	-	0.005
Duration	Hours	2	-	2	2	-	2	2	-	2	2	-	2
Usable Energy	MWh	0.01	-	0.01	0.01	-	0.01	0.01	-	0.01	0.01	-	0.01
100% Depth of Discharge Cycles/Day		1	-	1	1	-	1	1	-	1	1	-	1
Operating Days/Year		250	-	250	250	-	250	250	-	250	250	-	250
Project Life	Years	10	-	10	10	-	10	10	-	10	10	-	10
Memo: Annual Used Energy	MWh	3	-	3	3	-	3	3	-	3	3	-	3
Memo: Project Used Energy	MWh	25	-	25	25	-	25	25	-	25	25	-	25
Initial Capital Cost—DC	$/kWh	$769	-	$1,455	$900	-	$1,650	$800	-	$1,000	$1,370	-	$1,566
Initial Capital Cost—AC	$/kWh	$102	-	$102	$102	-	$102	$102	-	$102	$102	-	$102
Initial Other Owners Costs	$/kWh	$131	-	$234	$150	-	$263	$135	-	$165	$221	-	$250
Total Initial Installed Cost	$/kWh	$1,001	-	$1,791	$1,153	-	$2,015	$1,038	-	$1,268	$1,693	-	$1,918
Replacement Capital Cost—DC	$/kWh												
After Year 5		$0	-	$0	$0	-	$1,188	$650	-	$810	$0	-	$0
After Year 10		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
After Year 15		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
Replacement Capital Cost—AC	$/kWh												
After Year 5		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
After Year 10		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
After Year 15		$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
O&M Cost	$/kWh	$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
O&M % of Capex	%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%
Investment Tax Credit	%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%
Production Tax Credit	$/MWh	$0	-	$0	$0	-	$0	$0	-	$0	$0	-	$0
Charging Cost	$/MWh	$124	-	$124	$124	-	$124	$124	-	$124	$124	-	$124
Charging Cost Escalator	%	2.5%	-	2.5%	2.5%	-	2.5%	2.5%	-	2.5%	2.5%	-	2.5%
Efficiency	%	92%	-	92%	80%	-	76%	71%	-	67%	62%	-	55%
Levelized Cost of Storage	$/MWh	$890	-	$1,476	$1,025	-	$2,186	$1,241	-	$1,496	$1,476	-	$1,668

Source: Lazard and Enovation Partners estimates.