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LAZARD'S LEVELIZED COST OF STORAGE ANALYSIS—VERSION 1.0

LAZARD

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 selected energy storage technologies**
- **Description of ten defined use cases for energy storage**
- **Comparative levelized cost of storage 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 and tax, as applicable**
- **Comparison and analysis of capital costs for various use case and technology combinations, including in respect of projected/expected capital cost declines**
- **Summary assumptions for the various use case and technology combinations examined**

Energy storage systems are be 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 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.

Note: This study has been prepared by Lazard for general informational purposes only, and it is not intended to be, and should not be construed as, financial or other advice.

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

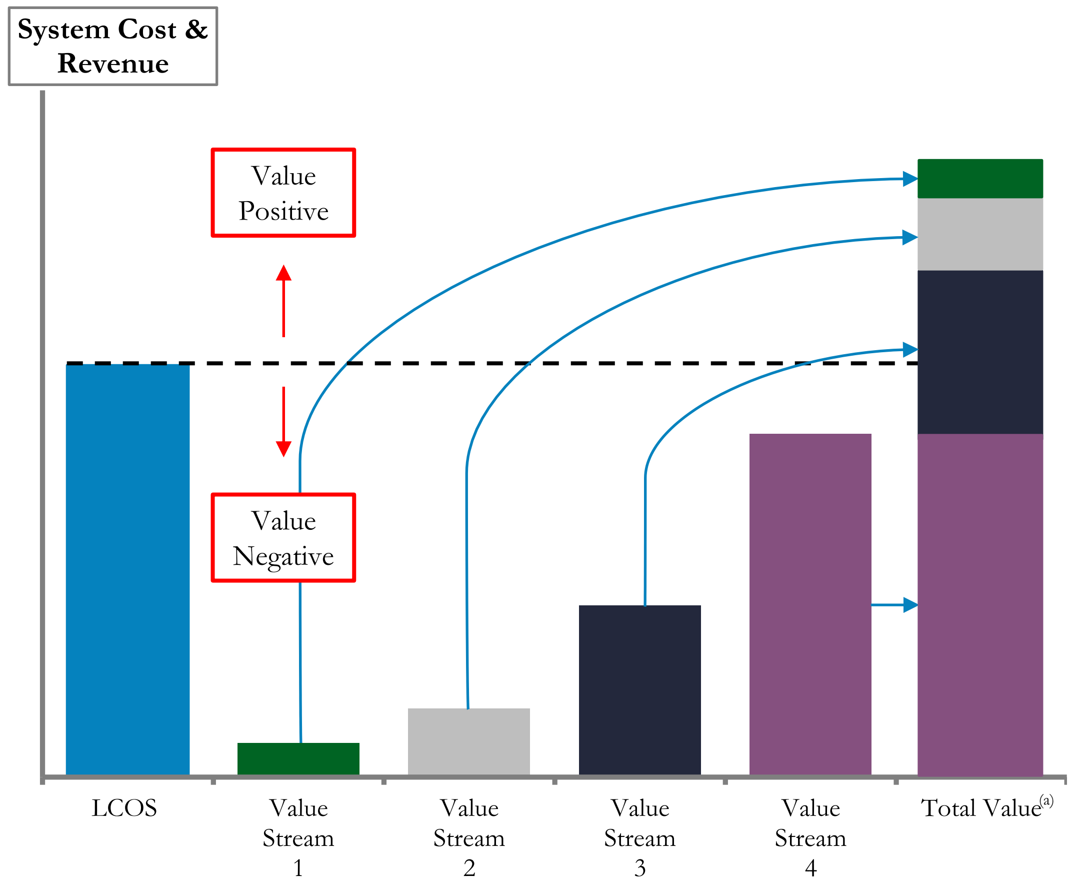
WHAT THE LCOS DOES NOT DO

- 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 market clearing 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
- Establish an authoritative framework for resource planning or decision-making

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.

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 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	15 – 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 sub-categories of flow batteries are defined by the chemical composition of the electrolyte solution; the most prevalent of such solutions are vanadium redox and zinc-bromine	15 – 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) ■ Flywheels typically have a low energy density and high power ratings—they release large amounts of power over a short period (i.e., minutes); 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 – 15 years
LITHIUM-ION‡	■ Lithium-ion batteries are relatively established and have historically been used in the electronics and advanced transportation industries ■ Lithium-ion batteries are increasingly replacing lead-acid batteries in many applications; they have relatively high energy density, low self-discharge and high charging efficiency	5 – 15 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‡	■ Sodium batteries are classified as "high temperature" and "liquid-electrolyte-flow" batteries, which have high power and energy density relative to alternatives (e.g., lead-acid); they are maintained at a temperature of 300° – 350°C	5 – 15 years
ZINC‡	■ Zinc batteries cover a wide range of possible technology variations, including metal-air derivatives ■ Zinc battery systems 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	5 – 15 years

Source: *Lazard estimates.*
‡ 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 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 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 ■ Low energy density ■ Exposure to natural gas price changes
FLOW BATTERY‡	■ Power and energy profiles highly and independently scalable ■ No degradation in "energy storage capacity"	■ Relatively high balance of system costs ■ Reduced efficiency due to rapid charge/discharge
FLYWHEEL	■ High power density, scalability and depth of discharge capability ■ Compact design with integrated AC motor	■ Relatively low energy capacity ■ High heat generation
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 (partly as a result of robust deployment in electric vehicles) ■ Efficient power and energy density	■ Remains relatively high cost ■ 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‡	■ Relatively mature technology (commercially available) ■ High energy capacity; long duration	■ Although mature, inherently higher costs ■ Operates at high temperature, resulting in potential flammability issues
ZINC‡	■ Currently quoted as low cost	■ Currently unproven commercially

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

Selected Energy Storage Use Cases—In Front of the Meter

Unlike technologies related to conventional generation, which have a single use case (i.e., the creation of electricity), energy storage technologies have a variety of use cases in a modern electric system, comprising both "in front of the meter" (or power grid-oriented) and "behind the meter" (or distributed) applications; each use case identified below solves for a particular grid or user "need," which is often most easily achieved with a subset of available energy storage technologies

- **Importantly, in practice, a single energy storage system may provide services across multiple use cases, although the feasibility of multiple application energy storage units may be limited by operational and design factors (e.g., sizing for a particular use case could preclude participation in another)**

	DESCRIPTION	SELECTED RELEVANT TECHNOLOGIES	SELECTED CONVENTIONAL ALTERNATIVES[(a)]
TRANSMISSION SYSTEM	Large-scale energy storage system to improve transmission grid performance and assist in the integration of large-scale renewable generation	Lead-Acid, Sodium, Flow Battery, Lithium-Ion, Zinc, Pumped Hydro, CAES	Transmission line upgrade Gas turbine
PEAKER REPLACEMENT	Large-scale energy storage system designed to replace peaking gas turbine facilities	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Gas turbine Diesel reciprocating engine
FREQUENCY REGULATION	Energy storage system designed to balance power to maintain frequency within a specified tolerance bound (i.e., ancillary service)	Flywheel, Lithium	Gas turbine
DISTRIBUTION SERVICES	Energy storage system placed at substations to provide flexible peaking capacity and mitigate stability problems	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Distribution system upgrade Gas turbine
PV INTEGRATION	Energy storage system designed to reduce potential integration challenges or improve the value of solar generation	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Gas turbine Diesel reciprocating engine Alteration of solar production profile

(a) Denotes an illustrative set of "base case" conventional alternatives for a given use case. Actual projects may displace a number of conventional alternatives, in certain scenarios.

Selected Energy Storage Use Cases—Behind the Meter

Unlike technologies related to conventional generation, which have a single use case (i.e., the creation of electricity), energy storage technologies have a variety of use cases in a modern electric system, comprising both "in front of the meter" (or power grid-oriented) and "behind the meter" (or distributed) applications; each of the use cases identified below solves for a particular grid or user "need," which is often most easily achieved with a subset of available energy storage technologies

- **Importantly, in practice, a single energy storage system may provide services across multiple use cases, although the feasibility of multiple application energy storage units may be limited by operational and design factors (e.g., sizing for a particular use case could preclude participation in another)**

	DESCRIPTION	SELECTED RELEVANT TECHNOLOGIES	SELECTED CONVENTIONAL ALTERNATIVES[(a)]
MICROGRID	Energy storage system used to enhance the stability and efficiency of a microgrid electricity system with specific local goals, such as reliability, diversification of energy sources and/or cost reduction, especially in the context of ramp control/mitigation (i.e., relatively short discharge profile)	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Diesel reciprocating engine Gas turbine Load profile alteration
ISLAND GRID	Energy storage system used to support the stability and efficiency of an isolated electricity system with specific local goals, such as reliability, diversification of energy sources and/or cost reduction, especially in the context of renewables integration (i.e., long discharge profile)	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Diesel reciprocating engine Gas turbine Load profile alteration
COMMERCIAL & INDUSTRIAL	Energy storage system primarily designed to provide peak shaving and demand charge reduction for commercial or industrial applications	Lead-Acid, Sodium, Zinc, Lithium-Ion, Flow Battery	Diesel reciprocating engine Gas turbine Utility service upgrade Load profile alteration
COMMERCIAL APPLIANCE	Energy storage system designed to provide demand charge reductions on a smaller scale and at a lower duration than commercial and industrial use cases	Lead-Acid, Zinc, Lithium-Ion, Flow Battery	Diesel reciprocating engine Utility service upgrade Load profile alteration
RESIDENTIAL	Energy storage system for residential home use designed to provide backup power and self-generation augmentation	Lead-Acid, Lithium-Ion, Flow Battery	Load profile alteration Backup generator

(a) Denotes an illustrative set of "base case" conventional alternatives for a given use case. Actual projects may displace a number of conventional alternatives, in certain scenarios.

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 prevalent current and contemplated energy storage applications and are derived from Industry survey data

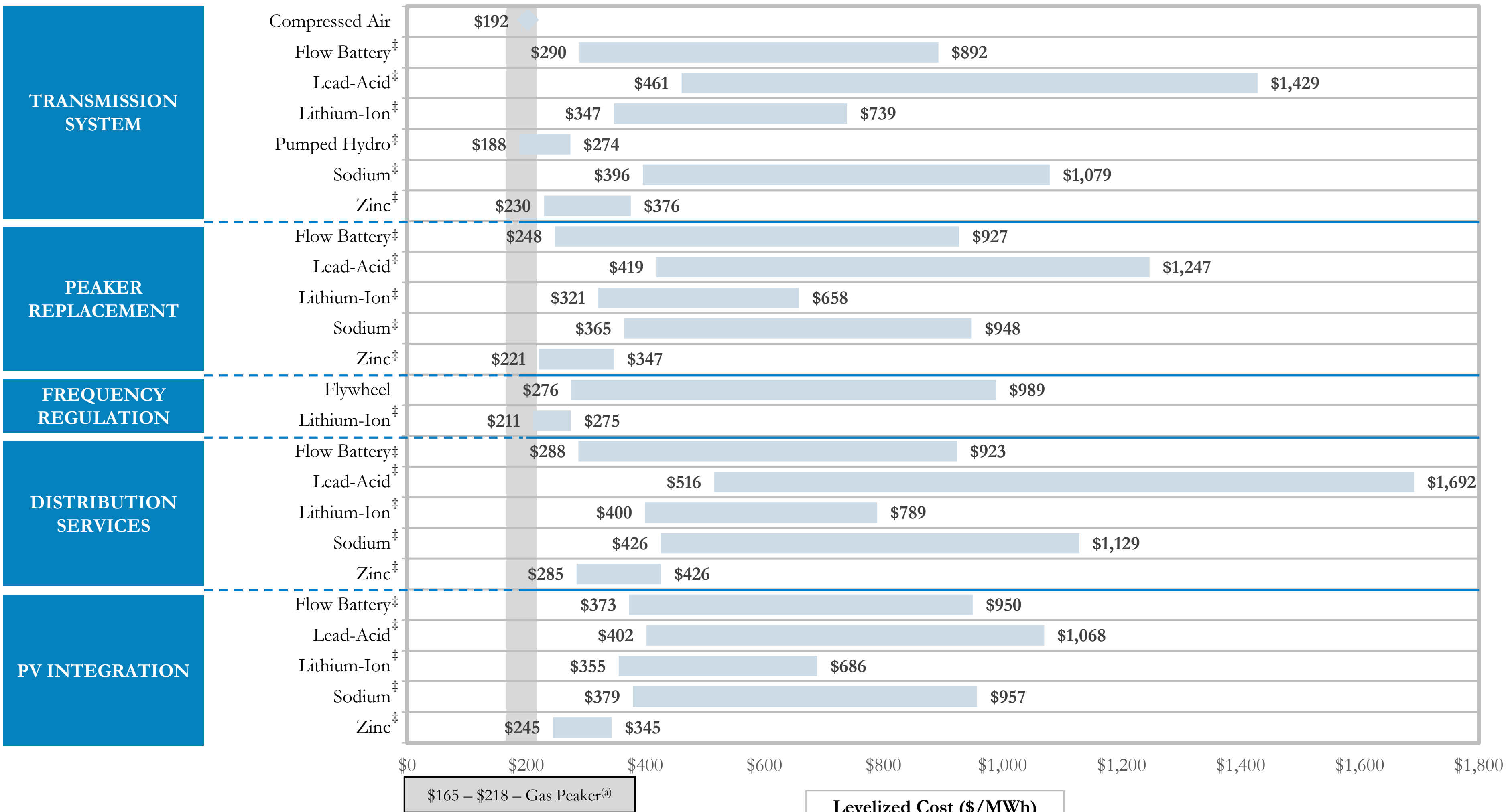
	PROJECT LIFE (YEARS)	MW[(a)]	MWh OF CAPACITY[(b)]	100% DOD CYCLES/ DAY[(c)]	DAYS / YEAR[(d)]	ANNUAL MWh	PROJECT MWh
TRANSMISSION SYSTEM	20	100	800	1	300	240,000	4,800,000
PEAKER REPLACEMENT	20	25	100	1	350	35,000	700,000
FREQUENCY REGULATION	20	10	5	4.8	350	8,400	168,000
DISTRIBUTION SERVICES	20	4	16	1	300	4,800	96,000
PV INTEGRATION	20	2	4	1.25	350	1,750	35,000
MICROGRID	20	2	2	2	350	1,400	28,000
ISLAND GRID	20	1	6	1	350	2,100	42,000
COMMERCIAL & INDUSTRIAL	10	1	4	1	350	1,400	14,000
COMMERCIAL APPLIANCE	10	0.1	0.2	1	250	50	500
RESIDENTIAL	10	0.005	0.01	1	300	3	30

[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.

Unsubsidized Levelized Cost of Storage Comparison

Certain "in front of the meter" technology and use case combinations are cost-competitive with their dominant or "base case" conventional alternatives under some scenarios, even without the benefit of subsidies or additional, non-optimized streams of revenue; such observation does not take into account potential social or environmental externalities associated with energy storage (e.g., environmental benefits associated with avoided gas peaker investment, etc.)



Source: *Lazard estimates.*

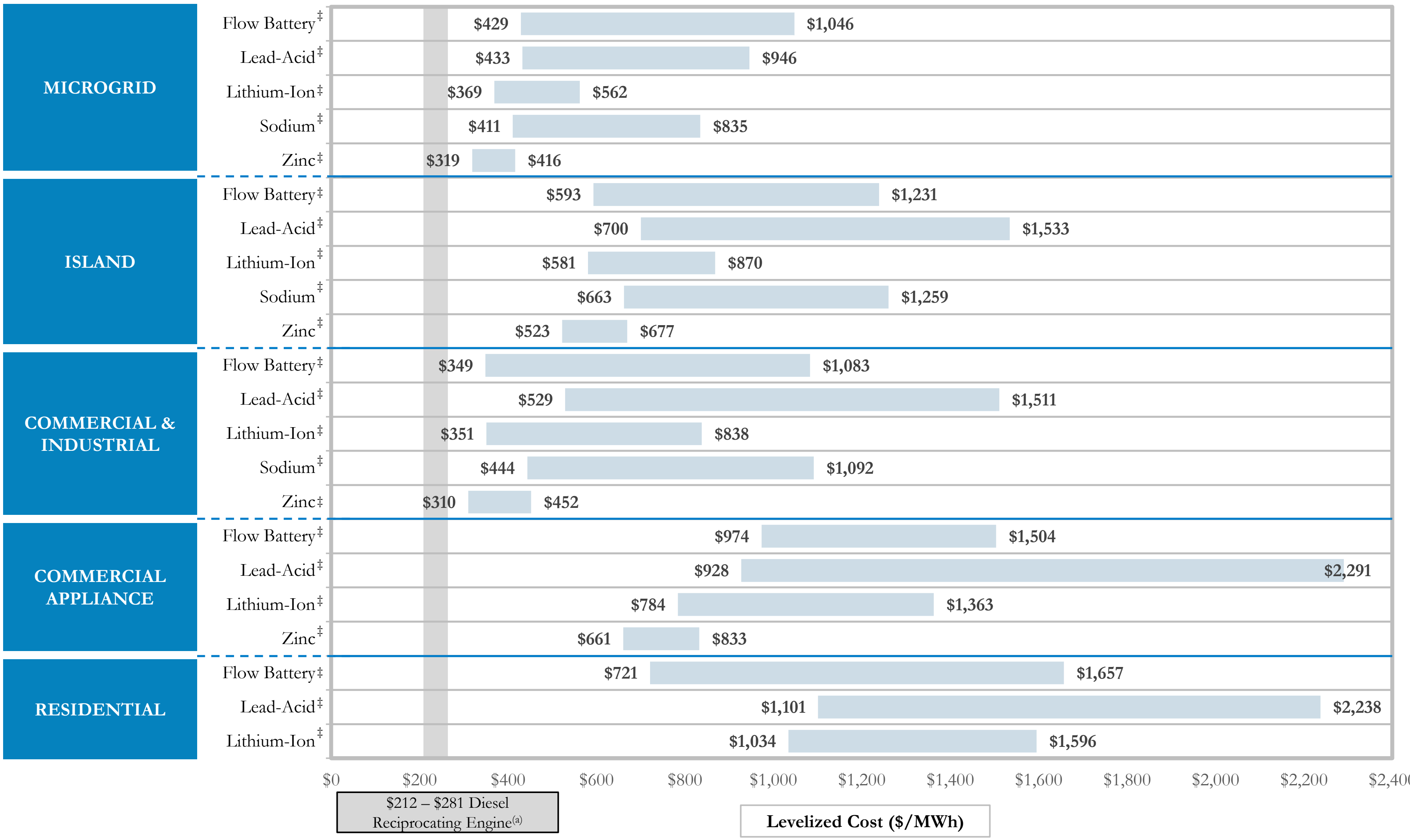
Note: Here and throughout this presentation, unless otherwise indicated, analysis assumes 20% debt at 8% interest rate and 80% equity at 12% cost for all technologies and use cases. Assumes seven year MACRS depreciation unless otherwise noted. Analysis does not reflect impact of evolving regulations/rules promulgated pursuant to the EPA's Clean Power Plan.

‡ Indicates battery technology.

(a) Indicates illustrative conventional alternative to energy storage. Not intended to reflect the sole conventional alternative (or source of value from replacing such alternatives). The lowest cost conventional alternative for a particular use case may not be the lowest cost conventional alternative for another use case.

Unsubsidized Levelized Cost of Storage Comparison (cont'd)

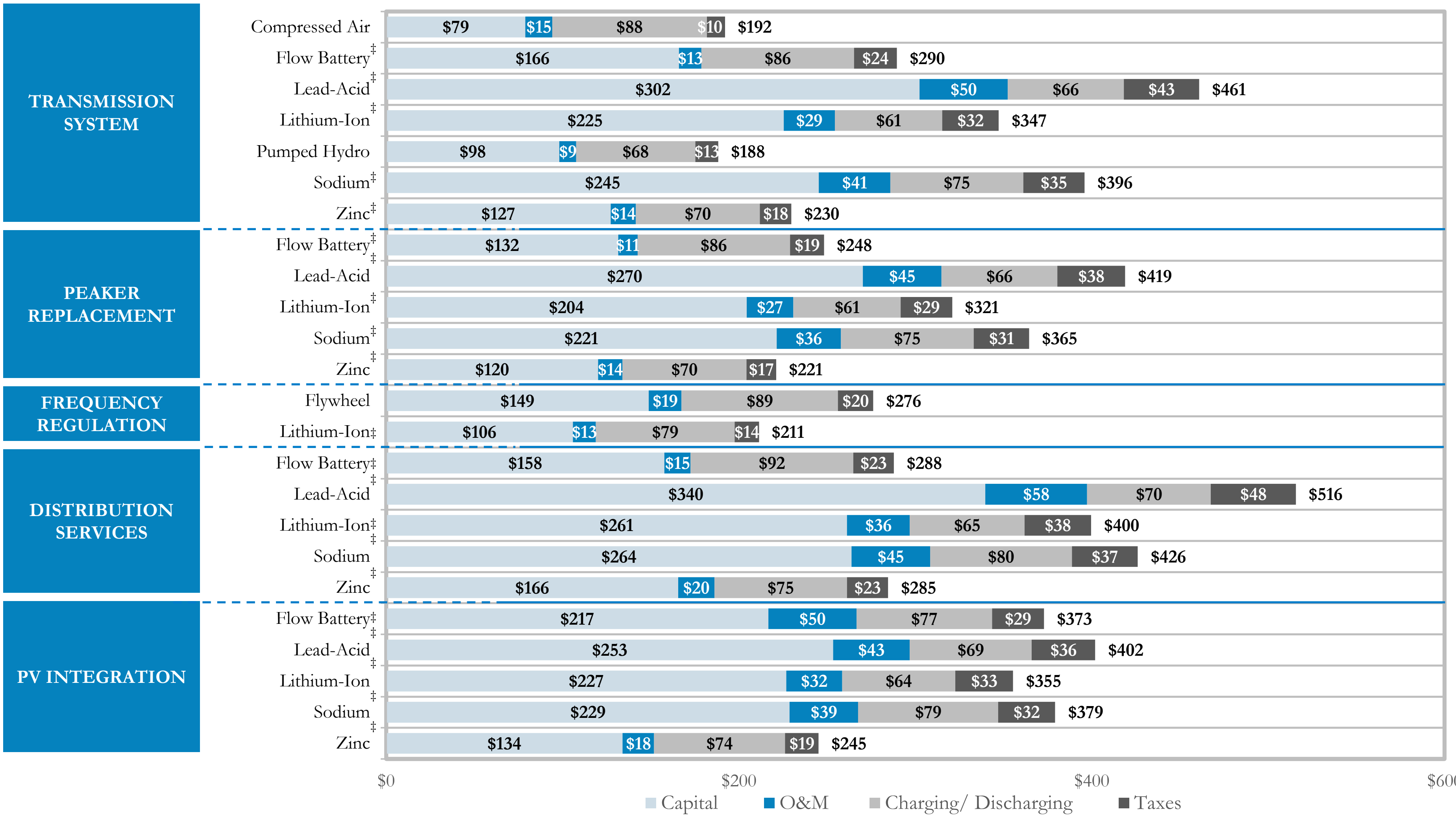
While no "behind the meter" technology and use case combination is strictly "in the money" from a cost perspective as compared to an illustrative conventional alternative, a number of combinations are within "striking distance" and, when paired with certain streams of value, may currently be economic for certain system owners in some scenarios; such observation does not take into account the social and environmental externalities associated with energy storage (e.g., the social costs of demand charge shaving, etc.)



Source: *Lazard estimates.*
‡ Indicates battery technology.
(a) Indicates illustrative conventional alternative to energy storage. Not intended to reflect the sole conventional alternative (or source of value from replacing such alternatives). The lowest cost conventional alternative for a particular use case may not be the lowest cost conventional alternative for another use case.

Levelized Cost of Storage Components—Low End

While each use case requires different operating parameters and each technology optimizes into these parameters differently according to its relative strengths and challenges, a key factor regarding the long-term competitiveness of energy storage across all use case and technology combinations is the ability of technological development and increased production volumes to materially lower the capital costs of certain energy storage technologies, and their levelized cost of energy, over time



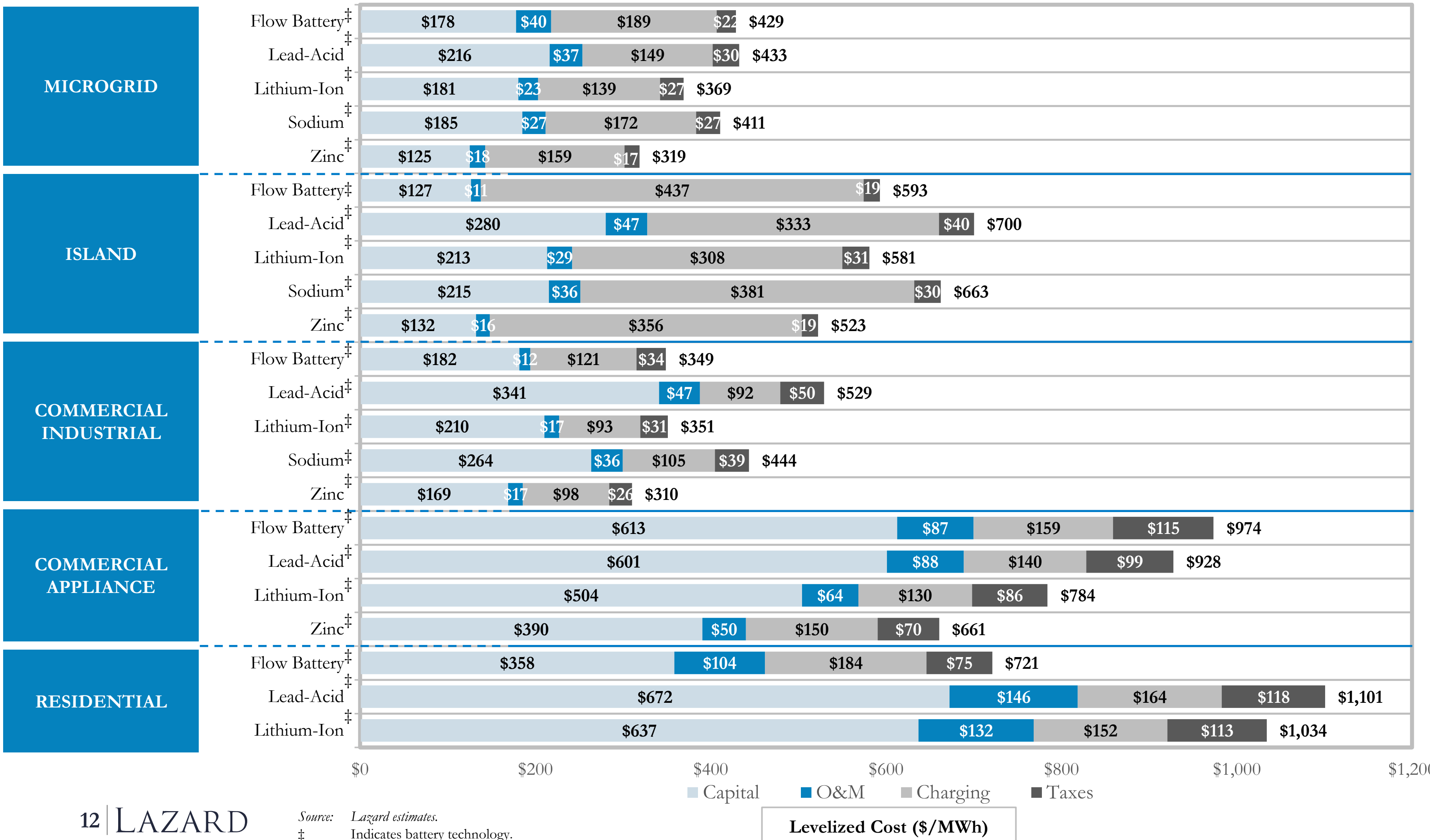
Levelized Cost ($/MWh)

Source: *Lazard estimates.*
‡ Indicates battery technology.

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

While each use case requires different operating parameters and each technology optimizes into these parameters differently according to its relative strengths and challenges, a key factor regarding the long-term competitiveness of energy storage across all use case and technology combinations is the ability of technological development and increased production volumes to materially lower the capital costs of certain energy storage technologies, and their levelized cost of energy, over time

- **A notable exception to the general theme of high capital cost components of levelized cost is the island use case, where high absolute costs of local electricity (e.g., fuel oil, diesel, renewables, etc.) result in materially greater charging costs as a percentage of LCOS**



Source: *Lazard estimates.*
‡ Indicates battery technology.

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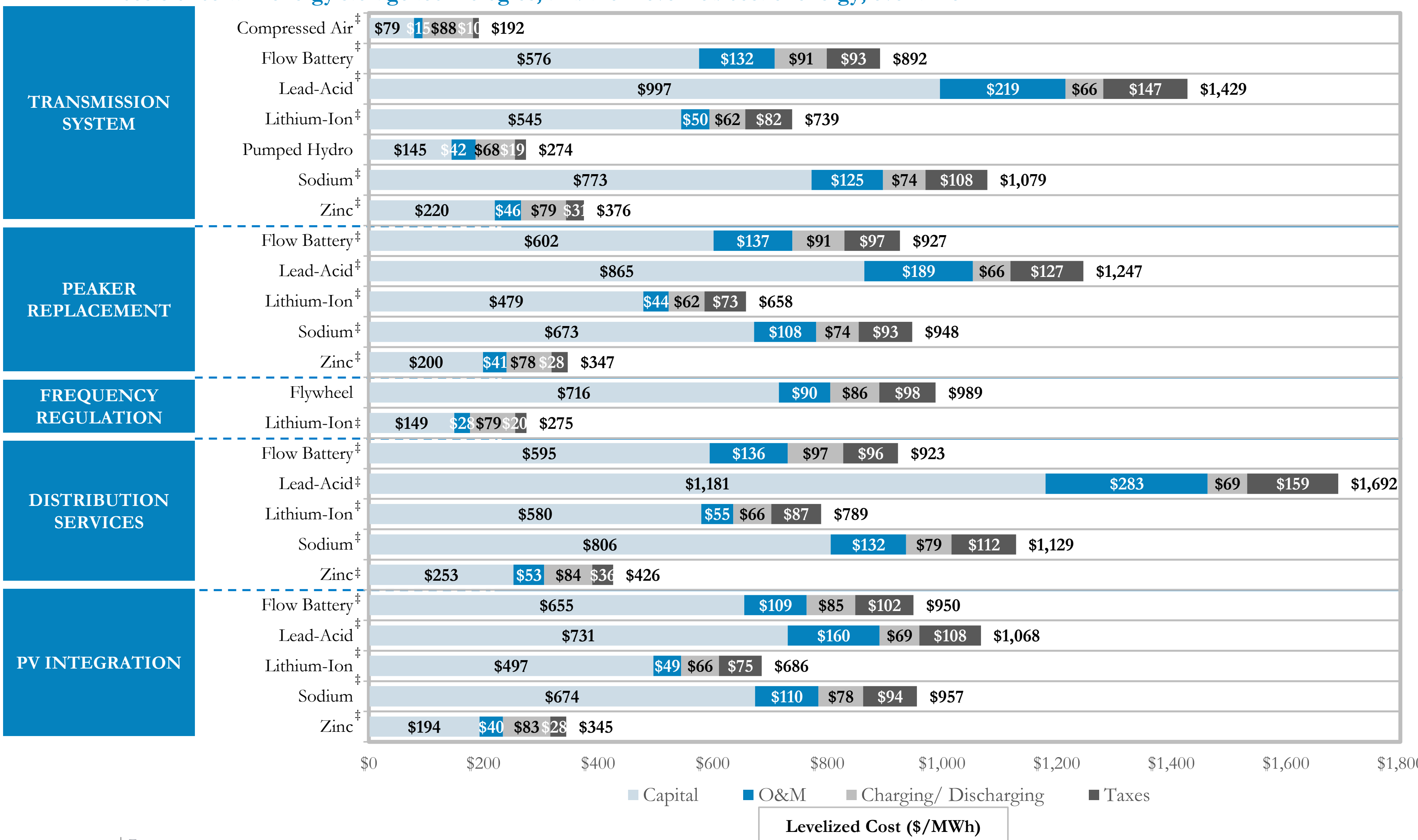
Levelized Cost of Storage Components—High End

While each use case requires different operating parameters and each technology optimizes into these parameters differently according to its relative strengths and challenges, a key factor regarding the long-term competitiveness of energy storage across all use case and technology combinations is the ability of technological development and increased production volumes to materially lower the capital costs of certain energy storage technologies, and their levelized cost of energy, over time



Source: *Lazard estimates.*
‡ Indicates battery technology.

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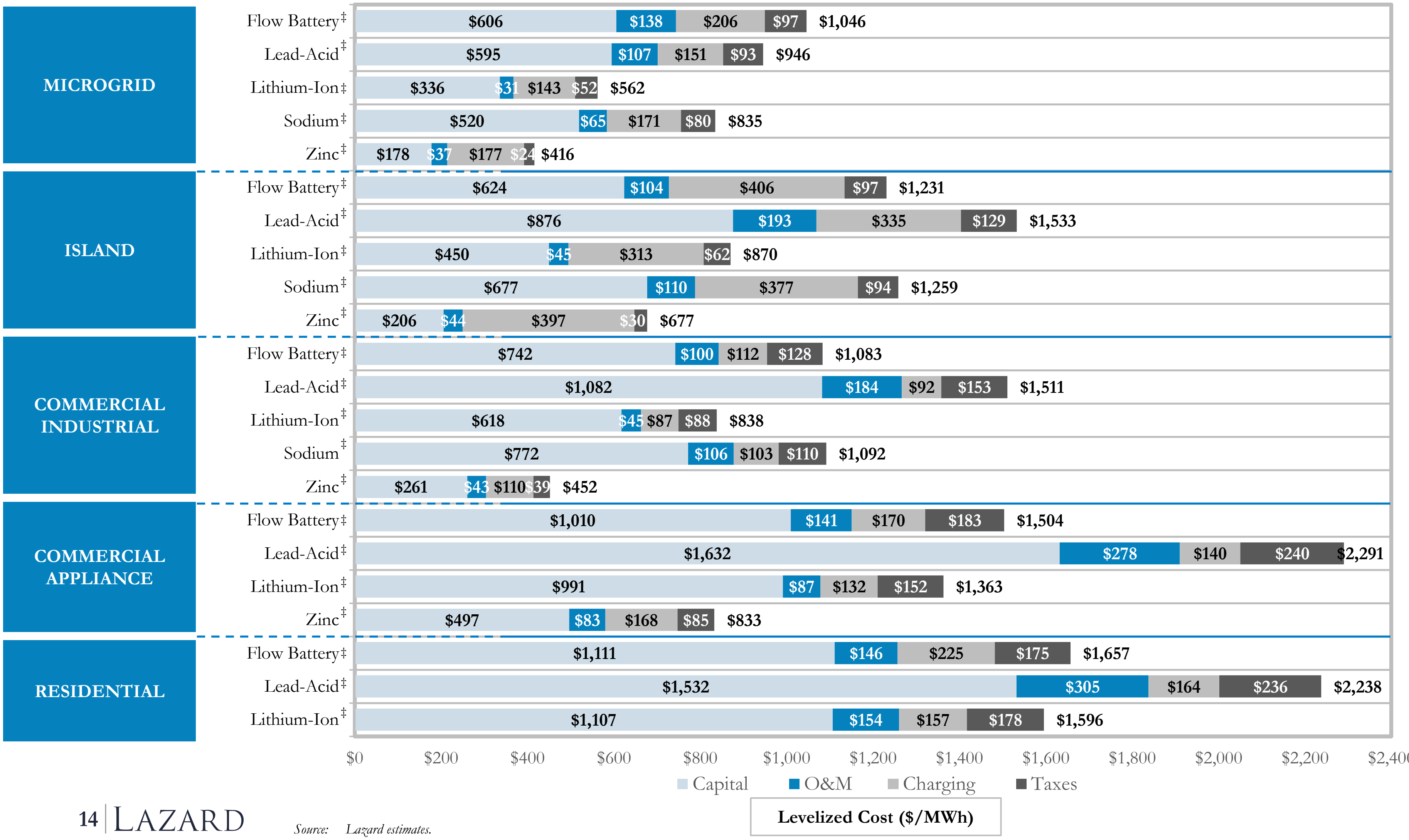
Levelized Cost of Storage Components—High End (cont'd)

While each use case requires different operating parameters and each technology optimizes into these parameters differently according to its relative strengths and challenges, a key factor regarding the long-term competitiveness of energy storage across all use case and technology combinations is the ability of technological development and increased production volumes to materially lower the capital costs of certain energy storage technologies, and their levelized cost of energy, over time

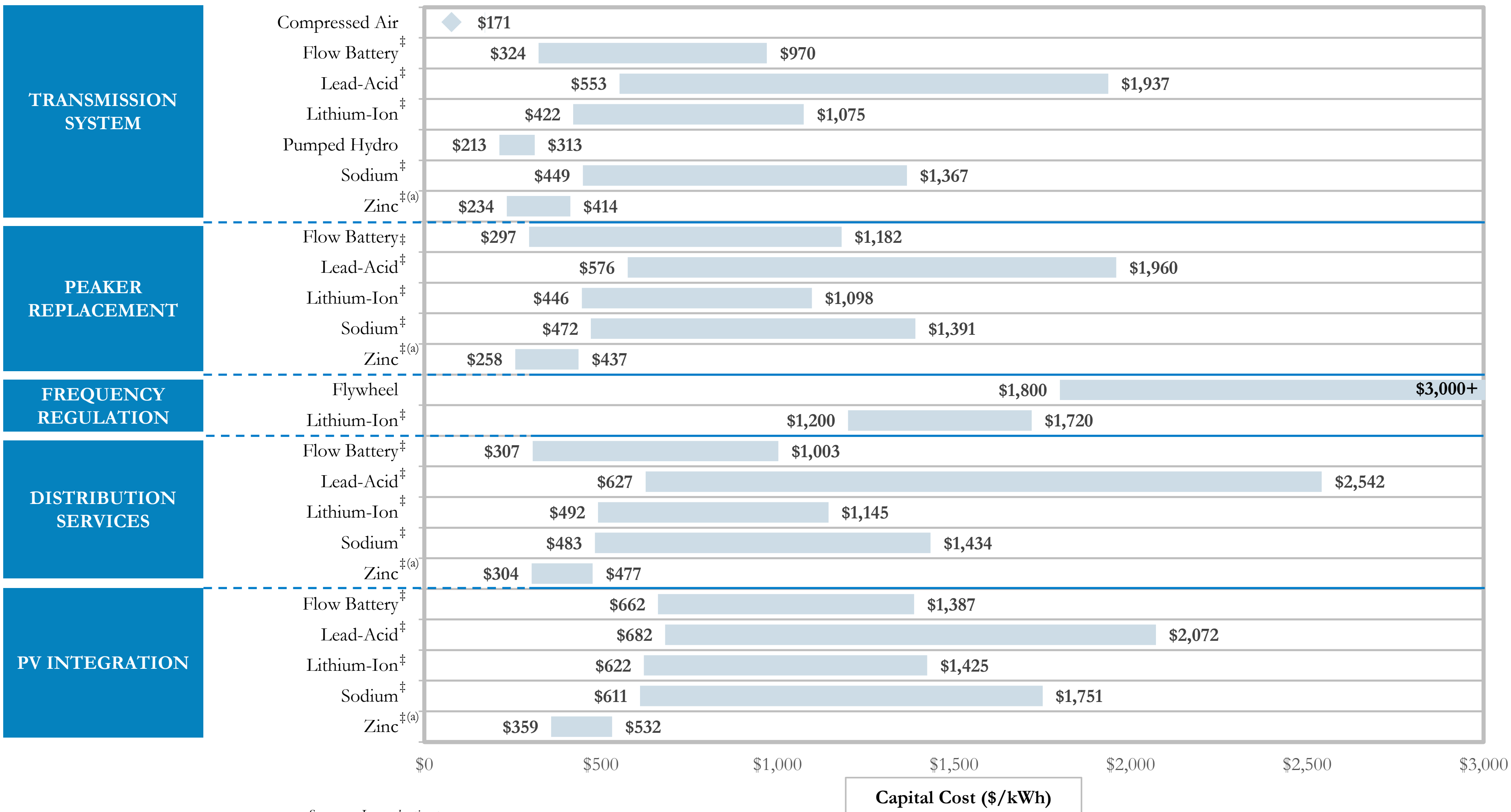
- **A notable exception to the general theme of high capital cost components of levelized cost is the island use case, where high absolute costs of local electricity (e.g., fuel oil, diesel, renewables) result in materially greater charging costs as a percentage of LCOS**



Source: *Lazard estimates.*
‡ Indicates battery technology.

Capital Cost Comparison

While capital costs of certain energy storage technology and use case combinations are currently high relative to selected conventional alternatives and, in some cases, more established energy storage technologies (e.g., pumped hydro, compressed air, etc.), capital costs must be considered along with a number of other factors that impact the levelized cost of energy storage (e.g., energy density, cycling capability, etc.)



Source: Lazard estimates.

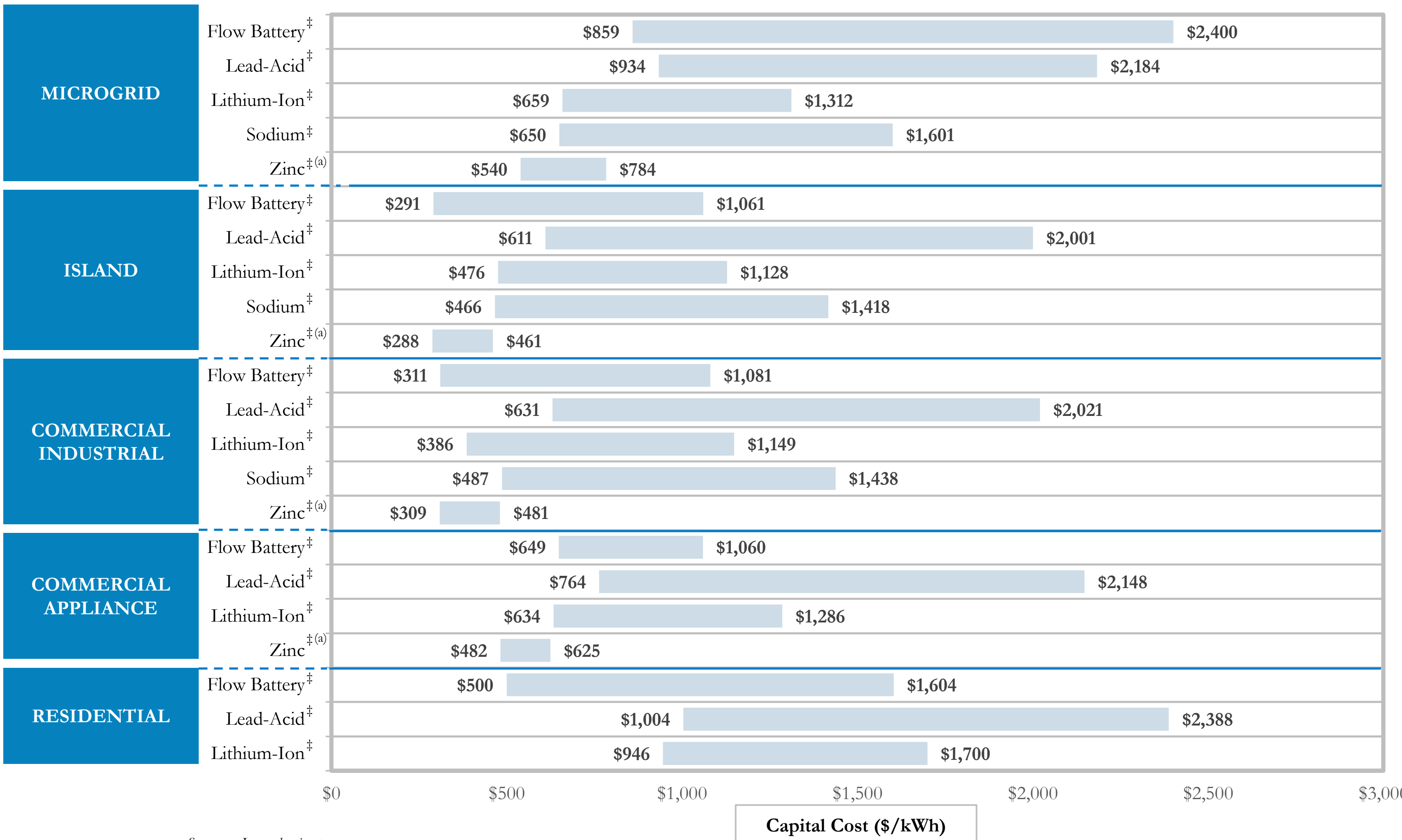
Note: Capital cost information presented on this page as the sum of AC and DC capital costs per kWh of usable energy. Figures as presented on this page exclude assumed EPC and administrative costs (assumed to be 15% of AC and DC capital costs).

‡ Indicates battery technology.

(a) Zinc technologies are not currently widely commercially deployed. Capital costs are likely lower than other energy storage technologies due to survey participants' willingness to incorporate possible future capital cost decreases into current quotes/estimates.

Capital Cost Comparison (cont'd)

While capital costs of certain energy storage technology and use case combinations are currently high relative to selected conventional alternatives and, in some cases, more established energy storage technologies (e.g., pumped hydro, compressed air, etc.), capital costs must be considered along with a number of other factors that impact the levelized cost of energy storage (e.g., energy density, cycling capability, etc.)



Source: *Lazard estimates.*
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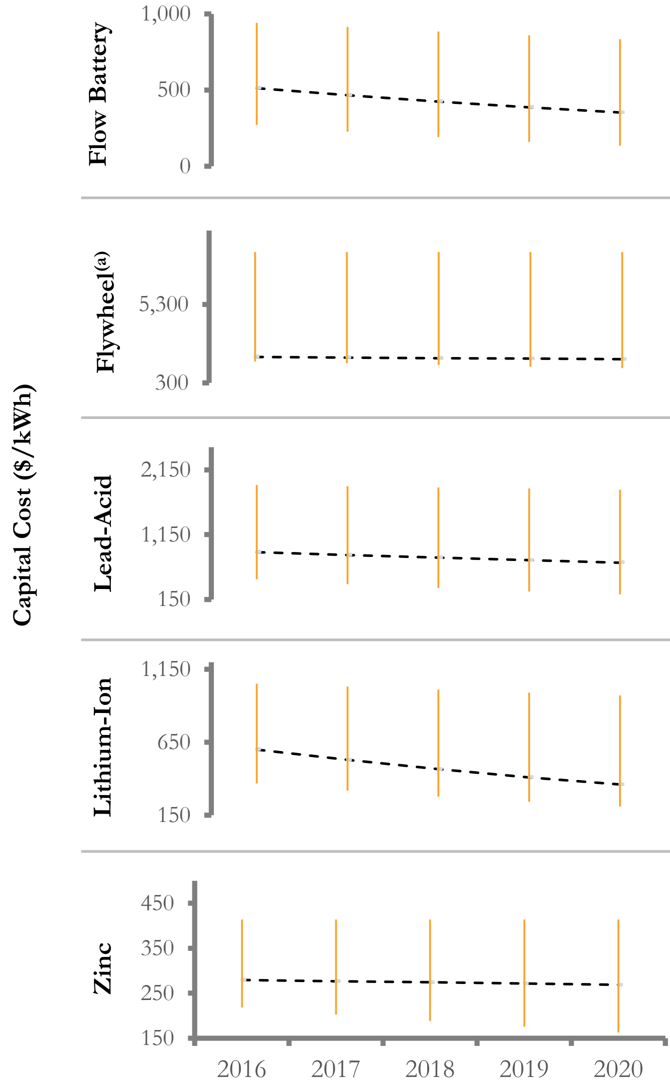
‡ Indicates battery technology.
(a) Zinc technologies are not currently widely commercially deployed. Capital costs are likely lower than other energy storage technologies due to survey participants' willingness to incorporate possible future capital cost decreases into current quotes/estimates.

Industry Estimated Capital Cost Outlook

Survey results indicate that Industry participants expect significant capital cost declines for the selected energy storage technologies over the next five years, driven primarily by increased manufacturing scale and design/engineering improvements

PROJECTED CAPITAL COST DECREASES



Technology		SLOW	MEDIAN	FAST
Flow Battery	CAGR	(3%)	(9%)	(16%)
	5-YEAR	(14%)	(38%)	(58%)
Flywheel[(a)]	CAGR	(1%)	(2%)	(12%)
	5-YEAR	(5%)	(10%)	(47%)
Lead-Acid	CAGR	(1%)	(5%)	(16%)
	5-YEAR	(5%)	(24%)	(58%)
Lithium-Ion	CAGR	(2%)	(12%)	(13%)
	5-YEAR	(10%)	(47%)	(50%)
Zinc	CAGR	0%	(1%)	(7%)
	5-YEAR	0%	(5%)	(30%)

LIKELY DRIVERS

Flow Battery
- Reduction in required high cost materials and scale
- Improved manufacturing and design
- Integration time for manufacturing

Flywheel
- Reduction in required high cost materials
- Improvement in control and response time
- Improvements in operation sustainability (e.g., ability to remove heat, higher efficiency motor/generator, etc.)

Lead-Acid
- Engineering/design improvements (e.g., additives to increase usable energy and capability envelope)
- Reduction in lead requirement

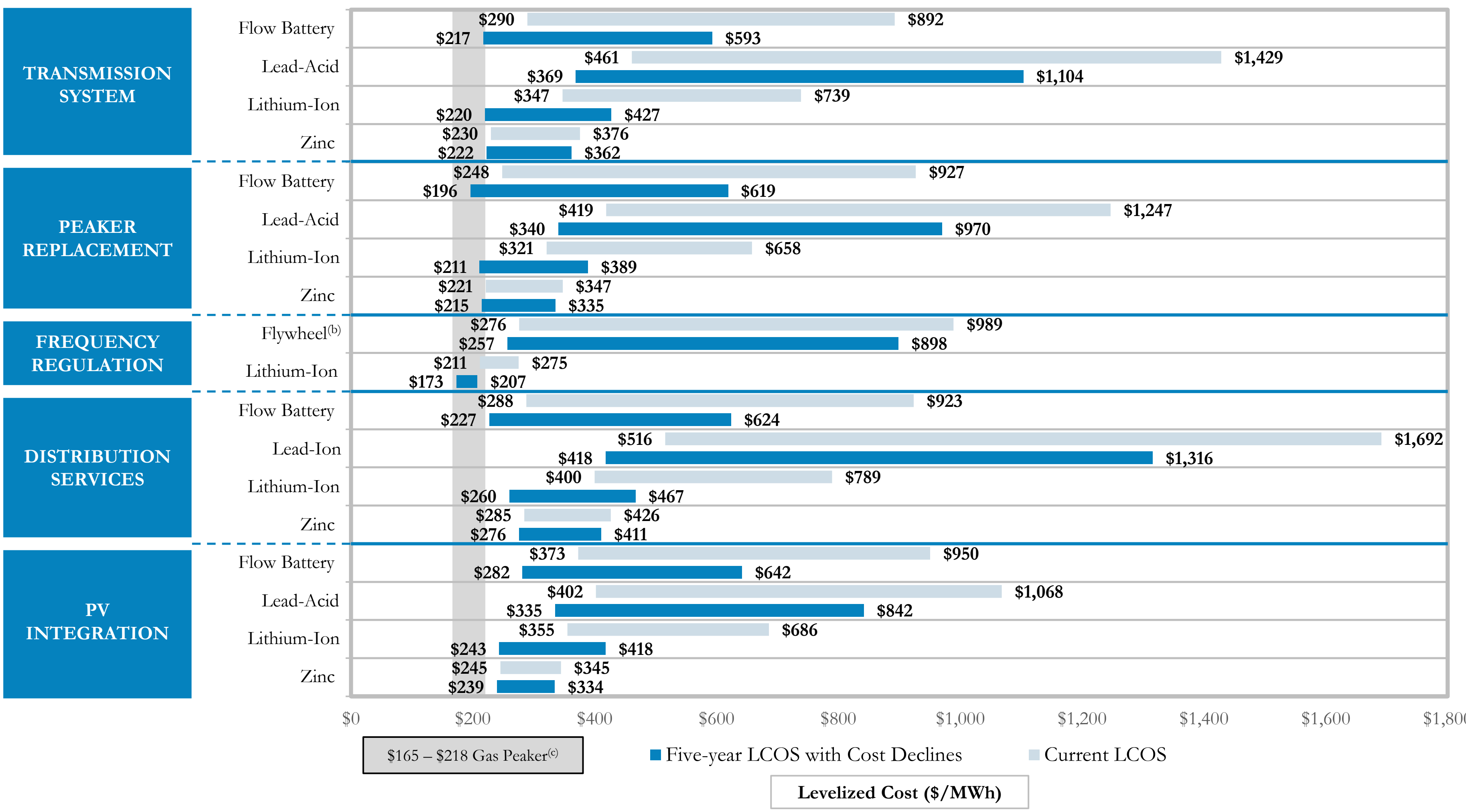
Lithium-Ion
- Increased manufacturing scale (e.g., Gigafactory)
- Reduction in required high cost materials
- Improvements in battery chemistry/design

Zinc
- Cost reduction depends on manufacturing at scale
- Design improvement to reduce high cost sub-components
- Chemistry improvements will increase lifespan and range of operation

Source: *Lazard estimates.*
Note: Capital cost information presented on this page represents DC capital costs per kWh of usable energy, unless otherwise indicated.
(a) Capital costs represent total capital costs, excluding EPC and administrative capital costs.
(b) Expected capital cost declines are somewhat muted for Zinc, likely due to zinc manufacturers/developers building expected cost declines into current quotes and the absence of meaningful market validators to such quotes.

Impact Analysis—Capital Cost Decline on Levelized Cost of Storage

Assuming that the Energy Storage Industry's capital cost decline expectations materialize, levelized costs of storage could decrease materially for some use case and technology combinations[(a)]; importantly, expected decreases in the levelized cost of storage are functions of the magnitude of capital cost decreases expected, as well as the relative weight of DC capital costs vs. balance of system and other costs

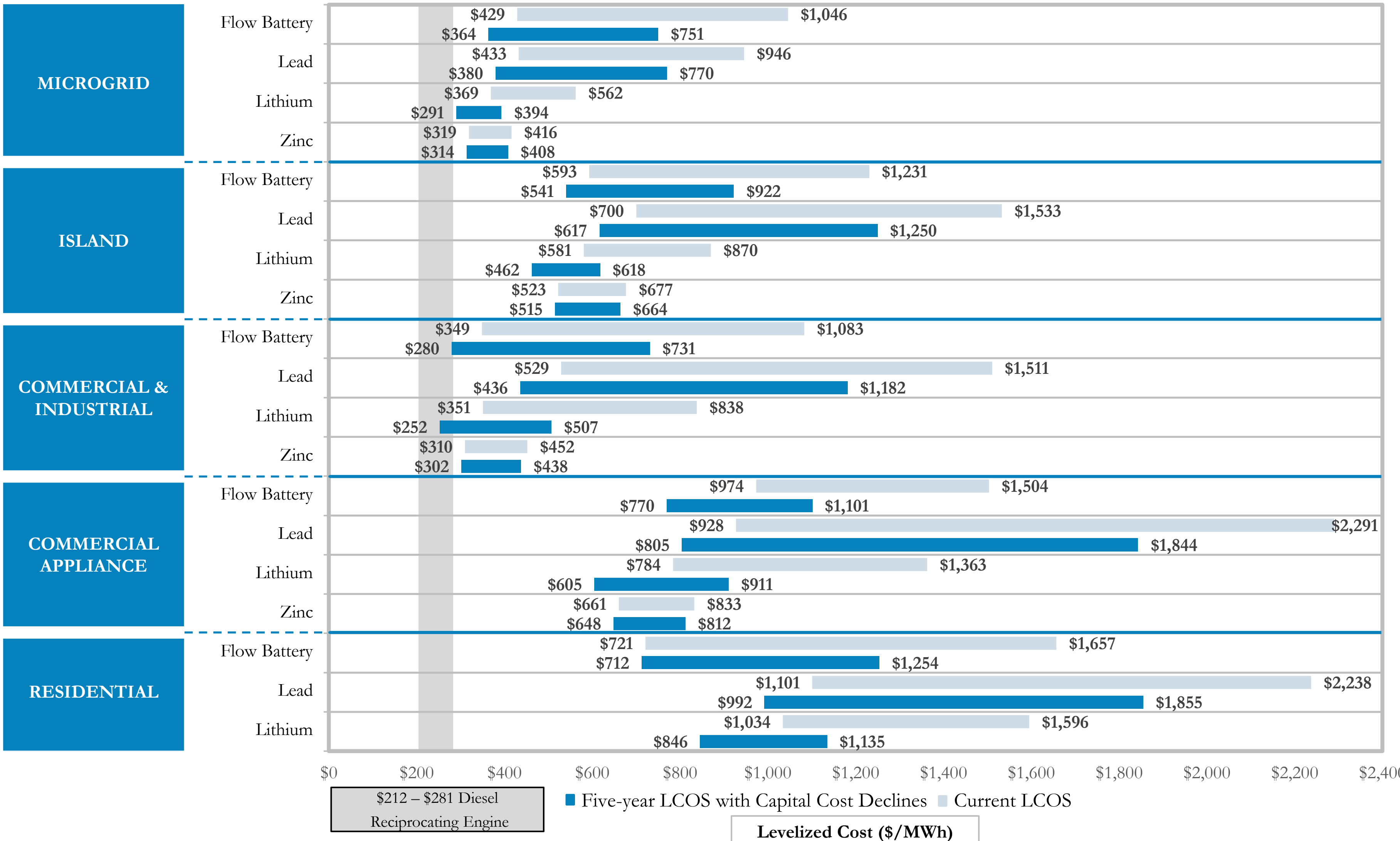


Source: Lazard estimates.

(a) Assumes median five-year expected DC capital cost declines only, unless otherwise indicated.
(b) Assumes median five-year expected total capital cost declines.
(c) Indicates illustrative conventional alternative to energy storage. Not intended to reflect the sole conventional alternative (or source of value from replacing such alternatives).

Impact Analysis—Capital Cost Decline on Levelized Cost of Storage (cont'd)

Assuming that the Energy Storage Industry's capital cost decline expectations materialize, levelized costs of storage could decrease materially for some technology and use case combinations(a); importantly, expected decreases in the levelized cost of storage are functions of the magnitude of capital cost decreases expected, as well as the relative weight of DC capital costs vs. balance of system and other costs



Source: Lazard estimates.

(a) Assumes median five-year expected DC capital cost declines only, unless otherwise indicated.
(b) Assumes median five-year expected total capital cost declines.
(c) Indicates illustrative conventional alternative to energy storage. Not intended to reflect the sole conventional alternative (or source of value from replacing such alternatives).

Levelized Cost of Storage—Key Assumptions

		Transmission						
	Units	**Pumped HS**	**Zinc**	**CAES**	**Flow Battery**	**Lithium**	**Lead**	**Sodium**
Power Rating	MW	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
Usable Energy	MWh	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
Operating Days/Year		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
Memo: Annual Used Energy	MWh	240,000 – 240,000	240,000 – 240,000	240,000 – 240,000	240,000 – 240,000	240,000 – 240,000	240,000 – 240,000	240,000 – 240,000
Memo: Project Used Energy	MWh	4,800,000 – 4,800,000	4,800,000 – 4,800,000	4,800,000 – 4,800,000	4,800,000 – 4,800,000	4,800,000 – 4,800,000	4,800,000 – 4,800,000	4,800,000 – 4,800,000
Initial Capital Cost—DC	$/kWh	--	$211 – $390	--	$300 – $946	$399 – $1,051	$529 – $1,913	$425 – $1,344
Initial Capital Cost—AC	$/kWh	--	$24 – $24	--	$24 – $24	$24 – $24	$24 – $24	$24 – $24
Initial Other Owners Costs	$/kWh	$32 – $47	$35 – $62	$26 – $26	$49 – $145	$63 – $161	$83 – $291	$67 – $205
Total Initial Installed Cost	$/kWh	$244 – $359	$270 – $476	$197 – $197	$372 – $1,115	$486 – $1,236	$636 – $2,227	$516 – $1,573
Replacement Capital Cost—DC	$/kWh							
After Year 5		$0 – $0	$0 – $0	$0 – $0	$0 – $317	$0 – $0	$0 – $0	$0 – $0
After Year 10		$0 – $0	$130 – $202	$0 – $0	$105 – $253	$209 – $304	$333 – $686	$269 – $1,033
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $222	$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
After Year 10		$0 – $0	$16 – $16	$0 – $0	$16 – $16	$16 – $16	$16 – $16	$16 – $16
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
O&M Cost	$/kWh	$2 – $11	$4 – $12	$4 – $4	$3 – $33	$7 – $13	$13 – $55	$10 – $31
O&M % of Capex	%	1.0% – 3.0%	1.3% – 2.5%	2.0% – 2.0%	0.9% – 3.0%	1.5% – 1.0%	2.0% – 2.5%	2.0% – 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%
Production Tax Credit	$/MWh	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
Charging Cost	$/MWh	$50 – $50	$50 – $50	$50 – $50	$50 – $50	$50 – $50	$50 – $50	$50 – $50
Charging Cost Escalator	%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%
Efficiency	%	82% – 81%	80% – 72%	75% – 75%	65% – 63%	93% – 91%	86% – 86%	75% – 76%
Levelized Cost of Storage	$/MWh	$188 – $274	$230 – $376	$192 – $192	$290 – $892	$347 – $739	$461 – $1,429	$396 – $1,079

Source: Lazard estimates.

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

		Peaker Replacement				
	Units	**Zinc**	**Lithium**	**Flow Battery**	**Lead**	**Sodium**
Power Rating	MW	25 – 25	25 – 25	25 – 25	25 – 25	25 – 25
Duration	Hours	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4
Usable Energy	MWh	100 – 100	100 – 100	100 – 100	100 – 100	100 – 100
100% Depth of Discharge Cycles/Day		1 – 1	1 – 1	1 – 1	1 – 1	1 – 1
Operating Days/Year		350 – 350	350 – 350	350 – 350	350 – 350	350 – 350
Project Life	Years	20 – 20	20 – 20	20 – 20	20 – 20	20 – 20
Memo: Annual Used Energy	MWh	35,000 – 35,000	35,000 – 35,000	35,000 – 35,000	35,000 – 35,000	35,000 – 35,000
Memo: Project Used Energy	MWh	700,000 – 700,000	700,000 – 700,000	700,000 – 700,000	700,000 – 700,000	700,000 – 700,000
Initial Capital Cost—DC	$/kWh	$211 – $390	$399 – $1,051	$250 – $1,135	$529 – $1,913	$425 – $1,344
Initial Capital Cost—AC	$/kWh	$47 – $47	$47 – $47	$47 – $47	$47 – $47	$47 – $47
Initial Other Owners Costs	$/kWh	$39 – $66	$67 – $165	$45 – $177	$86 – $294	$71 – $209
Total Initial Installed Cost	$/kWh	$297 – $503	$513 – $1,263	$342 – $1,360	$663 – $2,255	$543 – $1,600
Replacement Capital Cost—DC	$/kWh					
After Year 5		$0 – $0	$0 – $0	$0 – $380	$0 – $0	$0 – $0
After Year 10		$130 – $202	$209 – $304	$88 – $304	$333 – $686	$269 – $1,033
After Year 15		$0 – $0	$0 – $0	$0 – $266	$0 – $0	$0 – $0
Replacement Capital Cost—AC	$/kWh					
After Year 5		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
After Year 10		$32 – $32	$32 – $32	$32 – $32	$32 – $32	$32 – $32
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
O&M Cost	$/kWh	$4 – $12	$8 – $13	$3 – $40	$13 – $56	$11 – $32
O&M % of Capex	%	1.4% – 2.4%	1.5% – 1.0%	1.0% – 3.0%	2.0% – 2.5%	2.0% – 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%
Production Tax Credit	$/MWh	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
Charging Cost	$/MWh	$50 – $50	$50 – $50	$50 – $50	$50 – $50	$50 – $50
Charging Cost Escalator	%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%
Efficiency	%	80% – 72%	93% – 91%	65% – 63%	86% – 86%	75% – 76%
Levelized Cost of Storage	$/MWh	$221 – $347	$321 – $658	$248 – $927	$419 – $1,247	$365 – $948

Source: Lazard 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	20 – 20	20 – 20
Memo: Annual Used Energy	MWh	8,400 – 8,400	8,400 – 8,400
Memo: Project Used Energy	MWh	168,000 – 168,000	168,000 – 168,000
Initial Capital Cost—DC	$/kWh	$780 – $1,300	--
Initial Capital Cost—AC	$/kWh	$420 – $420	--
Initial Other Owners Costs	$/kWh	$180 – $258	$270 – $1,296
Total Initial Installed Cost	$/kWh	$1,380 – $1,978	$2,070 – $9,933
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		$302 – $302	$0 – $0
After Year 15		$0 – $0	$0 – $0
O&M Cost	$/kWh	$19 – $40	$27 – $129
O&M % of Capex	%	1.4% – 2.0%	1.3% – 1.3%
Investment Tax Credit	%	0.0% – 0.0%	0.0% – 0.0%
Production Tax Credit	$/MWh	$0 – $0	$0 – $0
Charging Cost	$/MWh	$66 – $66	$66 – $66
Charging Cost Escalator	%	1.5% – 1.5%	1.5% – 1.5%
Efficiency	%	93% – 93%	82% – 85%
Levelized Cost of Storage	$/MWh	$211 – $275	$276 – $989

Source: Lazard estimates.

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

		Distribution Services				
	Units	Zinc	Flow Battery	Lithium	Lead	Sodium
Power Rating	MW	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4
Duration	Hours	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4
Usable Energy	MWh	16 – 16	16 – 16	16 – 16	16 – 16	16 – 16
100% Depth of Discharge Cycles/Day		1.0 – 1.0	1.0 – 1.0	1.0 – 1.0	1.0 – 1.0	1.0 – 1.0
Operating Days/Year		300 – 300	300 – 300	300 – 300	300 – 300	300 – 300
Project Life	Years	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
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
Initial Capital Cost—DC	$/kWh	$247 – $420	$250 – $946	$435 – $1,088	$570 – $2,485	$425 – $1,377
Initial Capital Cost—AC	$/kWh	$57 – $57	$57 – $57	$57 – $57	$57 – $57	$57 – $57
Initial Other Owners Costs	$/kWh	$46 – $72	$46 – $150	$74 – $172	$94 – $381	$72 – $215
Total Initial Installed Cost	$/kWh	$350 – $549	$353 – $1,154	$566 – $1,316	$721 – $2,924	$555 – $1,649
Replacement Capital Cost—DC	$/kWh					
After Year 5		$0 – $0	$0 – $317	$0 – $0	$0 – $0	$0 – $0
After Year 10		$153 – $202	$79 – $253	$209 – $304	$333 – $0	$269 – $1,033
After Year 15		$0 – $0	$0 – $222	$0 – $0	$0 – $0	$0 – $0
Replacement Capital Cost—AC	$/kWh					
After Year 5		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
After Year 10		$38 – $38	$38 – $38	$38 – $38	$38 – $38	$38 – $38
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
O&M Cost	$/kWh	$5 – $14	$4 – $34	$9 – $14	$15 – $73	$11 – $33
O&M % of Capex	%	1.5% – 2.5%	1.1% – 3.0%	1.6% – 1.1%	2.0% – 2.5%	2.0% – 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%
Production Tax Credit	$/MWh	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
Charging Cost	$/MWh	$53 – $53	$53 – $53	$53 – $53	$53 – $53	$53 – $53
Charging Cost Escalator	%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%	1.5% – 1.5%
Efficiency	%	80% – 72%	65% – 63%	93% – 91%	86% – 86%	75% – 76%
Levelized Cost of Storage	$/MWh	$285 – $426	$288 – $923	$400 – $789	$516 – $1,692	$426 – $1,129

Source: Lazard estimates.

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

	Units	PV Integration														
		Zinc			Flow Battery			Lithium			Lead			Sodium		
Power Rating	MW	2	–	2	2	–	2	2	–	2	2	–	2	2	–	2
Duration	Hours	2	–	2	2	–	2	2	–	2	2	–	2	2	–	2
Usable Energy	MWh	4	–	4	4	–	4	4	–	4	4	–	4	4	–	4
100% Depth of Discharge Cycles/Day		1.25	–	1.25	1.25	–	1.25	1.25	–	1.25	1.25	–	1.25	1.25	–	1.25
Operating Days/Year		350	–	350	350	–	350	350	–	350	350	–	350	350	–	350
Project Life	Years	20	–	20	20	–	20	20	–	20	20	–	20	20	–	20
Memo: Annual Used Energy	MWh	1,750	–	1,750	1,750	–	1,750	1,750	–	1,750	1,750	–	1,750	1,750	–	1,750
Memo: Project Used Energy	MWh	35,000	–	35,000	35,000	–	35,000	35,000	–	35,000	35,000	–	35,000	35,000	–	35,000
Initial Capital Cost—DC	$/kWh	$247	–	$420	$550	–	$1,275	$510	–	$1,313	$570	–	$1,960	$499	–	$1,639
Initial Capital Cost—AC	$/kWh	$112	–	$112	$112	–	$112	$112	–	$112	$112	–	$112	$112	–	$112
Initial Other Owners Costs	$/kWh	$54	–	$80	$99	–	$208	$93	–	$214	$102	–	$311	$92	–	$263
Total Initial Installed Cost	$/kWh	$413	–	$612	$761	–	$1,595	$715	–	$1,638	$784	–	$2,383	$702	–	$2,014
Replacement Capital Cost—DC	$/kWh															
After Year 5		$0	–	$0	$0	–	$788	$0	–	$0	$0	–	$0	$0	–	$0
After Year 10		$153	–	$202	$0	–	$630	$245	–	$367	$333	–	$686	$316	–	$1,229
After Year 15		$0	–	$0	$0	–	$551	$0	–	$0	$0	–	$0	$0	–	$0
Replacement Capital Cost—AC	$/kWh															
After Year 5		$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0
After Year 10		$75	–	$75	$75	–	$75	$75	–	$75	$75	–	$75	$75	–	$75
After Year 15		$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0
O&M Cost	$/kWh	$7	–	$15	$19	–	$40	$12	–	$18	$16	–	$59	$14	–	$41
O&M % of Capex	%	1.6%	–	2.5%	2.5%	–	2.5%	1.6%	–	1.1%	2.0%	–	2.5%	2.1%	–	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%
Production Tax Credit	$/MWh	$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0
Charging Cost	$/MWh	$58	–	$58	$58	–	$58	$58	–	$58	$58	–	$58	$58	–	$58
Charging Cost Escalator	%	0.0%	–	0.0%	0.0%	–	0.0%	0.0%	–	0.0%	0.0%	–	0.0%	0.0%	–	0.0%
Efficiency	%	80%	–	72%	76%	–	72%	93%	–	91%	86%	–	86%	75%	–	76%
Levelized Cost of Storage	$/MWh	$245	–	$345	$373	–	$950	$355	–	$686	$402	–	$1,068	$379	–	$957

Source: Lazard estimates.

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

		Microgrid				
	Units	Zinc	Lithium	Flow Battery	Lead	Sodium
Power Rating	MW	2 – 2	2 – 2	2 – 2	2 – 2	2 – 2
Duration	Hours	1 – 1	1 – 1	1 – 1	1 – 1	1 – 1
Usable Energy	MWh	2 – 2	2 – 2	2 – 2	2 – 2	2 – 2
100% Depth of Discharge Cycles/Day		2.0 – 2.0	2.0 – 2.0	2.0 – 2.0	2.0 – 2.0	2.0 – 2.0
Operating Days/Year		350 – 350	350 – 350	350 – 350	350 – 350	350 – 350
Project Life	Years	20 – 20	20 – 20	20 – 20	20 – 20	20 – 20
Memo: Annual Used Energy	MWh	1,400 – 1,400	1,400 – 1,400	1,400 – 1,400	1,400 – 1,400	1,400 – 1,400
Memo: Project Used Energy	MWh	28,000 – 28,000	28,000 – 28,000	28,000 – 28,000	28,000 – 28,000	28,000 – 28,000
Initial Capital Cost—DC	$/kWh	$315 – $560	$435 – $1,088	$635 – $2,176	$710 – $1,960	$425 – $1,377
Initial Capital Cost—AC	$/kWh	$224 – $224	$224 – $224	$224 – $224	$224 – $224	$224 – $224
Initial Other Owners Costs	$/kWh	$81 – $118	$99 – $197	$129 – $360	$140 – $328	$97 – $240
Total Initial Installed Cost	$/kWh	$620 – $902	$758 – $1,508	$988 – $2,760	$1,074 – $2,512	$747 – $1,841
Replacement Capital Cost—DC	$/kWh					
After Year 5		$0 – $0	$274 – $442	$0 – $728	$0 – $980	$284 – $1,101
After Year 10		$195 – $269	$209 – $304	$0 – $582	$415 – $686	$269 – $1,033
After Year 15		$0 – $0	$152 – $213	$0 – $510	$0 – $588	$254 – $1,033
Replacement Capital Cost—AC	$/kWh					
After Year 5		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
After Year 10		$151 – $151	$151 – $151	$151 – $151	$151 – $151	$151 – $151
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
O&M Cost	$/kWh	$11 – $22	$13 – $18	$24 – $81	$22 – $62	$16 – $38
O&M % of Capex	%	1.7% – 2.4%	1.8% – 1.2%	2.4% – 2.9%	2.1% – 2.5%	2.1% – 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%
Production Tax Credit	$/MWh	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
Charging Cost	$/MWh	$108 – $108	$108 – $108	$108 – $108	$108 – $108	$108 – $108
Charging Cost Escalator	%	2.4% – 2.4%	2.4% – 2.4%	2.4% – 2.4%	2.4% – 2.4%	2.4% – 2.4%
Efficiency	%	80% – 72%	93% – 91%	67% – 63%	86% – 86%	75% – 76%
Levelized Cost of Storage	$/MWh	$319 – $416	$369 – $562	$429 – $1,046	$433 – $946	$411 – $835

Source: Lazard estimates.

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

		Island														
	Units	Zinc			Lithium			Flow Battery			Sodium			Lead		
Power Rating	MW	1	–	1	1	–	1	1	–	1	1	–	1	1	–	1
Duration	Hours	6	–	6	6	–	6	6	–	6	6	–	6	6	–	6
Usable Energy	MWh	6	–	6	6	–	6	6	–	6	6	–	6	6	–	6
100% Depth of Discharge Cycles/Day		1	–	1	1	–	1	1	–	1	1	–	1	1	–	1
Operating Days/Year		350	–	350	350	–	350	350	–	350	350	–	350	350	–	350
Project Life	Years	20	–	20	20	–	20	20	–	20	20	–	20	20	–	20
Memo: Annual Used Energy	MWh	2,100	–	2,100	2,100	–	2,100	2,100	–	2,100	2,100	–	2,100	2,100	–	2,100
Memo: Project Used Energy	MWh	42,000	–	42,000	42,000	–	42,000	42,000	–	42,000	42,000	–	42,000	42,000	–	42,000
Initial Capital Cost—DC	$/kWh	$247	–	$420	$435	–	$1,088	$250	–	$1,020	$425	–	$1,377	$570	–	$1,960
Initial Capital Cost—AC	$/kWh	$41	–	$41	$41	–	$41	$41	–	$41	$41	–	$41	$41	–	$41
Initial Other Owners Costs	$/kWh	$43	–	$69	$71	–	$169	$44	–	$159	$70	–	$213	$92	–	$300
Total Initial Installed Cost	$/kWh	$331	–	$530	$547	–	$1,298	$335	–	$1,220	$536	–	$1,630	$703	–	$2,301
Replacement Capital Cost—DC	$/kWh															
After Year 5		$0	–	$0	$0	–	$0	$0	–	$630	$0	–	$0	$0	–	$0
After Year 10		$153	–	$202	$209	–	$0	$88	–	$504	$269	–	$1,033	$333	–	$686
After Year 15		$0	–	$0	$0	–	$0	$0	–	$441	$0	–	$0	$0	–	$0
Replacement Capital Cost—AC	$/kWh															
After Year 5		$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0
After Year 10		$27	–	$27	$27	–	$27	$27	–	$27	$27	–	$27	$27	–	$27
After Year 15		$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0	$0	–	$0
O&M Cost	$/kWh	$5	–	$13	$9	–	$14	$3	–	$30	$11	–	$33	$14	–	$57
O&M % of Capex	%	1.4%	–	2.5%	1.6%	–	1.0%	1.0%	–	2.5%	2.0%	–	2.0%	2.0%	–	2.5%
Investment Tax Credit	%	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
Charging Cost	$/MWh	$281	–	$281	$281	–	$281	$281	–	$281	$281	–	$281	$281	–	$281
Charging Cost Escalator	%	0.0%	–	0.0%	0.0%	–	0.0%	0.0%	–	0.0%	0.0%	–	0.0%	0.0%	–	0.0%
Efficiency	%	80%	–	72%	93%	–	91%	65%	–	72%	75%	–	76%	86%	–	86%
Levelized Cost of Storage	$/MWh	$523	–	$677	$581	–	$870	$593	–	$1,231	$663	–	$1,259	$700	–	$1,533

Source: Lazard estimates.

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

		Commercial & Industrial				
	Units	**Zinc**	**Lithium**	**Flow Battery**	**Lead**	**Sodium**
Power Rating	MW	1 – 1	1 – 1	1 – 1	1 – 1	1 – 1
Duration	Hours	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4
Usable Energy	MWh	4 – 4	4 – 4	4 – 4	4 – 4	4 – 4
100% Depth of Discharge Cycles/Day		1 – 1	1 – 1	1 – 1	1 – 1	1 – 1
Operating Days/Year		350 – 350	350 – 350	350 – 350	350 – 350	350 – 350
Project Life	Years	10 – 10	10 – 10	10 – 10	10 – 10	10 – 10
Memo: Annual Used Energy	MWh	1,400 – 1,400	1,400 – 1,400	1,400 – 1,400	1,400 – 1,400	1,400 – 1,400
Memo: Project Used Energy	MWh	14,000 – 14,000	14,000 – 14,000	14,000 – 14,000	14,000 – 14,000	14,000 – 14,000
Initial Capital Cost—DC	$/kWh	$247 – $420	$325 – $1,088	$250 – $1,020	$570 – $1,960	$425 – $1,377
Initial Capital Cost—AC	$/kWh	$61 – $61	$61 – $61	$61 – $61	$61 – $61	$61 – $61
Initial Other Owners Costs	$/kWh	$46 – $72	$58 – $172	$47 – $162	$95 – $303	$73 – $216
Total Initial Installed Cost	$/kWh	$355 – $554	$444 – $1,321	$358 – $1,244	$726 – $2,325	$560 – $1,654
Replacement Capital Cost—DC	$/kWh					
After Year 5		$0 – $0	$0 – $0	$0 – $630	$0 – $0	$0 – $0
After Year 10		$0 – $0	$0 – $0	$84 – $0	$0 – $0	$0 – $0
After Year 15		$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
After Year 10		$41 – $41	$41 – $41	$41 – $41	$41 – $41	$41 – $41
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
O&M Cost	$/kWh	$5 – $14	$5 – $14	$4 – $31	$15 – $58	$11 – $33
O&M % of Capex	%	1.5% – 2.5%	1.2% – 1.1%	1.1% – 2.5%	2.0% – 2.5%	2.0% – 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%
Production Tax Credit	$/MWh	$0 – $0	$0 – $0	$0 – $0	$0 – $0	$0 – $0
Charging Cost	$/MWh	$70 – $70	$70 – $70	$70 – $70	$70 – $70	$70 – $70
Charging Cost Escalator	%	2.6% – 2.6%	2.6% – 2.6%	2.6% – 2.6%	2.6% – 2.6%	2.6% – 2.6%
Efficiency	%	80% – 72%	85% – 91%	65% – 72%	86% – 86%	75% – 76%
Levelized Cost of Storage	$/MWh	$310 – $452	$351 – $838	$349 – $1,083	$529 – $1,511	$444 – $1,092

Source: Lazard estimates.

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

		Commercial Appliance			
	Units	Zinc	Lithium	Lead	Flow Battery
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	$247 – $390	$399 – $1,051	$529 – $1,913	$414 – $825
Initial Capital Cost—AC	$/kWh	$235 – $235	$235 – $235	$235 – $235	$235 – $235
Initial Other Owners Costs	$/kWh	$72 – $94	$95 – $193	$115 – $322	$97 – $159
Total Initial Installed Cost	$/kWh	$555 – $719	$729 – $1,479	$879 – $2,471	$746 – $1,219
Replacement Capital Cost—DC	$/kWh				
After Year 5		$0 – $0	$0 – $0	$0 – $0	$276 – $525
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		$168 – $168	$168 – $168	$168 – $168	$168 – $168
After Year 15		$0 – $0	$0 – $0	$0 – $0	$0 – $0
O&M Cost	$/kWh	$11 – $19	$14 – $20	$20 – $63	$19 – $31
O&M % of Capex	%	2.0% – 2.6%	2.0% – 1.3%	2.2% – 2.5%	2.6% – 2.6%
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	$108 – $108	$108 – $108	$108 – $108	$108 – $108
Charging Cost Escalator	%	2.4% – 2.4%	2.4% – 2.4%	2.4% – 2.4%	2.4% – 2.4%
Efficiency	%	80% – 72%	93% – 91%	86% – 86%	77% – 72%
Levelized Cost of Storage	$/MWh	$661 – $833	$784 – $1,363	$928 – $2,291	$974 – $1,504

Source: Lazard estimates.

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

		Residential								
	Units	Lithium			Lead			Flow Battery		
Power Rating	MW	0.005	–	0.005	0.005	–	0.005	0.005	–	0.005
Duration	Hours	2	–	2	2	–	2	2	–	2
Usable Energy	MWh	0.01	–	0.01	0.01	–	0.01	0.01	–	0.01
100% Depth of Discharge Cycles/Day		1	–	1	1	–	1	1	–	1
Operating Days/Year		300	–	300	300	–	300	300	–	300
Project Life	Years	10	–	10	10	–	10	10	–	10
Memo: Annual Used Energy	MWh	3	–	3	3	–	3	3	–	3
Memo: Project Used Energy	MWh	30	–	30	30	–	30	30	–	30
Initial Capital Cost—DC	$/kWh	$471	–	$1,225	$529	–	$1,913	$25	–	$1,129
Initial Capital Cost—AC	$/kWh	$475	–	$475	$475	–	$475	$475	–	$475
Initial Other Owners Costs	$/kWh	$142	–	$255	$151	–	$358	$75	–	$241
Total Initial Installed Cost	$/kWh	$1,088	–	$1,955	$1,155	–	$2,747	$575	–	$1,845
Replacement Capital Cost—DC	$/kWh									
After Year 5		$0	–	$0	$0	–	$0	$0	–	$381
After Year 10		$0	–	$0	$0	–	$0	$0	–	$0
After Year 15		$0	–	$0	$0	–	$0	$0	–	$0
Replacement Capital Cost—AC	$/kWh									
After Year 5		$0	–	$0	$0	–	$0	$0	–	$0
After Year 10		$315	–	$315	$315	–	$315	$315	–	$0
After Year 15		$0	–	$0	$0	–	$0	$0	–	$0
O&M Cost	$/kWh	$35	–	$41	$39	–	$82	$28	–	$39
O&M % of Capex	%	3.3%	–	2.1%	3.4%	–	3.0%	4.9%	–	2.1%
Investment Tax Credit	%	0.0%	–	0.0%	0.0%	–	0.0%	0.0%	–	0.0%
Production Tax Credit	$/MWh	$0	–	$0	$0	–	$0	$0	–	$0
Charging Cost	$/MWh	$125	–	$125	$125	–	$125	$125	–	$125
Charging Cost Escalator	%	2.5%	–	2.5%	2.5%	–	2.5%	2.5%	–	2.5%
Efficiency	%	92%	–	89%	86%	–	86%	76%	–	63%
Levelized Cost of Storage	$/MWh	$1,034	–	$1,596	$1,101	–	$2,238	$721	–	$1,657

Source: Lazard estimates.