EXH. EAB-17
DOCKETS UE-220066/UG-220067
2022 PSE GENERAL RATE CASE
WITNESS: ED BURGESS

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, **Complainant,** **v.** **PUGET SOUND ENERGY,** **Respondent.**	**Docket UE-220066** **Docket UG-220067**

SIXTEENTH EXHIBIT (NONCONFIDENTIAL) TO THE PREFILED RESPONSE TESTIMONY OF

ED BURGESS

ON BEHALF OF NW ENERGY COALITION, FRONT AND CENTERED, AND SIERRA CLUB

JULY 28, 2022

INSIGHTS

Levelized Cost Of Energy, Levelized Cost Of Storage, and Levelized Cost Of Hydrogen

OCT 28 2021

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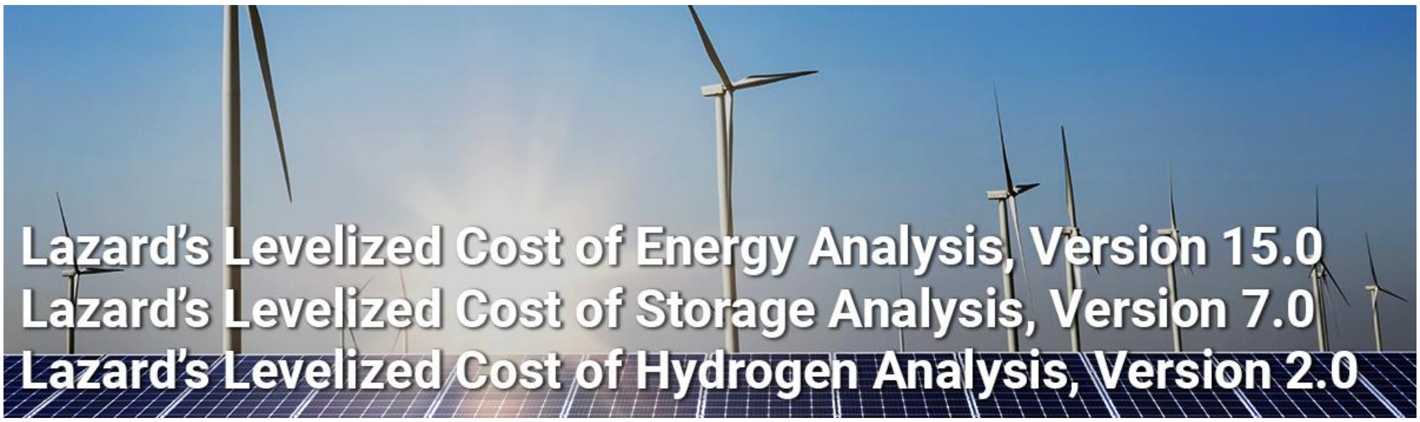

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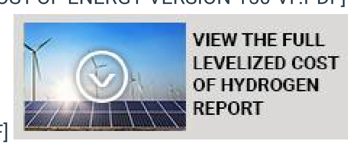

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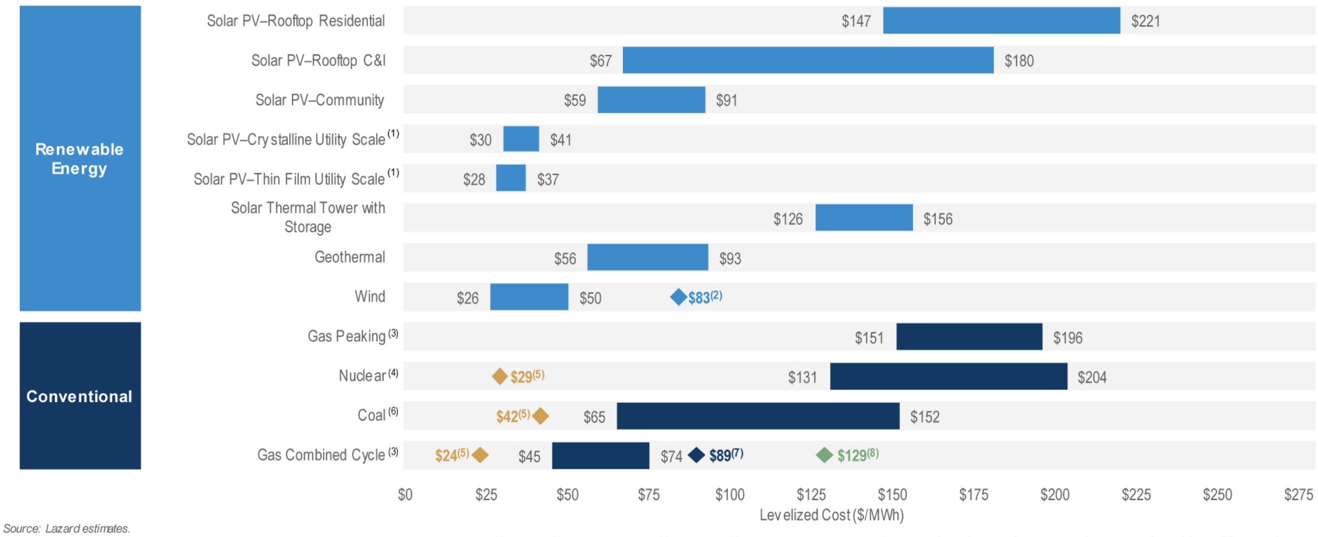
Levelized Cost of Energy

Lazard's latest annual Levelized Cost of Energy Analysis (LCOE 15.0) shows the continued cost-competitiveness of certain renewable energy technologies on a subsidized basis and the marginal cost of coal, nuclear and combined cycle gas generation. The costs of renewable energy technologies continue to decline globally, albeit at a slowing pace, reflecting reductions in capital costs, increased competition as the sector continues to mature and continued improvements in scale and technology.

Levelized Cost of Energy Comparison—Unsubsidized Analysis

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



Source: Lazard estimates.

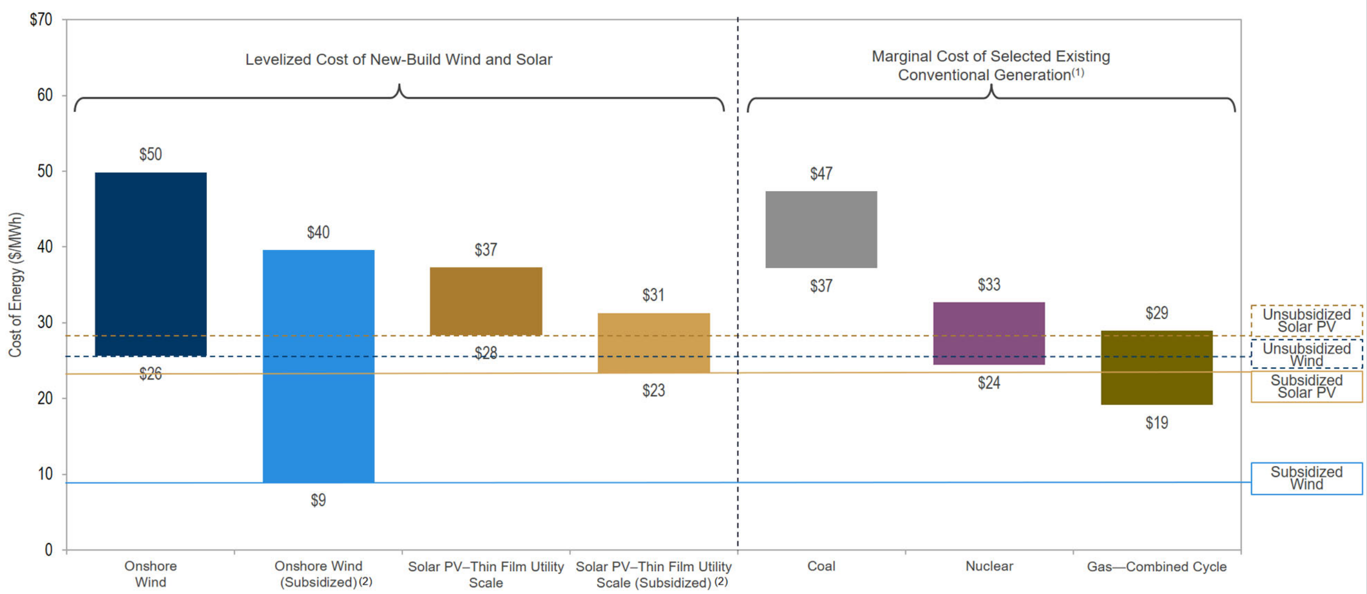
Note: Here and throughout this presentation, unless otherwise indicated, the analysis assumes 60% debt at 8% interest rate and 40% equity at 12% cost. Please see page titled "Levelized Cost of Energy Comparison—Sensitivity to Cost of Capital" for cost of capital sensitivities. These results are not intended to represent any particular geography. Please see page titled "Solar PV versus Gas Peaking and Wind versus CCGT—Global Markets" for regional sensitivities to selected technologies.

(1) Unless otherwise indicated herein, the low case represents a single-axis tracking system and the high case represents a fixed-tilt system.
(2) Represents the estimated implied midpoint of the LCOE of offshore wind, assuming a capital cost range of approximately $2,500 – $3,600/kW.
(3) The fuel cost assumption for Lazard's global, unsubsidized analysis for gas-fired generation resources is $3.45/MMBTU.
(4) Unless otherwise indicated, the analysis herein does not reflect decommissioning costs, ongoing maintenance-related capital expenditures or the potential economic impacts of federal loan guarantees or other subsidies.
(5) Represents the midpoint of the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Analysis assumes that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs. Inputs are derived from a benchmark of operating gas combined cycle, coal and nuclear assets across the U.S. Capacity factors, fuel, variable and fixed operating expenses are based on upper- and lower-quartile estimates derived from Lazard's research. Please see page titled "Levelized Cost of Energy Comparison—Renewable Energy versus Marginal Cost of Selected Existing Conventional Generation" for additional details.
(6) High end incorporates 90% carbon capture and storage. Does not include cost of transportation and storage.
(7) Represents the LCOE of the observed high case gas combined cycle inputs using a 20% blend of "Blue" hydrogen, (i.e., hydrogen produced from a steam-methane reformer, using natural gas as a feedstock and sequestering the resulting CO_2 in a nearby saline aquifer). No plant modifications are assumed beyond a 2% adjustment to the plant's heat rate. The corresponding fuel cost is $5.20/MMBTU, assuming $1.39/kg for Blue hydrogen.
(8) Represents the LCOE of the observed high case gas combined cycle inputs using a 20% blend of "Green" hydrogen, (i.e., hydrogen produced from an electrolyzer powered by a mix of wind and solar generation and stored in a nearby salt cavern). No plant modifications are assumed beyond a 2% adjustment to the plant's heat rate. The corresponding fuel cost is $10.05/MMBTU, assuming $4.15/kg for Green hydrogen.

Additional highlights for LCOE 15.0:

Levelized Cost of Energy Comparison—Renewable Energy versus Marginal Cost of Selected Existing Conventional Generation

Certain renewable energy generation technologies have an LCOE that is competitive with the marginal cost of existing conventional generation

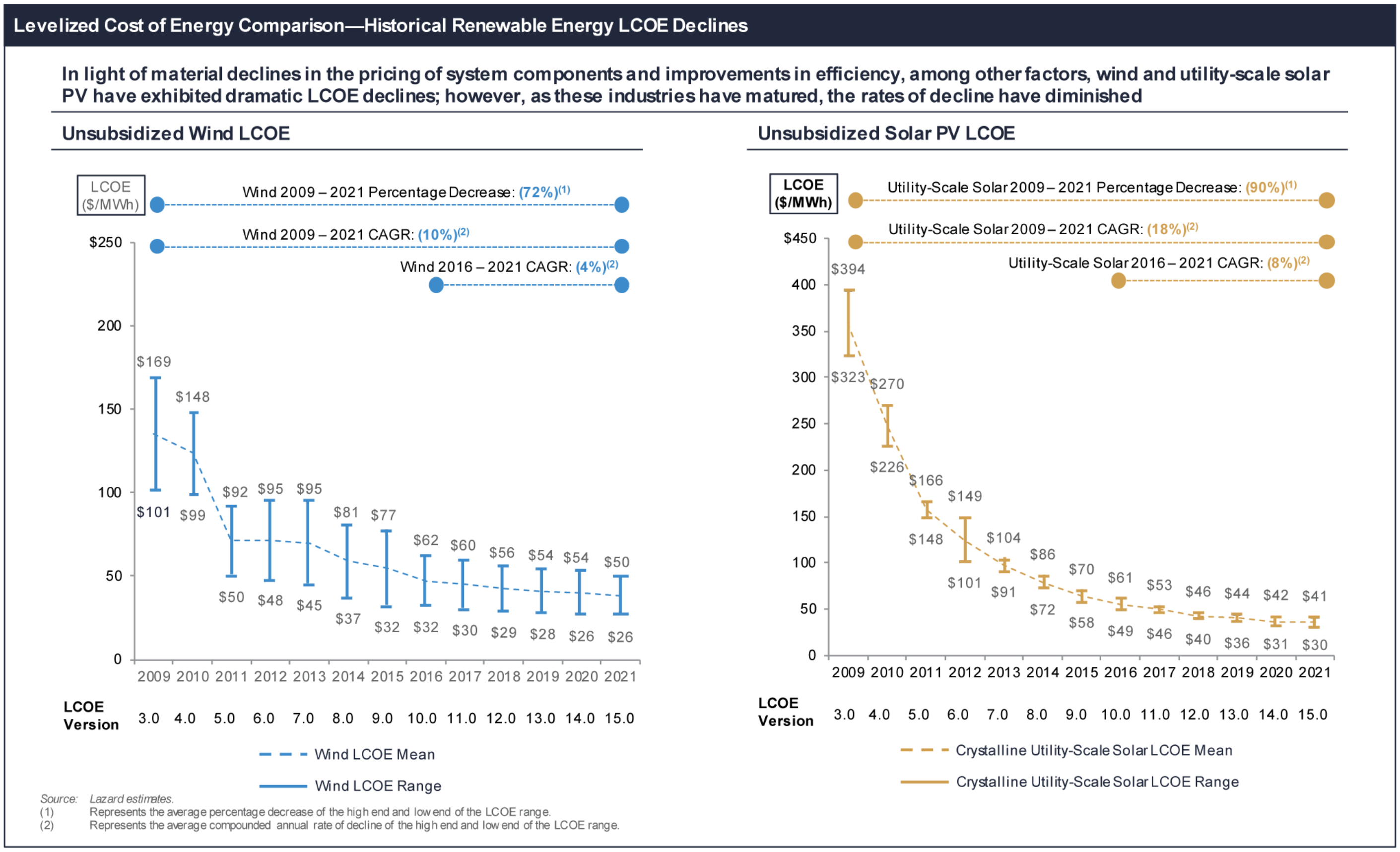


Source: Lazard estimates.

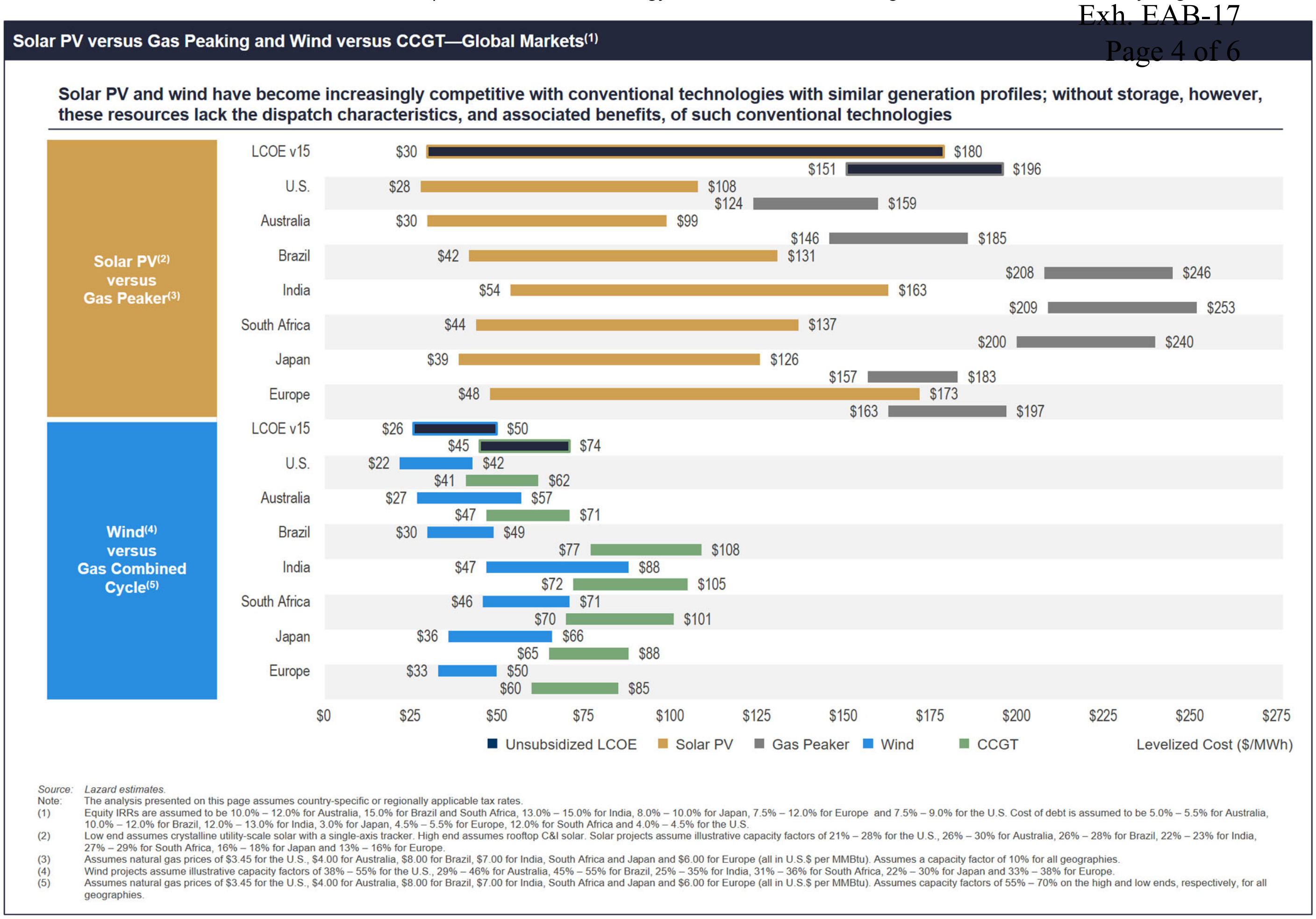
Note: Unless otherwise noted, the assumptions used in this sensitivity correspond to those used in the global, unsubsidized analysis as presented on the page titled "Levelized Cost of Energy Comparison—Unsubsidized Analysis".

(1) Represents the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Analysis assumes that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs. Inputs are derived from a benchmark of operating gas combined cycle, coal and nuclear assets across the U.S. Capacity factors, fuel, variable and fixed operating expenses are based on upper and lower quartile estimates derived from Lazard's research.
(2) The subsidized analysis includes sensitivities related to the TCJA and U.S. federal tax subsidies. Please see page titled "Levelized Cost of Energy Comparison—Sensitivity to U.S. Federal Tax Subsidies" for additional details.

When U.S. government subsidies are included, the cost of onshore wind and utility-scale solar continues to be competitive with the marginal cost of coal, nuclear and combined cycle gas generation. The former values average $27/MWh for utility-scale solar and $25/MWh for utility-scale wind, while the latter values average $42/MWh for coal, $29/MWh for nuclear and $24/MWh for combined cycle gas generation.



While rates of decline in the LCOE for utility-scale solar and onshore wind have slowed in recent years, the pace of decline for utility-scale solar continues to be higher than that for onshore wind (i.e., observed five-year compound annual declines of 8% in the average LCOE of utility-scale solar, compared to 4% for onshore wind).



Regional differences in resource availability and fuel costs can drive meaningful variance in the cost of certain technologies, although some of this variance can be mitigated by adjustments to a project's capital structure, reflecting the availability and cost of debt and equity.

Levelized Cost of Storage

Lazard's latest annual Levelized Cost of Storage Analysis (LCOS 7.0) shows that year-over-year changes in the cost of storage are mixed across use cases and technologies, driven in part by the confluence of emerging supply chain constraints and shifting preferences in battery chemistry.

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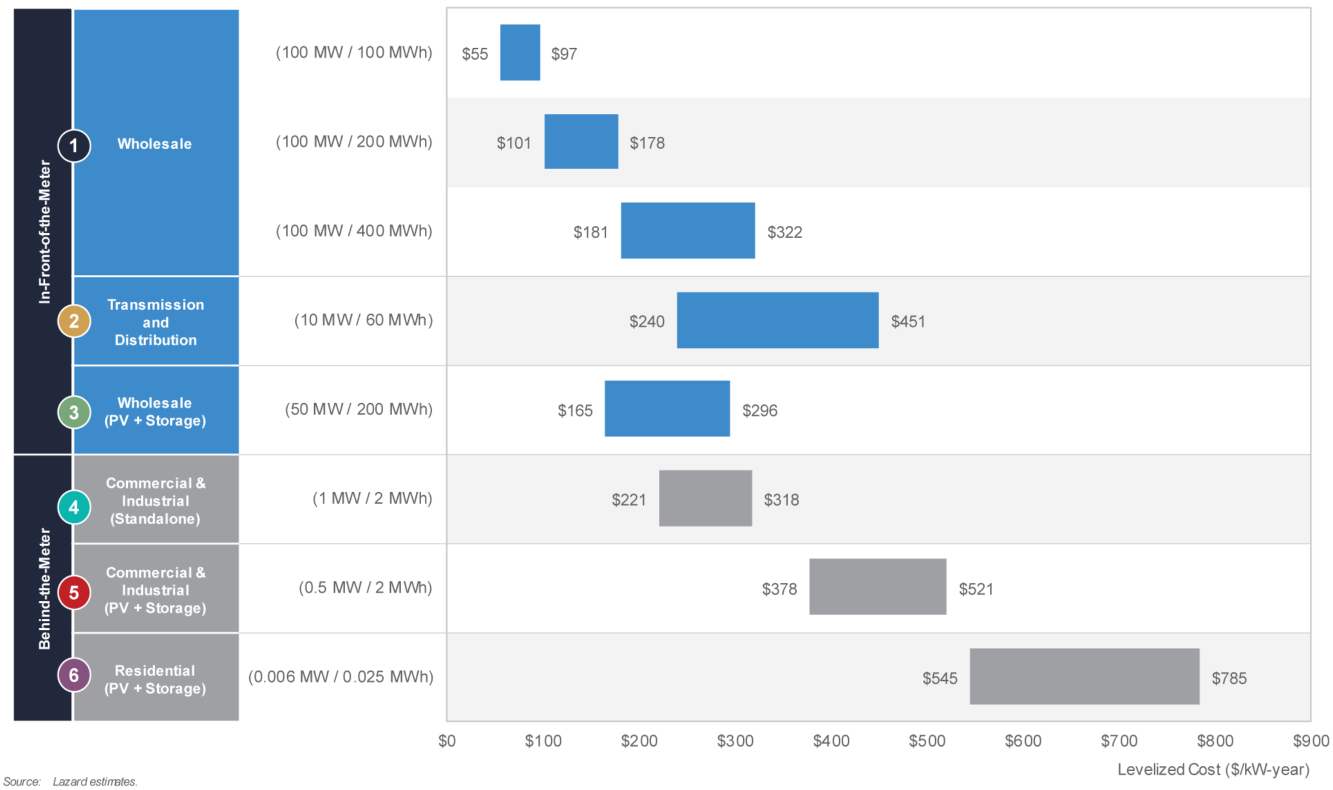
Unsubsidized Levelized Cost of Storage Comparison—Capacity ($/kW-year)

Lazard's LCOS analysis evaluates storage systems on a levelized basis to derive cost metrics based on nameplate capacity



Source: *Lazard estimates.*
Note: Here and throughout this presentation, unless otherwise indicated, analysis assumes a capital structure consisting of 20% debt at an 8% interest rate and 80% equity at a 12% cost of equity. Capital costs are composed of the storage module, balance-of-system and power conversion equipment, collectively referred to as the Energy Storage System ("ESS"), solar equipment (where applicable) and EPC. Augmentation costs are included as part of O&M expenses in this analysis and vary across use cases due to usage profiles and lifespans.

Unsubsidized Levelized Cost of Storage Comparison—Energy ($/MWh)

Lazard's LCOS analysis evaluates storage systems on a levelized basis to derive cost metrics based on annual energy output

Source: *Lazard estimates.*
(1) Given the operational parameters for the Transmission and Distribution use case (i.e., 25 cycles per year), certain levelized metrics are not comparable between this and other use cases presented in Lazard's Levelized Cost of Storage report. The corresponding levelized cost of storage for this case would be $1,613/MWh – $3,034/MWh.

Additional highlights from LCOS 7.0:

Industry preference is increasingly shifting towards Lithium-Iron-Phosphate ("LFP") technology, which is less expensive than competing lithium-ion technologies (especially in shorter-duration applications) and has more favorable thermal characteristics, despite its relatively lower volumetric energy density.

Upstream cost inflation (due to, among other factors, supply constraints in commodity markets and manufacturing activities) is putting pressure on energy storage capital costs.

Hybrid applications are becoming more valuable and widespread as grid operators begin adopting Estimated Load Carry Capability ("ELCC") methodologies to value resources. The adoption of ELCC methodologies is driving increasing deployment of hybrid resources (e.g., storage paired with solar) to mitigate resource intermittency.

Levelized Cost of Hydrogen

Lazard's Levelized Cost of Hydrogen Analysis (LCOH 2.0) shows that the cost of hydrogen is still largely dependent on the cost and availability of the energy resources required to produce it. Hydrogen applications which require minimal additional steps (e.g., conversion, storage, transportation, etc.) to reach the end user will most likely achieve cost competitiveness sooner than those that require greater site or application-specific investments.

Additional highlights from the LCOH 2.0:

Hydrogen is a versatile energy carrier with the potential to decarbonize a broad array of sectors, although hydrogen is currently more expensive than the fuels it would substitute.

Applications most readily suited to hydrogen conversion are those that need minimal transport, conversion or storage—these use cases will likely transition towards hydrogen most quickly.

Key drivers of hydrogen's levelized cost are the cost of electricity, capital expenditures for production equipment and utilization of the electrolyzer.