BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant,

v.
PUGET SOUND ENERGY, Respondent.

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


OCT 28 2021

Lazard's Levelized Cost of Energy Analysis, Version 15.0
Lazard's Levelized Cost of Storage Analysis, Version 7.0
Lazard's Levelized Cost of Hydrogen Analysis, Version 2.0

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.

- Solar PV-Rooftop Residential
- Solar PV-Rooftop C&I
- Solar PV-Community
- Solar PV-Crystalline Utility Scale
- Solar PV-Thin Film Utility Scale
- Solar Thermal Tower with Storage
- Geothermal
- Wind
- Nuclear
- Gas Peaking
- Coal
- Gas Combined Cycle

Source: Lazard estimates.

Notes:
1. Unless otherwise noted herein, the low case represents a single-axis tracking system and the high case represents a fixed tilt system.
2. Represents the estimated implied mid-point of the LCOE of onshore wind, assuming a capital cost rate of approximately $2.50/ W.
3. The fuel cost assumption for Lazard is $3.45/MMBtu.
4. The fuel cost assumption for Lazard is $3.45/MMBtu.
5. The fuel cost assumption for Lazard is $3.45/MMBtu.
6. Represents the mid-point of the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Estimates assume that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs.
7. Represents the mid-point of the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Estimates assume that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs.
8. Represents the mid-point of the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Estimates assume that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs.

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.

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 $2/MWh for utility-scale solar and $2.5/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.

![Levelized Cost of Energy Comparison — Historical Renewable Energy LCOE Declines](Image)

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.
# 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.

<table>
<thead>
<tr>
<th>In Front of the Meter</th>
<th>Wholesale</th>
<th>(100 MW / 100 MWh)</th>
<th>$65</th>
<th>$97</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(100 MW / 200 MWh)</td>
<td>$101</td>
<td>$178</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(100 MW / 400 MWh)</td>
<td>$181</td>
<td>$322</td>
</tr>
<tr>
<td></td>
<td>Transmission and Distribution</td>
<td>(10 MW / 60 MWh)</td>
<td>$240</td>
<td>$451</td>
</tr>
<tr>
<td></td>
<td>Wholesale (PV + Storage)</td>
<td>(50 MW / 200 MWh)</td>
<td>$165</td>
<td>$296</td>
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<tr>
<td>Behind the Meter</td>
<td>Commercial &amp; Industrial (Standalone)</td>
<td>(1 MW / 2 MWh)</td>
<td>$221</td>
<td>$318</td>
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<tr>
<td></td>
<td>Commercial &amp; Industrial (PV + Storage)</td>
<td>(0.5 MW / 2 MWh)</td>
<td>$378</td>
<td>$521</td>
</tr>
<tr>
<td></td>
<td>Residential (PV + Storage)</td>
<td>(0.006 MW / 0.025 MWh)</td>
<td>$545</td>
<td>$785</td>
</tr>
</tbody>
</table>

Source: Lazard estimates.
Note: Throughout this presentation, unless otherwise indicated, analysis assumes a capital structure consisting of 32% debt at an 8% interest rate and 68% 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 protocols.

# 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.

<table>
<thead>
<tr>
<th>In Front of the Meter</th>
<th>Wholesale</th>
<th>(100 MW / 100 MWh)</th>
<th>$160</th>
<th>$279</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(100 MW / 200 MWh)</td>
<td>$146</td>
<td>$257</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(100 MW / 400 MWh)</td>
<td>$131</td>
<td>$232</td>
</tr>
<tr>
<td></td>
<td>Transmission and Distribution</td>
<td>(10 MW / 60 MWh)</td>
<td>NA(1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wholesale (PV + Storage)</td>
<td>(50 MW / 200 MWh)</td>
<td>$85</td>
<td>$158</td>
</tr>
<tr>
<td></td>
<td>Commercial &amp; Industrial (Standalone)</td>
<td>(1 MW / 2 MWh)</td>
<td>$442</td>
<td>$643</td>
</tr>
<tr>
<td></td>
<td>Commercial &amp; Industrial (PV + Storage)</td>
<td>(0.5 MW / 2 MWh)</td>
<td>$235</td>
<td>$335</td>
</tr>
<tr>
<td></td>
<td>Residential (PV + Storage)</td>
<td>(0.006 MW / 0.025 MWh)</td>
<td>$416</td>
<td>$621</td>
</tr>
</tbody>
</table>

Source: Lazard estimates.

(1) Lazard estimates: Given the operational parameters for the Transmission and Distribution use case (i.e., 25 cycles per year), certain levelized metrics are not comparable to 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 $1.81/MWh – $3.04/MWh.
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.