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2022 Title 24 PV Measure

PV and Storage Cost Summary

October 6, 2020

Presented by: John Arent

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OBJECTIVES

- Determine costs for inclusion in economic analyses
- PV systems
  - Installation relative to array size
- Battery systems
  - Installation versus capacity and duration
  - Replacement costs for 10-year expected life

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METHODOLOGY

- Project and representative costs
  - Contacted top 50 installing contractors with commercial projects in CA
  - Contacted MEP and sustainability firms
  - Contacted facility managers of large corporations
  - Distributed cost survey to respondents for PV and storage prices
- Literature review for PV and storage prices
  - Current prices
  - Price trends
- Storage:
  - Contacted battery storage manufacturers and providers
  - Reviewed other sources of cost data

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SOURCES

- PV System Cost
  - EnergySage, 2020 Commercial PV estimates
  - LBNL – Barbose, Darghouth 2019. Tracking the Sun: Pricing and Design Trends for Distributed Photovoltaic Systems in the United States. October 2019
  - NREL - https://www.nrel.gov/analysis/solar-installed-system-cost.html
  - Sourced Survey Estimates (Solar Contracting Firms-2, MEP-1, Facility Manager-1)
  - Elshurfa, Amro et. al. 2018. Estimating the learning curve of solar PV balance-of-system for over 20 countries: Implications and policy recommendations. Journal of Cleaner Production 196: pp. 122-134
  - NEM Interconnected Data Set, https://www.californiadgstats.ca.gov/downloads/, accessed Sept. 24, 2020
  - Friedman, Brent 2014. Comparing Photovoltaic (PV) Costs and Deployment Drivers in the Japanese and U.S. Residential and Commercial Markets . Technical Report NREL/TP-6A20-60360 Revised June 2014
- Battery System Cost
  - NREL – Cole, Frazier 2019. Cost Projections for Utility-Scale Battery Storage. June 2019.
  - Solar Contracting Firm – survey estimate
  - Leading Manufacturer / Turnkey Provider – survey and interview
  - Lazard 2019. https://www.lazard.com/media/451087/lazards-levelized-cost-of-storage-version-50-vf.pdf

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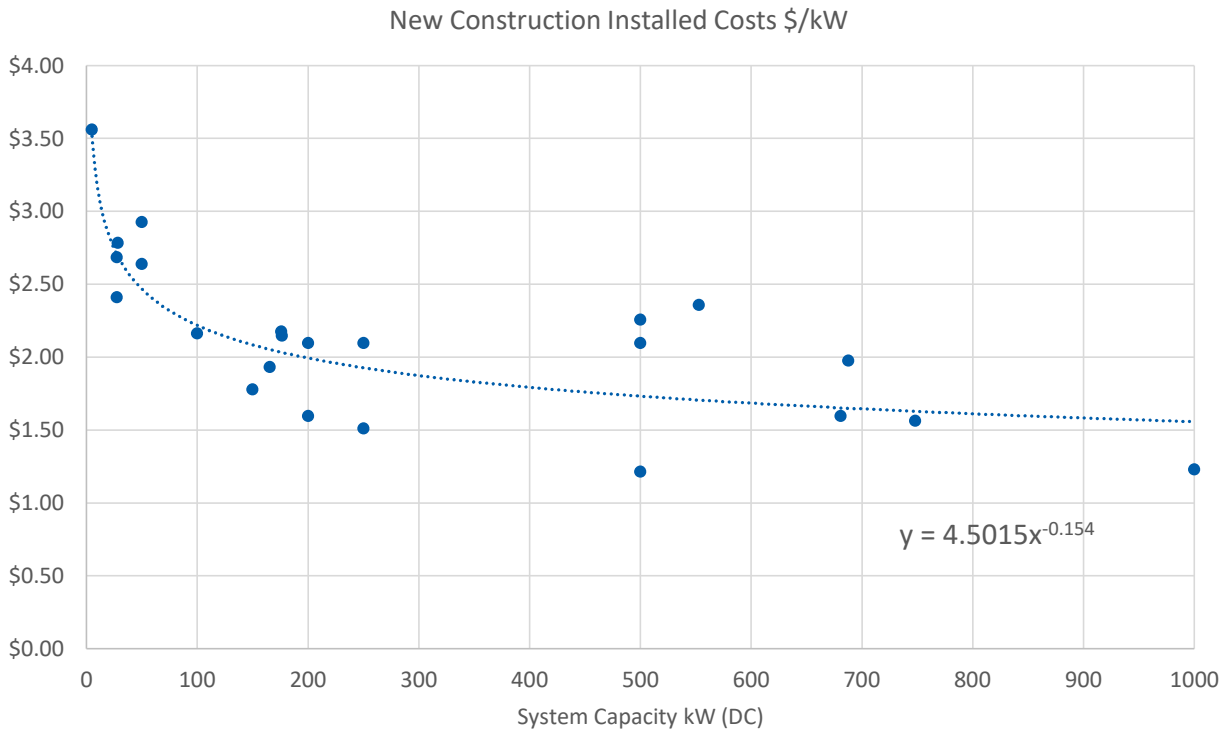
PV COST RESULTS – NEW CONSTRUCTION

- Combined Data Sources: Survey (contractors, Facility Mgr, MEP), LBNL data, NEM median binned data
- Adjusted data to NC with $0.18/W reduction for customer acquisition costs (Friedman 2014)
- Data gathered for 2018 through 2020 and includes commercial PV costs for 5 kW through 1000 kW
- Cost adjusted to 2023 based on projected PV cost. Inflation not applied



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NEW CONSTRUCTION COST REDUCTION - ACQUISITION COSTS

- Customer acquisition costs average $0.18/W for commercial projects (Friedman 2014)
- Companies with growth plan may incur higher acquisition costs
- Other soft costs include:
  - PII – permitting, inspection and interconnection
  - EPC – engineering, procurement and construction
- Possibility of additional reduction in operating costs
  - Reduction in other soft costs
  - Reduction in costs of balance-of-system (BOS) costs with infrastructure in place

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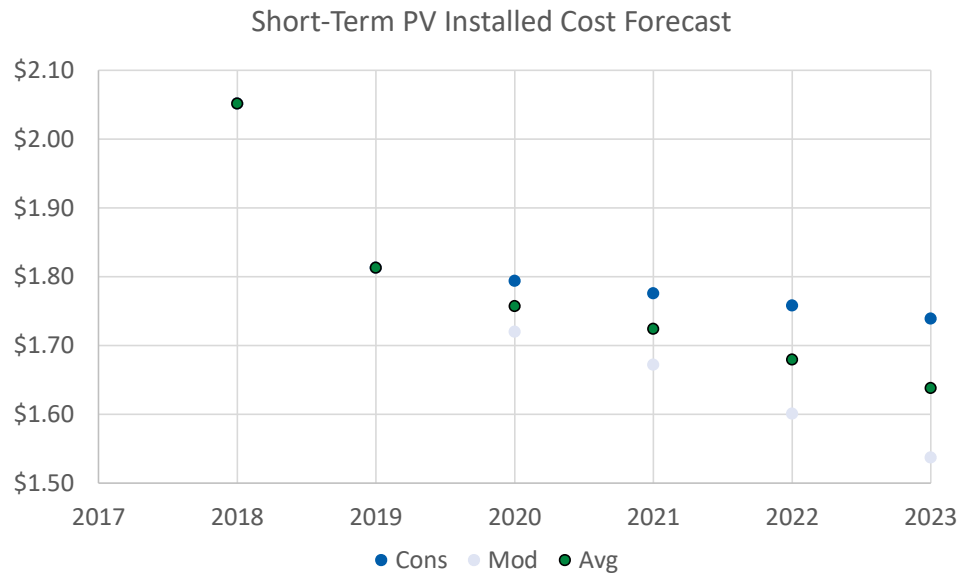
PV PROJECTION FOR 2023

- Between 2019 and 2023, the NREL Forecast Scenarios estimate a drop in installed costs of 3%, 15% or 20% for conservative, moderate, and aggressive scenarios, respectively
- This analysis assumes a reduction midway between the conservative and moderate scenarios, for a 9% reduction in cost between 2019 and 2023
- Applied adjustment factors to cost data based on year system was installed



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FURTHER STUDY

- Small commercial PV systems (< 25 kW) have a much higher cost ($/W) than larger systems
  - Requires further study to understand cost drivers

- Current data sources do not sufficiently differentiate between new construction and retrofit costs
  - In the process of collecting further information
  - Acquisition costs have been adjusted for, but there may be other costs that may not be incurred in new construction projects

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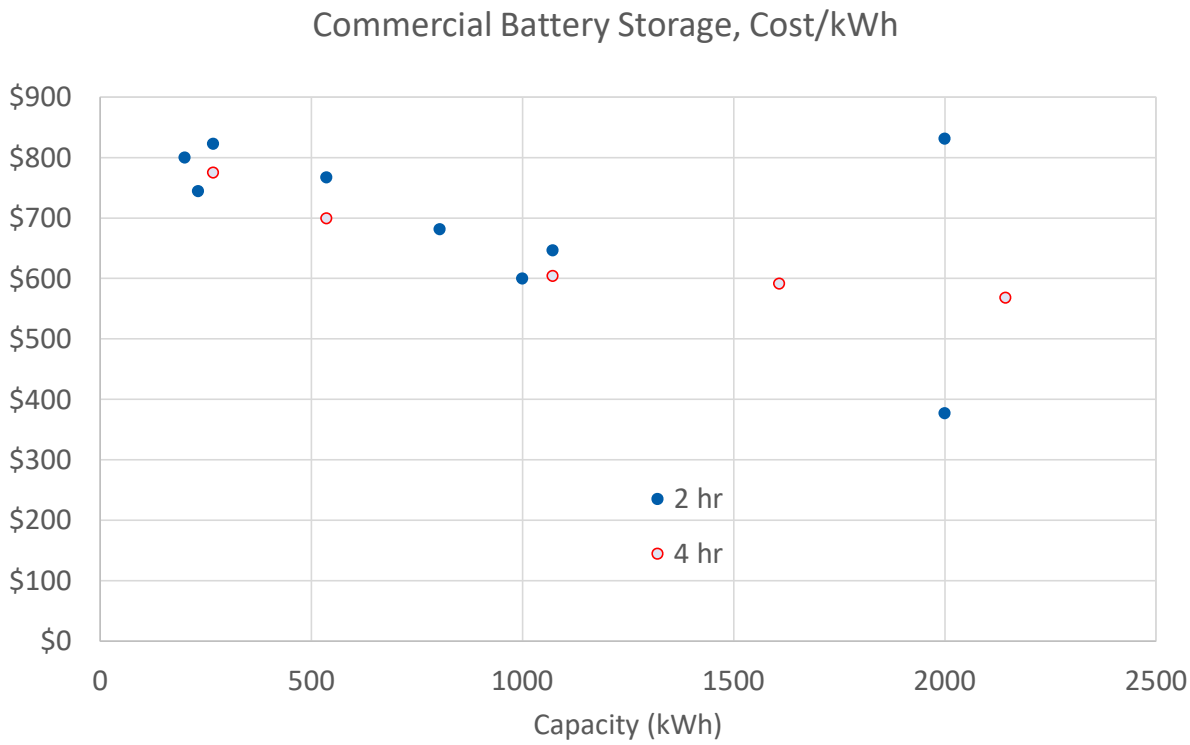
BATTERY STORAGE ESTIMATES

- Commercial Battery: installed costs of $600 to $800 per kWh
  - $600/kWh for large systems
  - $800/kWh for systems below 100 kW
- Battery cost of 4-hour storage is 10-15% lower than 2-hour storage
- Expected life of 10 years
  - Replacement costs will be at least 30% lower (2/3 are hard costs)
  - Future battery costs projected to drop by 30% at year 10
  - Overall replacement cost is 50% lower than first cost



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BATTERY STORAGE – DESIGN CONSIDERATIONS

- Some major battery installers do not offer systems below 100 kW
  - Tesla Powerwall may be offered by other providers
- Footprint: a 100 kW system takes up a full parking space
- Duration: systems available in 1- to 4-hour duration
  - 2 hour most common (aligned with SGIP program)
  - 4 hour more useful for alignment with ISO / grid
  - Costs are higher for higher current output (shorter duration): approximately 10-15% lower cost/kWh for 4-hr batteries, per contractor estimate and NREL study

BATTERY PROJECTION FOR 2023

- NREL Study shows battery storage costs dropping by 11%, 45%, to 67% for three projection scenarios. Future cost trends are important for storage, given 10-year expected life
- Recommend average of high (conservative) and Mid (moderate) scenarios, for an estimated 30% drop by 2030

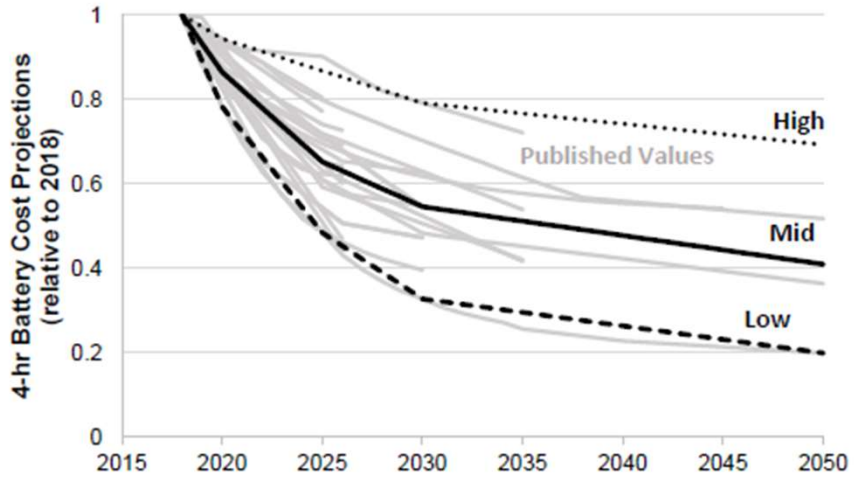

Figure 1. Battery cost projections for 4-hour lithium-ion systems, with values relative to 2018. The high, mid, and low cost projections developed in this work are shown as the bolded lines. Figure values are included in the Appendix.

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TESLA POWERWALL COSTS

- Slight cost reduction for multiple battery systems
- Potential additional cost reduction for new construction

Qty	kWh	Usable kWh	Battery Cost	Total System Cost	Cost/kWh	Source
1	14	13.5	$6,500	$11,000	$815	https://www.solarreviews.com/blog/is-the-tesla-powerwall-the-best-solar-battery-available
2	28	27	$13,000	$21,500	$796	https://www.solarreviews.com/blog/is-the-tesla-powerwall-the-best-solar-battery-available
5	70	67.5	$32,500	$53,000	$785	Projected based on reduced installation cost of second unit
1	14	13.5	$9,250	$13,400	$993	https://www.buildwithrise.com/stories/tesla-powerwall2-basics
3	42	40.5	$19,500	$24,691	$610	2020 Estimate for Davis Residence, from Tesla Palo Alto, CA

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PRELIMINARY RECOMMENDATIONS

- PV installed cost (regression from cost data):

  Cost ($/W) = 4.5015 x kW^-0.154

PV kW DC	PV Cost ($/W)
10	$3.16
20	$2.84
50	$2.46
100	$2.21
200	$1.99
500	$1.73
1000	$1.55

- Battery installed cost
  - Replacement Cost at 10 years:
    $600/kWh x 30% price drop – 30% soft costs
    = $284/kWh replacement
  - Replacement Cost at 20 years:
    $600/kWh x 38.5% price drop – 30% soft costs

Battery Size	Battery First Cost ($/kWh)	Battery Replacement Cost ($/kWh)
< 100 kW	$800	$392 (year 10) $344 (year 20)
> 100 kW	$600	$284 (year 10) $258 (year 20)

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NEXT STEPS

- Collect feedback from workshop attendees and incorporate into cost data
- Refine costs for small systems (< 25 kW)
- Investigate cost differential between new construction and retrofit projects

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ACKNOWLEDGEMENTS

NORESCO Team: Roger Hedrick, Silas Taylor, Rahul Athalye

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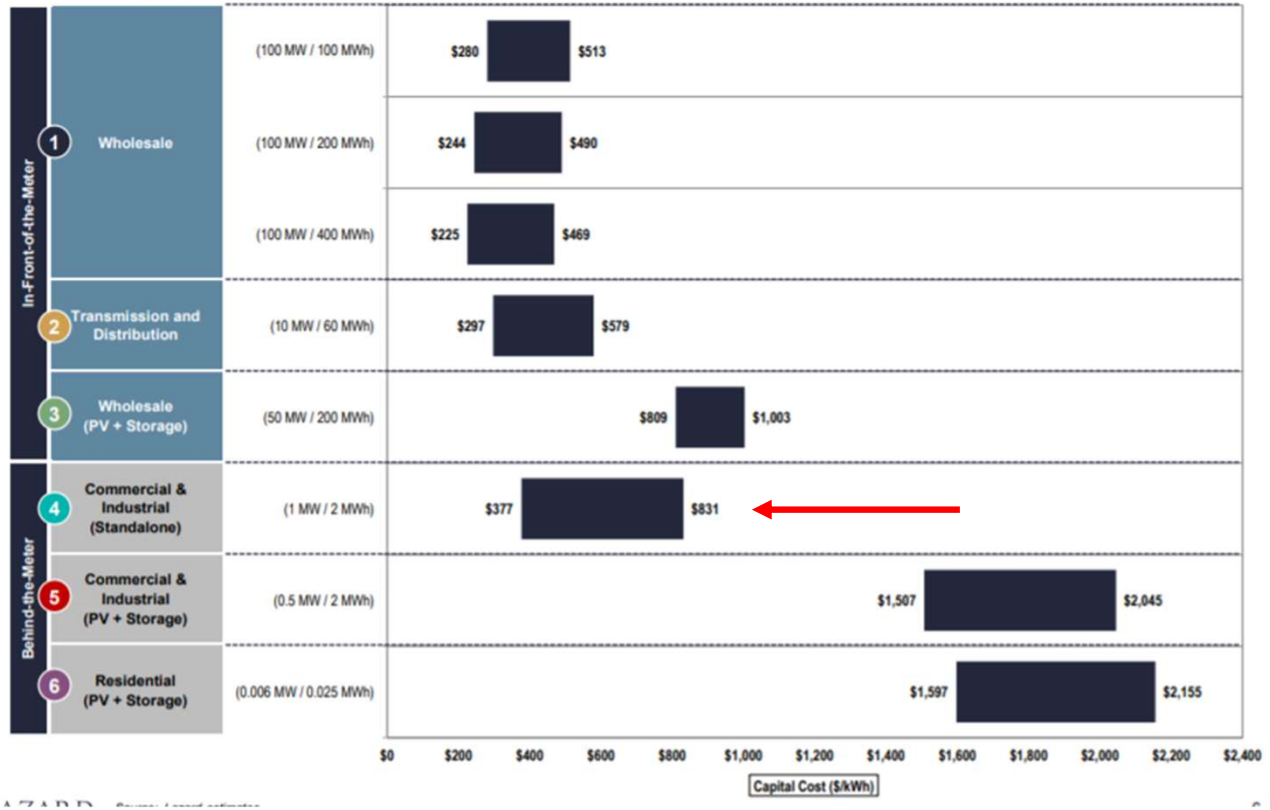
BACKUP SLIDE: BATTERY COST DATA FROM LAZARD

LAZARD

II LAZARD'S LEVELIZED COST OF STORAGE ANALYSIS V5.0

Capital Cost Comparison—Nameplate Energy ($/kWh)

In addition to analyzing storage costs on a levelized basis, Lazard's LCOS also evaluates system costs on the basis of nameplate energy



LAZARD

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