2017 Energy Storage Market Evaluation

Executive Summary

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Notice

1 Executive Summary

This report presents the results from the evaluation of two of NYSERDA's initiatives related to energy storage: Energy Storage Technology and Product Development Investment Plan,[1] and Reducing Barriers to Deploying Distributed Energy Storage Investment Plan.[2]

The market evaluation had three main objectives:

1. Develop a reliable, detailed, New York based estimate of current soft costs ($/kWh) of distributed energy storage systems as a component of the total installed cost ($/kWh, duration)
2. Develop a reliable, detailed estimate of current hardware and hardware balance of system costs ($/kWh) of energy storage systems
3. Develop a reliable, detailed estimate of the current performance of energy storage systems

The evaluators used primary and secondary data to achieve these objectives.

1.1 Summary of Evaluation Objectives and Methods

The evaluation objective and methods are shown in Table 1 and Table 2 below for this report and future evaluations.

[1]Clean Energy Fund Investment Plan: Renewables Optimization Chapter. Portfolio: Innovation & Research. Matter Number 16-00681, In the Matter of the Clean Energy Fund Investment Plan. September 7, 2018. https://www.nyserda.ny.gov/-/media/Files/About/Clean-Energy-Fund/CEF-Renewables-Optimization-chapter.pdf

[2] Clean Energy Fund Investment Plan: Energy Storage Chapter. Portfolio: Market Development. Matter Number 16-00681, In the Matter of the Clean Energy Fund Investment Plan. September 6, 2018. https://www.nyserda.ny.gov/-/media/Files/About/Clean-Energy-Fund/CEF-Energy-Storage.pdf

Table 1. Evaluation objectives mapped against evaluation questions, primary data collection

Objective	Evaluation Question(s)	2017 Findings
Develop a reliable, detailed, New York-based estimate of current soft costs ($/kWh) of distributed energy storage systems as a component of the total installed cost ($/kWh, duration).	What is the current estimate of soft costs ($/kWh capacity) of distributed energy storage systems?	Average = $146/kWh Median = $150/kWh *n=3*
	What is the cost per kWh capacity for energy storage systems by duration?	Average = $883/kWh Median = $850/kWh Duration not specified *n=3*
	How many alternative ownership models are being used?	The majority of the six relevant behind-the-meter projects survey respondents reported using site-based ownership, although a few use third-party ownership models. Limited data is available for front-of-the-meter projects, but third-party ownership and performance contracting models were reported in the survey responses. Given the that this an emerging market, this may not be indicative of larger trends over time.
	What is the percent conversion rate (%) of prospective installations from proposal to installed projects?	Median = 38% Average = 45% *n=6*
	What is the current cycle time (months) for the permitting process?	Insufficient data collected[3].
	Are there challenges with siting and permitting requirements?	Insufficient data collected[3].
	What is the cycle time (months) of projects from customer proposal to commissioning?	Insufficient data collected[3].

[3] Too few survey responses to accurately draw quantitative conclusions. Qualitative observations presented in Section 2.1.3.

Table 2. Evaluation objectives mapped against evaluation questions, secondary data collection

Objective	Evaluation Question(s)	2017 Findings
Develop a reliable, detailed estimate of current hardware and hardware balance of system (BOS) costs ($/kWh) of energy storage systems.	What is the current hardware cost ($/kWh) for energy storage devices?	Typical utility-scale lithium ion (Li-ion) battery cost = $270/kWh. Battery costs are ~30% higher for commercial and industrial (C&I) and ~50% higher for residential. Unit cost may be significantly higher for high-performance batteries.
	What is the current hardware BOS cost for energy storage systems including power electronics and hardware installation cost ($/kWh)?	Typical utility-scale power conversion system (PCS) hardware cost = $121/kW. PCS cost is ~75% higher for C&I and ~110% higher for residential. Typical utility-scale BOS hardware cost = $75/kW + $40/kWh.[4] BOS costs are ~10% lower for C&I and ~120% higher for residential. Installation cost not included.
Develop a reliable, detailed estimate of the current performance of energy storage systems.	What is the current performance of energy storage systems in terms of efficiency, life, energy/power density, etc.	Nameplate efficiency varies significantly by technology. Real efficiency varies widely and is significantly driven by use. Density varies widely and depends significantly on system design. Warranty life typically varies between 5 and 20 years. Limited field data exists on actual degradation rates.

1.2 Market Characterization and Assessment

This section summarizes the distributed energy storage (DES) system installation costs, project cycle times, characteristics of projects statewide, value propositions, ownership models, and barriers in the New York market. The data included in this analysis is compiled from 22 companies who responded to a survey of DES vendors. However, not all companies answered all survey questions, so much of the information provided is drawn from a smaller pool of respondents who answered a given question.

[4] For example, BOS costs for a 1 MW, 4 MWh system would cost approximately $235,000 ($75/kW x 1,000 kWh + $40/kWh x 4,000 kWh).

1.2.1 System Costs

The survey asked vendors to provide information on average installed costs for their primary use case DES systems. The evaluators collected information from two respondents serving residential behind-the-meter customers, four respondents serving C&I behind-the-meter customers, two respondents serving utility front-of-the-meter customers, and one respondent serving utility bulk scale customers. While the survey sample includes a small number of respondents, the storage market in New York is relatively new, with few players. Companies providing cost information represent 15% of all known storage companies in New York State, even those that have not installed projects yet or in the most recent year. Furthermore, this analysis captured the companies implementing the majority of projects in New York. Therefore, while the sample is small, it is considered representative and can serve as a baseline for future program years.

Table 3 shows the average costs C&I behind-the-meter DES installations.

Table 3. Average costs NY State C&I behind-the-meter DES projects in 2017, by component (n=3)

Name	Unit	**Average**	**Median**
Total average installed system	$/kWh	$883	$850
Hardware costs	%	62	60
Engineering and construction	%	22	20
Soft costs	**%**	**17**	**15**
Customer acquisition costs	*%*	*3*	*3*
Permitting	*%*	*8*	*10*
Interconnection	*%*	*5*	*5*
Financing costs	*%*	*1*	*0*

1.3 Secondary Data Collection Results

The objective of the secondary data collection was to provide a 2017 benchmark for energy storage hardware costs and performance metrics, which in turn provides a basis for evaluating future cost reductions and informs efforts to reduce costs and improve performance. Hardware costs were evaluated based on the cost of three components: the battery, power conversion system

(PCS), and balance of system (BOS). Performance analysis was based on three metrics: efficiency, energy density, and lifetime (cycle and calendar). The evaluation also considered key parameters that impact cost and/or performance: duration, size, and use case. The secondary data analysis was based on data taken from a variety of sources, which are listed in the Appendix.

1.3.1 Cost

The results of this analysis indicate that battery costs constitute the majority of hardware for systems with a duration greater than or equal to two hours. Hardware costs primarily vary based on duration and size. No direct trends were identified based upon use case (e.g., frequency regulation), but the duration and grid location together inform expected costs based upon use case. Recent cost reductions have exceeded 10% per year, and annual reductions are expected to remain around 10% over the next few years.

1.3.1.1 Variability in Costs

As shown in Figure 1-1, the variability in costs can be significant and is driven largely by variations in battery costs. A major driver of variability in battery costs is the technology. Even within Li-ion, the costs can vary significantly depending upon the chemistry. Chemistries that are more durable and high-performing tend to come at a premium. Technology assumptions are also a significant factor for PCS costs, which can vary depending upon assumed functionalities, such as islanding.

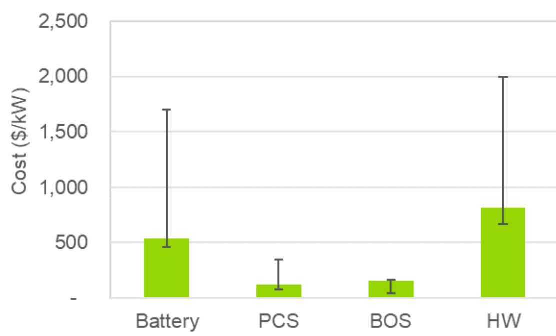

Figure 1-1. Cost Variability (2017, Li-ion, Utility-scale, 2 hr)

1.3.2 Performance

The performance analysis focused on three metrics: efficiency,[5] energy density,[6] and lifetime (cycle and calendar).[7] The impact of duration, size, and use case, as well as variations over time, were evaluated, but significant dependencies were generally not observed. Two notable exceptions are the dependence of efficiency on the use case and the dependence of energy density on the size of the energy storage system.

1.3.2.1 Variability in Performance

Performance is largely driven by technology, but variability in performance data is also driven by a number of other factors. For example, stated efficiencies do not always indicate whether it is for an AC or DC basis. Performance data also does not consistently indicate whether the basis for the data is at the cell, module, rack, or system level. Cycle life data does not consistently report underlying assumptions of whether partial or full cycles are assumed, and both cycle and calendar life data do not consistently report assumptions regarding augmentation (e.g., adding batteries to offset degradation) or sizing (e.g., oversizing initially to maintain rated energy for longer).

1.3.2.2 Efficiency

Energy storage system efficiency primarily depends upon technology and utilization. While, as noted above, uncertainties in the AC vs. DC basis for reported efficiency data lead to drive variability, inverter efficiencies can be quite high (Figure 2), and the variability is driven as much or more by variations in battery chemistry and system design.

Technology is the primary driver of differences in nameplate efficiency. For example, as shown in Figure 2, flow batteries tend to have significantly lower efficiencies and a greater range of efficiency than the Li-ion batteries.

However, nameplate efficiencies typically do not reflect expected standby and auxiliary losses, which drive down real efficiencies of energy storage systems. Real efficiencies are driven

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[5] Efficiency = ratio between power output (discharge) and power input (charging and auxiliary power)

[6] Energy density = Energy stored (MWh) on volumetric (per unit volume), gravimetric (per unit weight), or areal (per unit area) basis

[7] Lifetime is typically expressed based upon the battery warranty or the point at which batteries reach 80% of their original energy capacity. Cycle life is expressed as the number of full charge-discharge cycles. Calendar life is expressed in years.

primarily by utilization. Performance data from energy storage systems funded by California's Self-Generation Incentive Program (SGIP) show significant variability/range (Figure 3). The low efficiencies of many of these systems is due to the fact that they are used primarily for demand charge management, which may require infrequent discharge. Losses from self-discharge and powering of auxiliary components in standby (neither charging nor discharging) result in low system efficiencies.

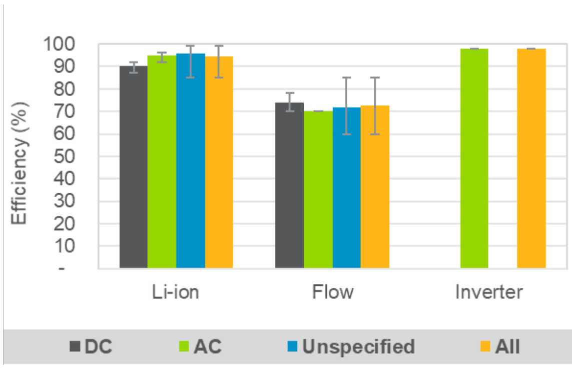

Figure 2. Efficiency (AC vs. DC, Nameplate)

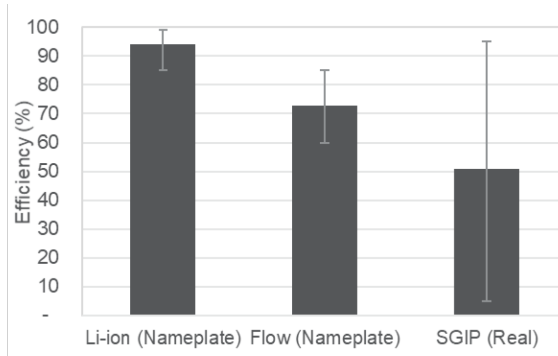

Figure 3. Efficiency