2019 Energy Storage Market Evaluation

Executive Summary

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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 objectives and select results from the 2018 primary a data collection and literature review efforts completed by the evaluator are shown in Table 1 and Table 2.

[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 questions mapped with 2018 primary data collection results

Objective: Develop a reliable, detailed, New York-based estimate of current soft costs ($/kWh) of DES systems as a component of the total installed cost ($/kWh, duration)

Evaluation Question(s)	2018 Findings
What is the current estimate of soft costs ($/kWh capacity) of DES systems?[3]	Average = $212/kWh Median = $200/kWh *n*=5
What is the installed cost per kilowatt-hour capacity for energy storage systems by duration?[4]	Average = $1,000/kWh Median = $1,000/kWh Duration not specified[5] *n*=5
How many alternative ownership models (e.g., third-party ownership, end-user ownership, performance contracting) are being used?	Limited data was reported in 2018 for both behind-the-meter (BTM) and front-of-the-meter (FTM) projects, though third-party performance contracting models and end-user ownership were mentioned by survey respondents. Given that this is 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 = 5% Average = 18% *n*=5
What is the current cycle time (months) for the permitting process?[6]	Insufficient data collected.[7]
Are there challenges with siting and permitting requirements?	Two survey respondents mentioned known challenges with permitting requirements in New York City which have been the subject of significant NYSERDA engagement.
What is the cycle time (months) of projects from customer proposal to commissioning?	Reported total cycle time for BTM projects was 12 months. Insufficient data was collected for FTM projects; however, it appears this cycle time can be up to two times longer.

[3] Includes a combination of two- to four-hour systems.

[4] Duration is defined as the ratio of the storage system's energy capacity to power capacity which indicates the length of the system's full discharge.

[5] NYSERDA opted not to collect data in 2018 regarding system duration characteristics given the anticipated limited number of survey respondents.

[6] Definition of cycle time and permitting process details can be found in the survey document (Appendix A)

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

Table 2: Evaluation questions mapped with literature review results

Objective: Develop a reliable, detailed estimate of current hardware and hardware balance of system (BOS) costs ($/kWh) of energy storage systems

Evaluation Question(s)	2018 Findings
What is the current hardware cost ($/kWh) for energy storage devices?	Typical utility-scale lithium ion (Li-ion) battery cost = $200/kWh. Battery costs are ~20% higher for commercial and industrial (C&I) and ~55% higher for residential. Unit cost may be significantly higher for high-performing batteries.
What is the current hardware BOS cost for energy storage systems including power electronics and hardware installation cost ($/kWh)?	Typical utility-scale power conversion system (PCS) hardware cost = $95/kW. PCS cost is ~90% higher for C&I and ~120% higher for residential. Typical utility-scale BOS hardware cost = $13/kW + $36/kWh. BOS costs are ~70% lower for C&I and ~300% higher for residential.
What is the current performance of energy storage systems in terms of efficiency, life, energy/power density, etc.	Nameplate efficiency varies from 85% to 100%, depending on technology. Real efficiency varies widely and is driven by use case. Density varies widely and depends on system design.

1.2 Market Characterization and Assessment

This section summarizes 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 was compiled from 26 companies that responded to the evaluation survey. The analysis included all companies that contracted or completed DES projects in New York State in 2018. Not all companies answered all survey questions, however, so the evaluator presents the number of responses for each set of results.

1.2.1 System Costs

The survey asked responding companies to provide information on average installed costs for their primary use case DES systems.[8] The evaluator collected information from five respondents serving commercial and industrial (C&I) BTM customers and three respondents serving utility front-of-the-meter (FTM) customers. While the survey sample includes a small number of respondents, the storage market in New York is relatively nascent with few players. NYSERDA tracks operational projects in New York State and has confirmed the survey responses collected by the primary research activities are representative of the market and capture the companies implementing most projects in the state.[9]

Survey respondents reported that 10 use cases were electrochemical systems, with nine lithium ion (Li-ion) installations (including one secondary use case) and another secondary use case lead-acid installation. Five of the Li-ion installations and the one lead-acid installation were BTM and the remaining four Li-ion installations were FTM. Three DES systems were installed in New York City, four in Westchester County, and the remaining two were installed in other parts of the state. Reported system size ranged from 60 kWh to 20,000 kWh, with the average and median system size both equaling 500 kWh. While the average system duration was not collected in the

[8] The survey also asked companies to provide information on average installed costs for secondary use case DES systems. Two respondents provided both primary and secondary use case information as defined in the survey document (See Appendix A).

[9] A database of all distributed energy resource projects installed throughout New York is available here: https://der.nyserda.ny.gov/

2018 survey, the evaluator recognizes that system duration affects total system cost—shorter duration systems will be more expensive.[10]

The results presented in Table 3 are for respondents who provided complete soft cost data. The evaluator excluded from the analysis one respondent who provided incomplete soft cost data.

Table 3: Average costs of BTM C&I DES projects in 2017 and 2018, by component*

Name	Unit	2017		2018	
		Average	Median	Average	Median
Total average installed system cost	$/kWh	$883	$850	$1,000	$1,000
Hardware costs	%	62	60	55	50
Engineering and construction	%	22	20	24	20
Soft costs	**%**	**17**	**15**	**21**	**20**
Customer acquisition costs	*%*	*3*	*3*	*2*	*2*
Permitting	*%*	*8*	*10*	*6*	*8*
Interconnection	*%*	*5*	*5*	*10*	*10*
Financing costs	*%*	*1*	*0*	*3*	*0*

*The percent sum of average hardware costs, engineering and construction costs, and soft costs should sum to 100, any variance is due to rounding. The median values do not necessarily sum to 100, due to the variance within data points. Soft costs are a sum of the average customer acquisition costs, permitting, interconnection, and financing costs. These also sum to 100 for average columns, but not the median columns.

Survey respondents indicated that average installed system costs in 2018 were $1,000/kWh. This value is slightly higher than the 2017 value. The percent of costs attributable to soft costs was 21% on average in 2018, which is also higher than the percent observed in 2017 (17%). While trends in installed system costs and soft costs appear to have increased over time, the limited number of respondents means that a few projects could skew these generalized results from one year to the next. The evaluator will continue to collect time-series data regarding these metrics in the coming years so that NYSERDA and other program stakeholders can monitor these trends as the market matures and an increasing number of DES projects are installed in New York State.

Few 2018 survey respondents reported installing FTM DES systems; however, of those that did, it appears that the larger scale of these installations located outside of the Con Edison service

[10] NYSERDA opted not to collect data in 2018 regarding system duration characteristics given the anticipated limited number of survey respondents.

territory led to a lower average installed cost per kilowatt-hour than the BTM projects reported in Table 3.

1.3 Literature Review Results

The objective of the 2018 literature review was to primarily provide a reference for energy storage cost and performance metrics, with the data below providing an update to the more in-depth prior analysis for 2017. In addition to hardware costs for the battery, PCS, and BOS evaluated in 2017, the evaluators expanded the cost study to consider three additional cost components: energy management system (EMS); engineering, procurement, and construction (EPC); and total installed cost. The evaluators reviewed three performance metrics: efficiency, energy density, and lifetime (cycle and calendar). The 2018 analysis was based upon new data collected by the evaluator since the 2017 report, in addition to data collected for the prior analysis.

1.3.2 System Costs

The results of this analysis indicate that updated 2018 costs are lower than projected 2018 costs from the 2017 report.[11] Although a rapid decline in hardware costs is observed between 2017 and 2018, costs are expected to fall at a slower, though still significant, rate in future years (Section 0).

The 2018 data analysis shifted from primarily using a 2-hr baseline for the batteries to using a 4-hr baseline, which is consistent with the typical duration reported in the primary data collection in this evaluation. Hardware, EPC and soft costs derived from the primary data collection were higher than the costs derived from the literature review, which may be attributable to higher costs in New York State.

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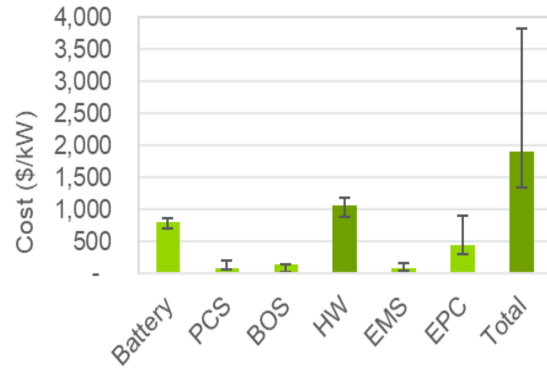
[11] NYSERDA. 2018. *2017 Energy Storage Market Evaluation*. Prepared by Navigant Consulting, Inc.

Variability in Costs

As shown in Figure 1, the variability in costs is driven primarily by labor and soft costs (EPC). Hardware (HW) and software (EMS) costs, on the other hand, show limited variability. Battery cost variability appears lower relative to last year due to the exclusion of high-cost batteries from the analysis.[13] Variability for other hardware components appears lower due to analysis of utility-scale costs only. Relative costs for behind-the-meter (BTM) systems are provided in Section **Error! Reference source not found.**. Note that total costs in Figure 1 are based on reported total system costs and are not equal to the sum of the component costs. Comparison of Costs between 2018 and 2017 Analyses

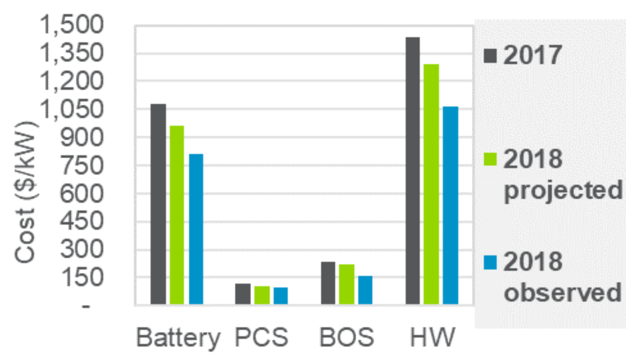
Figure 1. Cost Variability (2018, Li-ion, Utility-scale, 4-hr)[12]



Source: Evaluator Analysis

Overall, observed 2018 costs are lower than projected 2018 costs. As shown in Figure 2, significant cost reductions were observed for all hardware components. Battery cost reductions are the biggest driver of overall hardware cost reductions, while PCS reductions were minimal in comparison. Although BOS costs fell by the largest relative percentage compared to other hardware components, this is likely due to refinements in cost estimates obtained through the additional data collected than actual cost reductions.

Figure 2. Cost by Scale (2017 vs. 2018 Analyses, Li-ion, 4-hr)



Source: Evaluator Analysis

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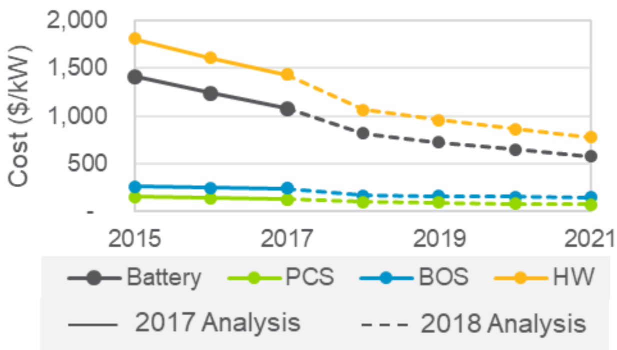
[12] Hardware (HW) is based upon the sum of battery, PCS, and BOS components, while Total Cost is based upon assessment of reported total system costs (not a sum of the values found for individual components).

[13] An example is lithium titanate (LTO), which is a high-performance technology primarily used for short-duration applications, whereas this analysis focuses on 4-hr batteries as a baseline.

Cost Reductions over Time

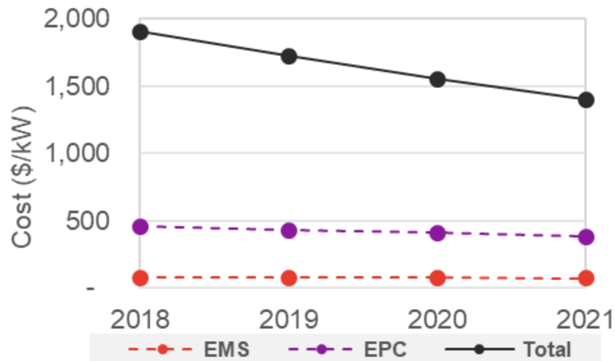
As shown in Figure 3, a rapid decline in hardware costs is observed between 2017 and 2018. The same rate of decline, however, is not expected to continue in the future. Instead, future annual cost declines are expected to be similar to those observed prior to 2017. Total costs reductions are also projected to be similar to hardware cost reductions (Figure 4).

Figure 3. Cost by Year (Li-ion, Utility-scale, 4-hr, Hardware components)



Source: Evaluator Analysis

Figure 4. Cost by Year (Li-ion, Utility-scale, 4-hr, Non-hardware components)[14]

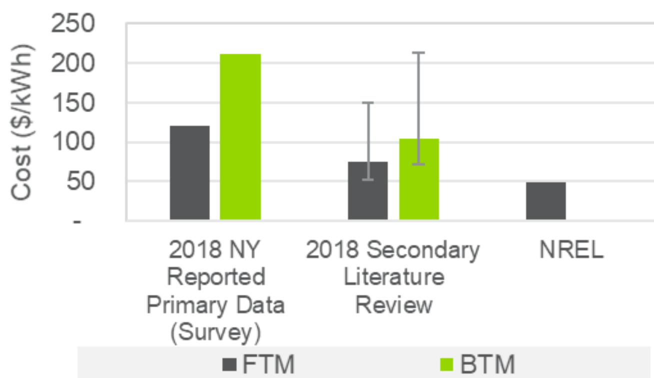


Source: Evaluator Analysis

Comparison of Primary Data and Literature Review Results

Figure 5 provides a comparison of the soft costs from the 2018 NY reported primary data and literature review, as well as a data point from the NREL report *2018 U.S. Utility-Scale Photovoltaics-Plus-Energy Storage System Costs Benchmark*, as this provides a reference for utility-scale soft costs that is consistent with the scope of the survey analysis. Soft costs from the survey data appear to be higher than calculated soft

Figure 5. Soft Cost Comparison (2018, Li-ion, 4-hr)



Source: Evaluator Analysis

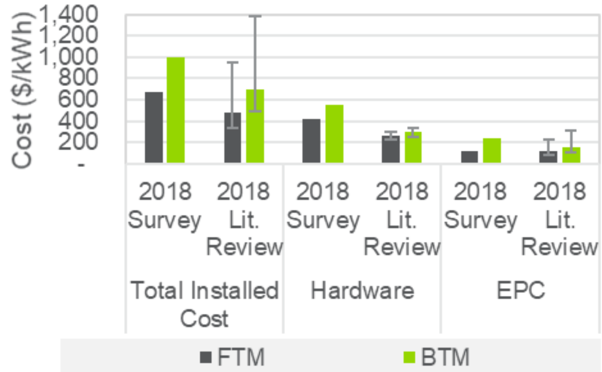
[14] Dashed lines represent costs at the component level while solid line represents cost for non-hardware components.

costs from the literature review, as well as from NREL specifically. This may be partially attributable to higher reported costs in New York State. The significantly lower costs for the

NREL data may also be partially attributable to economies of scale (i.e., 60 MW basis).

Figure 6 provides a comparison of the total installed, hardware and EPC costs from the survey and literature review. The literature review generally finds lower average costs than the survey, though costs from the survey are generally within the range of error from the literature review. The exception is hardware costs. The reason for this discrepancy is unclear but the discrepancy may be due in part to high labor costs for upstream hardware providers being built into the hardware price and/or to more stringent technical requirements for permits and interconnection (e.g., additional containerization).

Figure 6. Comparison of Literature Review and Survey Results (2018, Li-ion, 4-hr)[15]



Source: Evaluator Analysis

[15] *2018 Survey* refers to 2018 NY Reported Primary Data while *2018 Lit. Review* refers to 2018 Literature Review