2019 Energy Storage Market Evaluation

Executive Summary

Prepared for:

New York State Energy Research and Development Authority

Albany, New York

Dana Nilsson
Project Manager

Prepared by:

Guidehouse

Boulder, Colorado

Rachel Marty
Managing Consultant

Brent Barkett
Director

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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 Primary Data 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 combines information from 40 responses to the evaluation survey and 60 customers that provided NYSERDA with energy storage incentive program application data in 2019. The survey targeted all companies that contracted or completed DES projects in New York State in 2019. Not all companies answered all survey questions. Incentive program application data provided only total average cost. All data represented in this analysis is for real projects, but it includes a mix of projects installed in 2019 and projects contracted in 2019 with anticipated commissioning dates in 2020-2022. The data from the contracted projects not yet installed necessitated estimates.

[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

1.1.1 System Costs

The survey asked responding companies to provide information on average installed costs for their primary use case DES systems and secondary use case DES systems, if applicable.[3] The market evaluation team collected information from 10 C&I BTM use cases, 11 utility FTM (retail) use cases, and one bulk use case. The market evaluation team excluded two retail use cases. Of the 40 respondents who took the survey, 17 provided cost data.

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 represent the market and capture the companies implementing the most projects in the state.[4]

The NYSERDA incentive program application data provided an additional two BTM systems, 50 utility FTM systems, and eight bulk systems.

Survey respondents reported that 21 use cases were lithium ion (Li-ion) installations, two of which were secondary use cases. Respondents reported no other battery technologies. Respondents and applicants provided geographic data for 59 DES systems, presented in Table 1.

Table 1: Geographic locations of installed or planned DES systems, 2019

Source: Market evaluation team analysis of survey data

Geography	Bulk	BTM	FTM (Retail)	Total
New York City	0	0	0	**0**
Long Island	0	0	0	**0**
Westchester	0	0	5	**5**
Other New York State	7	2	45	**54**

[3] Two respondents provided primary and secondary use case information as defined in the survey document (see Appendix B).

[4] A database of all distributed energy resource projects installed throughout New York is available on NYSERDA's website: https://der.nyserda.ny.gov/

Reported retail system size ranged from 36 kWh to 20,000 kWh, with an average size of 9,487 kWh and a median size of 10,000 kWh. Reported bulk retail system size ranged from 16,500 kWh to 800,000 kWh, with an average size of 153,500 kWh and a median size of 80,000 kWh.

The market evaluation team asked companies to estimate what percentage of total system cost constituted hardware, engineering and construction, and soft costs. These categories are defined as follows:

- **Hardware costs:** Battery module, inverter, and BOS costs such as fire controls, power electronics, communication system, containerization, insulation, HVAC system, meter, control system, and outdoor containerization (when necessary).
- **Engineering and construction costs:** Cost of design, site preparation, transportation, siting, Professional Engineer approval, testing and commissioning, electrician and installation labor, wiring, fencing, and other overhead.
- **Soft costs:** Cost of customer acquisition, permitting, interconnection, and financing.

Survey respondents provided soft cost information for 16 use cases, including five BTM and 11 FTM retail use cases. The incentive program application data provided average cost information in addition to data collected via the survey. Table 2 (BTM), Table 3 (FTM Retail), and Table 4 (bulk) present all cost data available to the market evaluation team, with n counts to designate the number of use cases and systems that informed each calculation.[5] The 2019 survey collected average system duration for the first time, and the market evaluation team analyzed average system cost data by system duration where possible.

Table 2 presents cost data for BTM retail storage projects collected over the past 3 years.[6] The final or anticipated commissioning dates for the 2019 projects represented are from 2019 to 2022. The table presents average installed system costs in aggregate, not broken out by duration, due to limited number of responses received.

[5] One survey respondent provided bulk use case data, including hardware, engineering and construction, and soft costs; however, the market evaluation team elected not to report this data to protect anonymity and avoid bias created by a sample size of one.

[6] 2017 and 2018 data does not include incentive program application data, only the 2019 average installed system cost does.

Table 2: Average costs of BTM DES projects by component,[a] 2017-2019

Source: Market evaluation team analysis of survey and incentive program data

Cost	Unit	2017 n	2017 Average	2017 Median	2018 n	2018 Average	2018 Median	2019 n	2019 Average	2019 Median
Average installed system cost	$/ kWh	3	$883	$850	5	$1,000	$1,000	7	$1,279	$833
Hardware costs	%	3	62	60	5	55	50	5	45	40
Engineering and construction costs	%	3	22	20	5	24	20	5	30	25
Soft costs	**%**	**3**	**17**	**15**	**5**	**21**	**20**	**5**	**25**	**30**
Customer acquisition	*%*	*3*	*3*	*3*	*5*	*2*	*2*	*5*	*5*	*3*
Permitting	*%*	*3*	*8*	*10*	*5*	*6*	*8*	*5*	*12*	*10*
Interconnection	*%*	*3*	*5*	*5*	*5*	*10*	*10*	*5*	*7*	*10*
Financing	*%*	*3*	*1*	*0*	*5*	*3*	*0*	*5*	*1*	*0*

[a] 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 because of 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.

The market evaluation team considered correlations between geographic location and costs and found that 2019 BTM storage projects in New York City, Long Island, and Westchester counties are more than twice as expensive as those projects in the rest of the state. This finding does not take into account differences in project size or duration.

Installed system costs for BTM projects in 2019 averaged $1,279. This value is higher than both the 2017 average ($883) and 2018 average ($1,000). Notably, the median installed system costs for BTM projects in 2019 were $833, which is slightly lower than both the 2017 median ($850) and 2018 median ($1,000), indicating that fewer, more expensive projects may be driving up the average installed system cost for 2019.

The percentage of costs attributable to soft costs for BTM projects, 25% on average in 2019, increased from the percentage observed in 2017 (17%) and 2018 (21%). While trends in installed system costs and soft costs appear to have increased over time, the limited number of respondents and variability between specific projects could skew these generalized results from one year to the next.

Table 3 and Table 4 present 2019 FTM and bulk DES project average installed system costs in aggregate, not broken out by duration, due to the limited number of responses received. The 2017 and 2018 reports were unable to provide cost estimates beyond average installed costs for FTM projects because of the limited number of survey responses.

Table 3: Average costs of FTM Retail DES projects by component,[a] 2019

Source: Market evaluation team analysis of survey and incentive program data

Cost	Unit	2019 n	2019 Average	2019 Median
Average installed system cost	**$/kWh**	**61**	**$434**	**$405**
Average system costs; <3-hour duration	$/kWh	15	$489	$503
Average system costs; ≥3-hour duration	$/kWh	46	$416	$392
Hardware costs	%	11	72	70
Engineering and construction costs	%	11	11	13
Soft costs	**%**	**11**	**18**	**18**
Customer/site acquisition	*%*	*11*	*2*	*1*
Permitting	*%*	*11*	*5*	*3*
Interconnection	*%*	*11*	*8*	*8*
Financing	*%*	*11*	*3*	*2*

[a] 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 because of 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.

Table 3 presents retail storage projects installed in front of the meter, sized up to 5 MW. The final or anticipated commissioning dates for the projects represented are from 2019 to 2022.

On average, systems with durations shorter than 3 hours are roughly 15% more expensive than systems with durations longer than 3 hours. Again, the market evaluation team considered correlations between geographic location and costs and found that FTM retail storage projects in New York City, Long Island, and Westchester counties are roughly 20% more expensive than those projects in the rest of the state. This finding does not take into account differences in project size or duration.

The percentage of costs attributable to soft costs for FTM retail projects were 18% in 2019, also lower than that of BTM projects in 2019 (25%).

Table 4: Average costs of bulk DES projects, 2019

Source: Market evaluation team analysis of survey and incentive program data

Cost	Unit	2019 n	Average	Median
Average installed system cost	$/kWh	8	$416	$463

Table 4 presents bulk storage projects installed in front of the meter, sized greater than 5 MW. The anticipated commissioning dates for the projects represented are 2020-2021.

All bulk project cost data, except for one data point, represents data collected in the NYSERDA incentive program application process. The application collected only total project costs, not component costs.

Average installed system costs for FTM retail projects and bulk projects in 2019 were $434 and $416, respectively, both significantly lower than the average installed system costs for BTM projects ($1,279).

1.2 Literature Review Results

The primary objective of the 2019 literature review was to provide a reference for energy storage costs based on new data collected by the market evaluation team since the 2018 report.

The market evaluation team quantified typical costs of hardware and non-hardware components in addition to total installed cost:

- **Battery:** Battery rack with battery management system
- **PCS:** Inverter
- **BOS:** Enclosure, HVAC, transformer, switchgear, wiring, etc. (excludes interconnection and software costs)
- **Energy Management System (EMS):** Software and controls
- **Engineering, procurement, and construction (EPC):** May include development and other soft costs
- **Total installed cost:** Includes all components

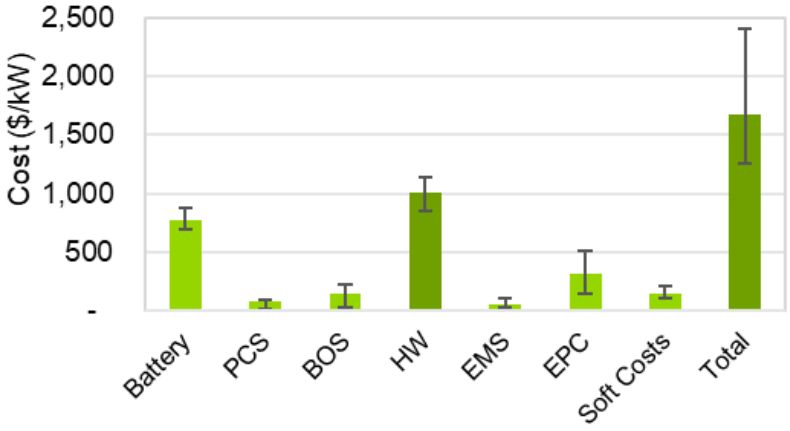
Hardware (abbreviated as HW in charts) is based on the sum of the battery, PCS, and BOS components, while total cost is based on the assessment of reported total system costs (not a sum of the values found for individual components).

1.2.1 Variability in Costs

As Figure 1 shows, the variability in costs can be significant and is driven by a combination of EPC and hardware costs, with EPC costs showing the most variability. Variability for BOS is higher relative to 2018, which appears to be because of additional data sources in the 2019 analysis.

Figure 1: Variability in costs (2019, Li-Ion, utility-scale, 4-hour)[a]

Source: Market evaluation team analysis



[a] Range in variability represents the highest and lowest cost data points for each hardware component, EMS, EPC, and total costs. Range in variability for hardware costs were based upon the sum of the highest and lowest cost data points for battery, BOS, and PCS components, while range in variability for soft costs was based upon same relative range for total costs.

Several uncertainties drive variability in costs:

- Data sources do not always indicate whether the data includes profit margins.
- Data sources do not always specify whether theoretical maximum energy or actual usable energy is the basis for battery costs.
- There is a limited number of sources for costs by component for C&I and residential systems.
- Cost forecasts may not account for unexpected circumstances (e.g., coronavirus outbreak effects on supply chains).
- Components may be defined differently across supports; non-hardware costs are reported differently across sources, making direct comparisons challenging.
- Assumptions of size or grid location are not always clearly specified.

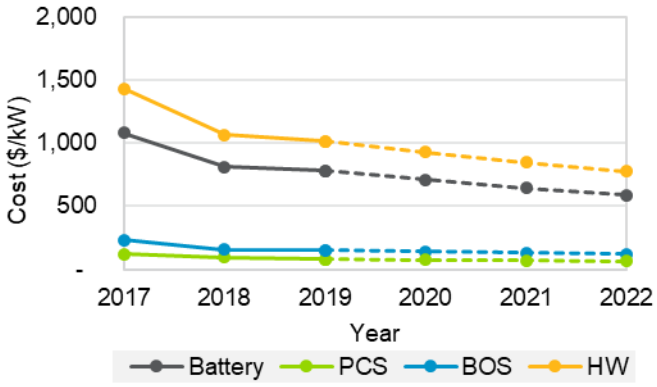
1.2.2 Cost Reductions Over Time

As Figure 2 shows, a modest decline in hardware costs is observed between 2018 and 2019. The same rate of decline is not expected to continue in the future. Instead, costs are expected to

decline more rapidly, at a rate between what was observed for 2017-2018 and 2018-2019. For non-hardware components, what appear to be significant cost reductions are more likely due to refined cost estimates from additional data than actual cost reductions (Figure 3).

Figure 2: Cost by year (Li-ion, utility-scale, 4-hour, hardware components)[a]

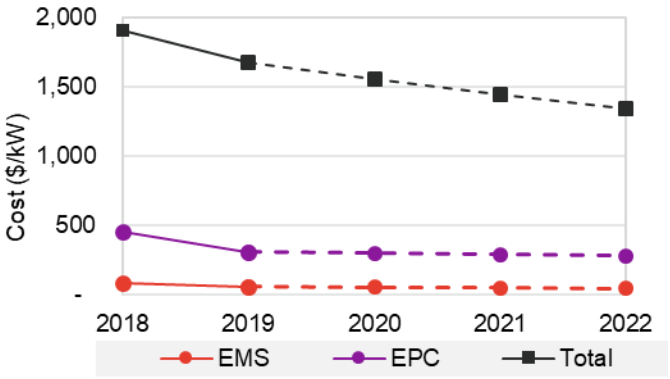
Source: Market evaluation team analysis



[a] Dashed lines represent cost forecasts and solid lines represent actual costs.

Figure 3: Cost by year (Li-ion, utility-scale, 4-hour, total and non-hardware) [a]

Source: Market evaluation team analysis



[a] Dashed lines represent cost forecasts and solid lines represent actual costs.

Battery cost reductions, in particular, were modest in 2018-2019. This modesty is likely because of supply constraints due to the growth of the EV market, which kept battery prices from

declining significantly for stationary projects.[7] As noted previously for hardware costs, battery costs are expected to decline more rapidly in the future.

[7] Maloney, Peter. 2018. "Electric vehicle and stationary storage batteries begin to diverge as performance priorities evolve." *Utility Dive.* August 1. https://www.utilitydive.com/news/batteries-for-electric-vehicles-and-stationary-storage-are-showing-signs-of/528848/