NYSERDA ENERGY STORAGE AND NY-BEST PROGRAM: IMPACT EVALUATION

Final Report

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1 Introduction, Research Questions and Methods

EMI Consulting and Industrial Economics, Inc., were selected to carry out an evaluation of the NY-BEST Consortium and provide supporting market characterization and baseline information for NYSERDA's Energy Storage activities going forward. The purpose of this evaluation was to assess the impact on New York State's energy storage industry and market by the NYSERDA-supported NY-BEST Consortium. The evaluation period primarily covers the period from 2010 to 2015 with updates on the number of members and project status provided in the first quarter of 2016.

The three-part evaluation included distinct analysis tasks that provided insight into the state of the market in 2010 when NY-BEST began, the state of the market in 2015, the outlook for NY-BEST and the overall market, as well as a verification of NY-BEST's industry and economic impacts. These analysis tasks resulted in four reports:1) a 2015 market characterization of the New York energy storage industry,[7] 2) an economic analysis of potential future market and economic impacts,[8] 3) a patent analysis, and 4) an impact evaluation of the NY-BEST Consortium since 2010 (this report).

This impact evaluation focuses on documenting the influence the NY-BEST Consortium has had through early 2016 on the energy storage market in New York State. This study examines NY-BEST's growth in relation to the broader energy storage market;[9] documents outcomes of projects that received awards through NY-BEST including improvements in Technology Readiness Levels (TRL); and assesses whether the program is meeting its definition of success (see Appendix B for map of logic model outcomes and indicators addressed in the evaluation questions and data sources).

1.1 Research Questions

Key research questions addressed in this report include:

1. What was the state of the energy storage market when NY-BEST launched in 2010?
2. In 2015, to what extent and in what ways was NY-BEST viewed as a domestic and/or international leader in supporting the energy storage industry? How had this changed, if at all, since 2010?
3. In 2015, how did the program stand relative to its definition of success?
4. As of 2015, what impact had the Battery and Energy Storage Technology Test and Commercialization Center (BTCC) and Battery Prototyping Center (BPC) had on NY-BEST members' organizations and technologies tested at the BTCC and BPC labs?
5. As of 2015, what were the outcomes of projects that received awards through NY-BEST?

[7] The market characterization and assessment is available on NYSERDA's website: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2017ContractorReports/Energy-Storage-NY-BEST-Market-Characterization-Report.pdf

[8] The economic analysis is available on NYSERDA's website: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2016ContractorReports/2016-10-energy-storage-industry-growth-projections-report.pdf

[9] Completed as part of this evaluation, the report NYSERDA Energy Storage and NY-BEST Program Market Characterization and Assessment describes the current state of the market in greater detail and The Energy Storage Industry in New York: Recent Growth and Projections, 2015 Update provides an updated economic forecast for projected energy storage market growth and historical perspective on changes since NY-BEST was formed.

1.2 Methods

The evaluators applied a mixed-methods design to address the research questions and gather metrics used to assess NY-BEST progress towards its goals. With the exception of soliciting high-level updates on NY-BEST operations, activities, and progress towards goals, all data used for this analysis was collected from January 2016 to June 2016. Quantitative and qualitative methods were used to triangulate findings and ensure the accuracy of the conclusions including:

- **Program data review** of membership, financial, event, and website records; annual reports; and NYSERDA-funded project progress reports
- **Secondary literature review** of market trend reports, energy storage policies, media sources, and a 2015 NY-BEST process evaluation, *NYSERDA NY-BEST Rapid-Feedback Process Evaluation*
- **In-depth interviews** (30-60 minutes each) with NYSERDA and NY-BEST staff, industry experts, and NY-BEST members and non-members.
- Incorporation of concurrent research reports:
    - A market characterization report: *NYSERDA Energy Storage and NY-BEST Program Market Characterization and Assessment (Finalized February 2017).*
    - An economic analysis: *The Energy Storage Industry in New York: Recent Growth and Projections, 2015 Update (Finalized September 2016).*
    - A patent analysis:[10] *An Analysis of the Technological Impact of NY-BEST Funded Energy Storage Research (Finalized June 2016).*

First, Table 1-1 provides a quick description of the methods used to address the research questions. Second,

Table 1-2 includes a summary of the interviewee groups and sample sizes. Appendix A includes a more detailed description of the methods and sample.

[10] The patent analysis traced the influence of NYSERDA-funded NY-BEST projects on other research and patents.

Table 1-1. Methods Used to Address Research Questions

Research Question	Program Data Review	Secondary Literature Review	In-Depth Interviews	Patent Analysis
1) What was the state of the energy storage market when NY-BEST launched in 2010?	X	X	X	
2) In 2015, to what extent and in what ways was NY-BEST viewed as a domestic and/or international leader in supporting the energy storage industry? How had this changed, if at all, since 2010?		X	X	
3) As of 2015, what were the outcomes of projects that received awards through NY-BEST?	X		X	X
4) In 2015, how did the program stand relative to its definition of success?	X		X	X
5) As of 2015, what impact had the Battery and Energy Storage Technology Test and Commercialization Center (BTCC) and Battery Prototyping Center (BPC) had on NY-BEST members' organizations and technologies tested at the BTCC and BPC labs?	X		X	

Table 1-2. Interviewee Groups and Sample Sizes

Interviewee Group	Number of Interviews
NYSERDA Program Manager	1
NY-BEST Staff	2
NY-BEST Member Organizations (N=151) Members with CAIR-funded projects (N=42) Members with no CAIR-funded project (N=109)	20 11 9
NY-BEST Non-Member Organizations	10
Energy Storage Industry Experts	5

2 Energy Storage Market Changes between 2010 and 2015

In considering the influence that the NY-BEST Consortium has had on the energy storage market in New York State, it is important to recognize the global nature of the energy storage market and acknowledge the global and national trends that influence the New York State market. Given that the report *NYSERDA Energy Storage and NY-BEST Program Market Characterization and Assessment* offers a more in-depth description of the current market, this section of the report provides a brief discussion of relevant market changes in which we situate the subsequent discussion of NY-BEST's influence on the market.

The energy storage market experienced substantial growth in the period from 2010 to 2015, as new technologies became available and awareness of these technologies increased. This growth was present in multiple sectors, including grid energy storage, transportation, and portable devices across global, national, and New York State markets (EMI Consulting 2017):

- New products (e.g., residential battery storage units by companies like Sonnen and Mercedes-Benz) entered the market, as did new versions of existing products (e.g., electric vehicles like the Tesla Model S).
- At the same time, novel storage technologies such as ultracapacitors and flow batteries had begun to attract more attention as possible competitors to more traditional battery technologies.
- Global grid storage market segment grew from roughly 125 GW in 2010 to roughly 185 GW (including planned projects, based on the DOE's Energy Storage Database) in 2015 (International Energy Agency 2014).
- The U.S. grid storage market grew from a valuation of $134M in 2014 to $432M in 2015. This corresponded to the addition of roughly 221 MW of utility-side grid storage in 2015 (Manghani 2016).
- From 2012 to 2015 the energy storage market in New York State experienced increase in revenues from $598M to $908M (estimated) and from 2,992 to 3,931 jobs (estimated).[11]

The energy storage market within New York State followed a growth pattern quite similar to the broader global market during the period 2010-2015. As described in the economic analysis report included as part of this study, the energy storage industry in New York State has steadily increased both in terms of revenue and employment since 2012, with revenues increasing from $598M in 2012 to $906M in 2015 (estimated).[12] Similarly, the State has experienced an increase in energy storage industry employment (estimated) from 2,992 jobs in 2012 to 3,931 jobs in 2015 (Industrial Economics Inc. 2016).

NY-BEST, formed in 2010, has played a positive role in developing the energy storage market within New York State during this time period. Evidence from interviews conducted as part of this research

[11] Employment and revenue data from 2010 was not available in a format that allowed for a direct comparison to later years.

[12] This report builds from the 2012 economic assessment report, *The Economic Impact of Developing and Energy Storage Industry in New York State,* which included revenues and projections for 2012 forward; 2010 revenues were not available.

suggest that NY-BEST is a highly-respected organization within the energy storage field and has helped promote policies and markets favorable to energy storage technologies within New York State.

2.1 Changes in Key Market Actors

While a comprehensive comparison of energy storage companies in 2010 and 2015 is not feasible, it is informative to note that many of the key players in 2010 remained key players in 2015 – and that many more players had joined the vendor landscape during this period, including a few corporations and a large number of startup companies (some of which grew rapidly). A list of many of the larger companies operating in the energy storage space is shown in Table 2-1, with those companies that were either founded or entered the energy storage market in 2010 or later in orange/bold letters.

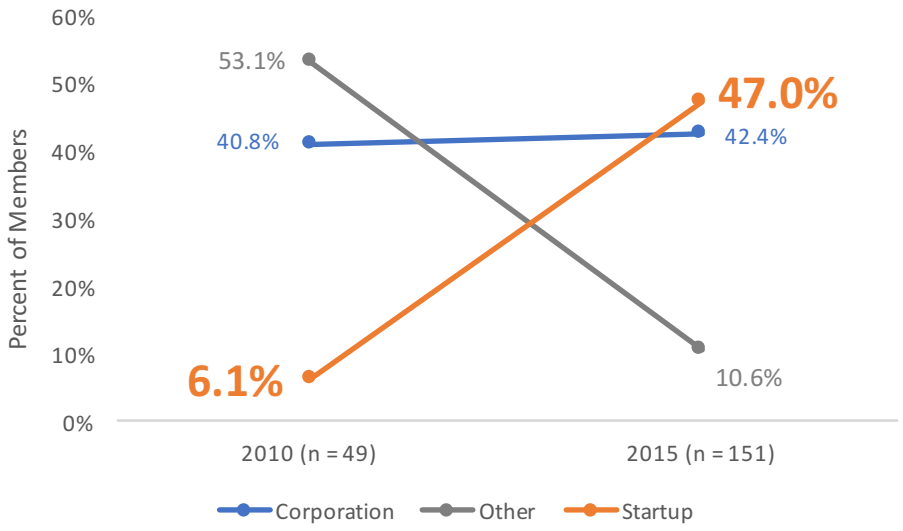
Table 2-1. Key Market Actors by Primary Focus (Partial List)

Components/Electronics		Systems/Integrators		Software
A123 Systems	OutBack Power	ABB	**Mercedes-Benz Energy ***	**1 Energy Systems**
ABB	Panasonic Sanyo	Abengoa/Abeinsa	NEC Corporation	ABB
AES *	Parker	**Advanced Microgrid Solutions**	NextEra Energy	AES *
Ashlawn Energy	Princeton Power Systems	AES *	NRG Energy *	Bosch
Blue Energy	S&C Electric Co.	Alevo	Parker	Enbala Power Networks *
Bosch	Saft	Beacon Power	**Powin Energy**	Green Charge
BYD	Samsung	Bosch	RES Americas	Greensmith
Dynapower	Schneider Electric	BYD	S&C Electric Co. *	OutBack Power
Eaton Corp.	SciEssence Intl.	ENEL	Saft	Stem, Inc.
GE *	Siemens	Engie	Sener	**Sunverge**
Gildemeister	**SK Energy**	**Exergonix/CODA Energy**	SHARP	Toshiba
GS Yuasa	SMA	Demand Energy	**Solar Grid Storage**	Viridity Energy
Hitachi	Sony	Kokam	**Sonnen Batterie**	Xtreme Power
Ingeteam	Toshiba	Korea Electric Power Corp.	Stem, Inc.	Younicos
Johnson Controls	**UniEnergy Technologies**	Green Charge	Storage Battery Systems	
Kokam	**Woojin Industrial Systems**	Greensmith	**Sunverge**	
LG Chem *	Younicos	Hitachi	TAS Energy	
Litec		**JLM Energy**	Tesla/SolarCity	
Lithium Energy Japan (LEJ)		**Johnson Controls**	Younicos	
NEC Energy Solutions		LG CNS *		
Nidec ASI		**Lockheed Martin ***		

Note: Orange/bold font indicates that a company was either founded or entered the energy storage business in 2010 or later. Asterisks denote NY-BEST membership as of 2015.

Focusing on New York State, a comparison of NY-BEST membership in 2010 with NY-BEST membership in 2015 provides a window into understanding the large increase in new market entrants. As shown in Figure 2-1, startup companies constituted a very small percentage of NY-BEST members in 2010 (6.1%), but grew to become the most common type of member in 2015 (47.0%).

Figure 2-1. Relative Comparison Between 2010 NY-BEST Membership and 2015 NY-BEST Membership



Overall, key developments in the United States included the following trends:

- **Increasing competitiveness of the vendor landscape.** Newer entrants like Tesla[13] have brought potentially disruptive products to the emerging behind-the-meter (BTM) residential and commercial energy storage market (e.g., the Powerwall) and transportation battery markets (e.g., electric vehicles like the Model S). At the same time, more established firms in adjacent industries began exploring energy storage as a new market opportunity. Industry leaders like Johnson Controls began developing internal energy storage divisions after a failed attempt to acquire the assets of failed energy storage company A123(Hoium 2015). Similarly, German company Daimler AG began offering its own version of a BTM battery unit to residential and commercial end users in 2015 (Beetz 2015).
- **A movement toward strategic alliances between companies focused on different aspects of energy storage.** Strategic alliances were formed between companies like Sonnen (which focuses on hardware) and Enbala (which produces utility-scale energy storage software) to enhance the connectivity and grid integration capabilities of battery units on the grid.
- **Established industry players turning their focus to the BTM residential and commercial grid storage segment.** Companies like Greensmith, whose core business has typically been in the front-of-the-meter (FOM) grid storage segment, and Sonnen, which has focused mostly on the residential BTM storage segment, began developing offerings aimed at the commercial BTM segment (Spector 2016).

[13] Tesla was founded in 2003, making it one of the youngest companies of its type (auto manufacturer and crossover battery storage developer).

Many of these trends were also present in New York State:

- **In the grid storage market segment, major international market actors turned their attention to energy storage.** GE (which has a presence in New York State) had been investing in energy storage since before 2010, and has continued that investment (Pyper 2016). Other major players include Johnson Controls and Siemens, both of which have multiple locations in New York State, increased their focus on energy storage over this time period.
- **Start-up companies focused on emerging battery chemistries submitted patent applications, many with the assistance of NYSERDA and NY-BEST.** Examples include:
    - Five patent applications submitted by Cerion Enterprises.
    - Four patent applications submitted by Paper Battery Company (including two that were awarded).
    - Three patent applications submitted by Custom Electronics Inc. and three applications submitted by Combined Energies.
    - Two patent applications submitted by Bettergy Corp.
    - One patent application submitted by General Motors and Cornell University, and one patent application submitted by Rensselaer Polytechnic Institute.

2.2 Changes in Technology, Demand, and Market Direction

As described by NY-BEST staff, energy storage in 2010, specifically batteries for commercial and residential grid storage, was considered an expensive novelty that could not be trusted to last 10 years or perform well. Energy storage-related companies were not mature enough to handle the technologies coming out of the universities. The conversation in 2010 among those outside the industry placed battery storage in the category of an "emerging technology." Furthermore, in 2010, there remained substantial uncertainty regarding exactly how grid storage technologies might be best connected to the grid (i.e., interconnection issues), who should pay for these technologies, and how utilities should consider storage in their long-term planning.

In 2015, energy storage was a rapidly-growing market in multiple segments, including grid storage and transportation, and has become an important topic as public concerns about the environmental impacts of energy consumption have become more common. While there are still outstanding questions regarding specific interconnection standards, ownership models, and planning considerations for energy storage technologies, research efforts during the period 2010-2015 were aimed at answering these questions.

Many of the most prominent changes in energy storage technologies between 2010-2015 were related to incremental efficiency and cost improvements, especially for battery technologies.[14] For example, electric vehicle battery prices had fallen 40% since 2010, making electric vehicles a much more attractive proposition for many consumers (Bloomberg New Energy Finance, n.d.).

[14] For more detailed information, please see the corresponding market characterization and assessment produced as part of this research.

These improvements in efficiency and cost led to a corresponding increase in demand for energy storage technologies in a range of contexts, including both grid-connected storage and transportation storage. To put this growth in perspective for grid-connected storage:

- The global pipeline for grid-connected storage contained about 900 megawatts (MW) expected to be commissioned in 2016, which would effectively double the global installed capacity of energy storage systems (excluding pumped storage hydropower) by 2017 (Pentland 2016).
- A report by Citigroup estimates that the global battery storage market (not including car batteries) will increase to 240 gigawatts (GW) by the year 2030. The bulk of this growth will come from lithium-ion (Li-ion) technologies (Citigroup 2015).

Similarly, a significant increase in demand is predicted for transportation batteries:

- Bloomberg New Energy Finance released a report in early 2016 that predicted sales of electric vehicles will hit 41M by 2040 (including battery EVs and plug-in hybrid EVs), representing over a third (35%) of new light duty vehicle sales. (Bloomberg New Energy Finance 2016).
- The market for electric bus batteries is also projected to grow substantially over the next decade. One recent report projects the global electric bus market growing to $30 billion in 2026, potentially making it the largest segment of the overall transportation battery market (Research and Markets 2016).

2.3 Changes in Policy

Globally, a number of policy changes took place between 2010 and 2015, most notably in countries like China, Germany and Australia, which have progressive policies toward energy storage technologies:

- China implemented several policies that will drive growth in the energy storage industry, and set ambitious renewables procurement targets.
    - In 2009-2010, China updated its national Renewable Energy Law to better align grid planning with renewable energy and energy storage resources. It also compelled Chinese utilities to purchase power from renewable sources, when possible (Popper, Hove, and Zhang 2012).
    - In 2011, the Chinese National Development and Reform Commission (NDRC) published its "Guiding Catalogue of Industrial Structure Development for 2011," which seeks to encourage the development of certain types of technologies. Several types of energy storage technologies were included in the "encouraged" section of the report (Popper, Hove, and Zhang 2012).
    - In 2014 and 2015, the City of Beijing enacted a number of policies promoting the adoption of EVs and the development of EV infrastructure (China Energy Storage Alliance 2015). As the country continues to develop and modernize, it is expected that China will have more than 10M electric vehicles on the road by 2020. China also has plans to install major grid storage projects in the next few years (Kempener and Borden 2015).

- Germany, which is recognized as a world leader in renewable energy implementation, continues to offer a subsidy for small-scale energy storage units that are integrated with solar PV. Renewable energy sources produce around 30% of all electricity consumed in Germany in 2015, and are set to increase to at least 80% of electricity consumption by 2050. Solar power and wind power will anchor this renewable energy production (Blume 2015).
- In Australia, state and local policies are supportive of energy storage deployments, in some part because Australia has a number of remote power-generation facilities that burn fossil fuels and are good candidates for solar generation with storage (GTM Research 2015).
    - Beginning in 2009, many provinces began offering feed-in tariffs to customers with PV solar and incentivizing the sale of solar power back to the grid. While many of these schemes have since been phased out, they helped promote the adoption of distributed solar resources, which in turn drove the need for distributed energy storage (Climate Council of Australia 2015).
    - In 2014, the Australian Energy Market Commission issued a ruling requiring electricity network companies to introduce tariffs that vary based on when and how customers use power (similar to how some U.S. utilities have introduced time-of-use rates) (Australian Energy Market Commission, n.d.).
- In the United States, several key policies began reducing regulatory uncertainty around the value determination of energy storage assets on the grid.
    - In 2011, the Federal Energy Regulatory Commission (FERC) issued Order 755, which required regional transmission operators (RTOs) and Independent System Operators (ISOs) to consider the response speed of resources used for frequency regulation resources (rather than only considering the capacity). This order made energy storage assets (which are typically fast-acting) increasingly attractive from a financial and accounting perspective (Wesoff and GreenTech Media 2013).
    - In 2013, FERC Order 784 further increased the financial appeal of energy storage technologies by allowing them to compete more directly with non-storage alternatives such as generators in wholesale markets.
    - Between 2011 and 2014, at least 10 states introduced legislative bills tied to energy storage, though not all of them have passed (NREL 2014).
- In the United States transportation sector, it was predicted as early as 2010 that electric vehicles would become an increasingly important technology, and that the production of lithium-ion batteries would be a critical piece of the EV value chain. As of 2010, the U.S. had only a minimal share of the production of lithium-ion batteries (Lowe et al. 2010).

New York State is home to a number of researchers and companies participating in the global energy storage supply chain, mainly at the systems integration and deployment level. The State implemented several major statewide policy changes between 2010 and 2015, including:

- **Reforming the Energy Vision (REV).**[15] This major market transformation initiative put forth by the Public Service Commission in 2014 aims to attain the following clean energy goals: (New York State 2016)
    - 40% reduction in greenhouse gas emissions from 1990 levels
    - 50% of energy generation from renewable energy sources
    - 600 trillion Btu increase in statewide energy efficiency (New York State 2015).
- **New York State Clean Energy Fund.** In January of 2016, the New York State Public Service Commission approved a 10-year, $5 billion fund to accelerate the growth of New York's clean energy economy. The fund is designed to attract third-party capital to support the Governor's aggressive Clean Energy Standard, one of the nation's most ambitious goals to meet 50 percent of New York's electricity needs with renewable resources by 2030.

Legislative developments like these positioned New York State as one of the most progressive states in terms of aligning energy storage and state policy, along with states like California and Hawaii, although many of the mechanisms under these policies by which energy storage may be compensated are still being formulated.[16]

[15] Description of Reforming the Energy Vision and links to documents related to its proceedings can be found here: http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument

[16] See NYSERDA Energy Storage and NY-BEST Program Market Characterization and Assessment for full description of current California and Hawaii policies.

3 NY-BEST Development

In this section, we discuss NY-BEST as an organization, and how it developed from 2010 to 2015. Specifically, we discuss NY-BEST membership trends and finances, NY-BEST's relationship with non-member organizations, and the status of NY-BEST projects in 2015. This section is intentionally descriptive; we discuss the influence of these developments in Section 6 (also see Figure 3-1).

3.1 NY-BEST Membership Trends

An analysis of program data shows that since 2010, NY-BEST membership has grown and most NY-BEST members have renewed their membership. We note the following trends and distributional information regarding membership, retention, location, and sector focus of NY-BEST members (also shown in Figure 3-1):

- **Membership**: Membership steadily increased from February 2010 to February 2016. The consortium has more than tripled its membership during this time period (from 49 member organizations to 151 member organizations). This corresponds to an average increase of about 20 members per year from 2010 to 2015.
- **Retention**: The NY-BEST member retention rate was reported as 100% in the 2010-11 Clean Air Interstate Rule (CAIR) report, which marked the first report following the consortium's first full year of operation. According to the 2013-14 annual CAIR report, there was a 25% increase in membership outside of NY State since the previous reporting period (2012-2013).[17] Also in the 2013-14 report, the retention rate was 82%. The non-retention was "primarily reflecting startup companies discontinuing operations and service providers not renewing" (p. 3). As one interviewee (a NY-BEST member) indicated, it is important to note that when start-ups shut down, the staff are likely to move to other energy storage-related companies, not leave the field entirely. Thus this retention rate should not be interpreted solely as a reflection on interest in NY-BEST but also as the result of market actors exiting the market altogether.
- **Location**: As of February 2016, 60.3% of NY-BEST member organizations were in NY State (n = 91), 34.4% were outside of NY State (n = 52), and 5.3% were outside the US (n = 8).
- **Sector focus:** Most NY-BEST members focused on grid storage (62.6%, n = 92) and transportation (25.9%, n = 38). Others focused on defense/military/government (15.6%, n = 23) and portable electronics (15.0%, n = 22). In addition, about 20% of members represented other sectors such as health/medical, law practice, professional services, and public safety. Four NY-BEST members did not report their sector.
- **Type of Organization:** Most NY-BEST members were start-up organizations (47.0%, n =71) and corporate organizations (42.4%, n = 64), followed by 10.6% of members representing academic, government, or non-profit organizations (n = 16).
- **Size of Organization:** Many NY-BEST member organizations were relatively small companies with 50 staff members or fewer (55.6%, n = 69). In addition, 21.8% of members

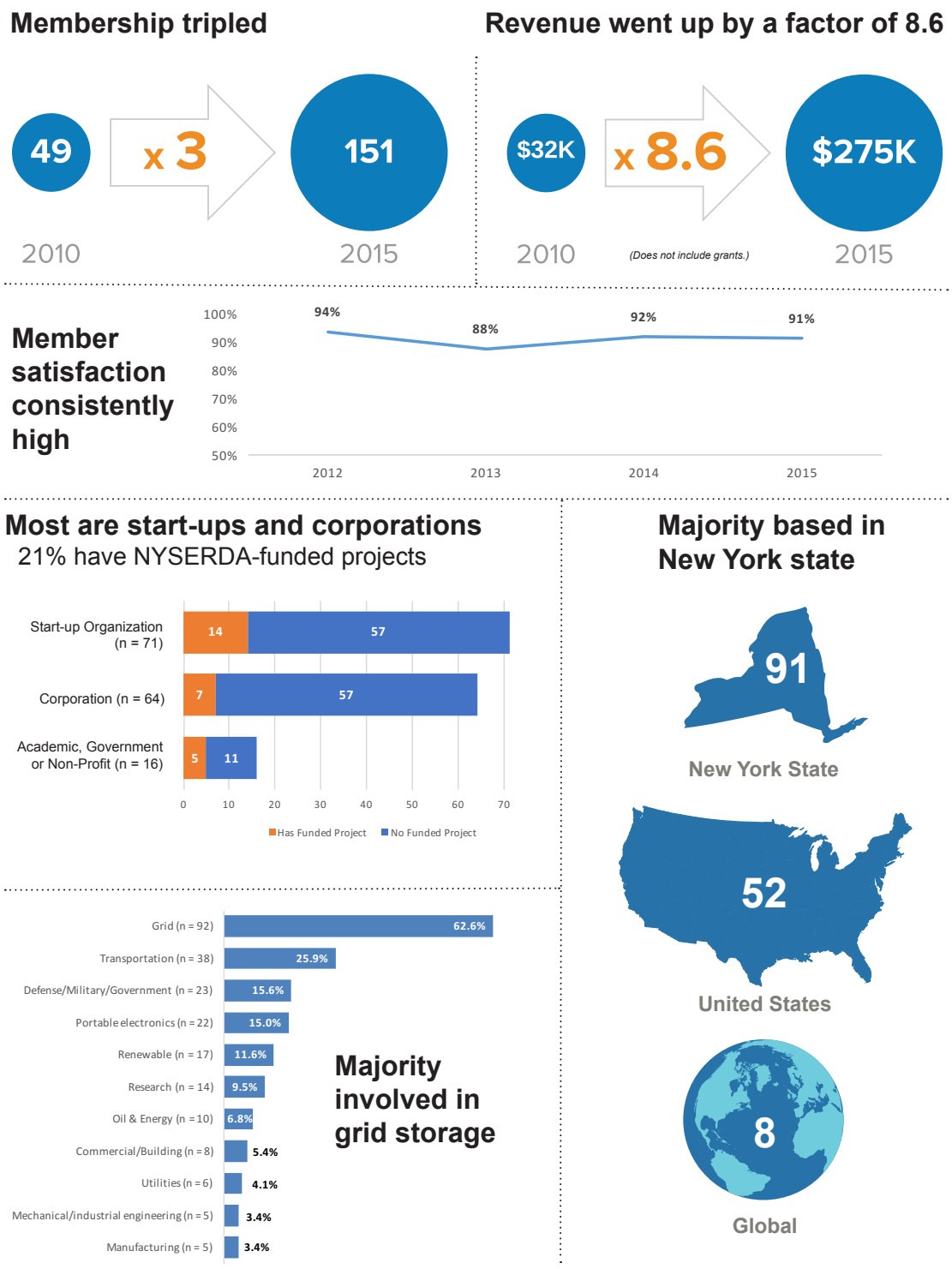
[17] Retention data was not available for the period between 2011 and 2013.

were staffed with 51 to 500 employees (n = 27), and 22.6% with more than 500 employees (n = 28). Twenty-seven members did not report their staffing.

- **Members with NYSERDA-funded R&D Projects:** 32 member organizations (21.2%) had at least one NYSERDA-funded R&D project.[18]
- **Satisfaction with Membership:** According to the NY-BEST Annual Member Survey, from 2012 to 2015, members consistently were either very satisfied or satisfied with their membership, as shown above in Figure 3-1.This complements results from the 2015 Process Evaluation, suggesting that members would recommend NY-BEST to a colleague: 37 out 43 (86%) who responded to the question marked an 8-10 of likelihood of recommending NY-BEST (9 out of the 13 developers and 28 out of the 30 implementers).

[18] Six organizations awarded NYSERDA funds in the past are no longer members—they do not show up in the current NY-BEST member list: Cerion Enterprises, General Motors, Impact Technologies, Ioxus, and Stony Brook University

Figure 3-1. NY-BEST Membership and Revenue Trends, 2010-2015



3.2 NY-BEST Finances

In its first two years of existence, NY-BEST experienced an early period of rapid growth, both in terms of revenue and expenses, a trend which remained positive but leveled out through year-end 2015. From 2011-2015, the consortium's total revenues (including grant money) showed a consistently positive trend, increasing at an average year-over-year rate of 155%. As shown in Table 3-1, the bulk of the total revenue came from grants (particularly in 2013 and 2014, which included funding for the BTCC), and as should be expected, NY-BEST incurred increasing expenses over this time period to accommodate the increase in revenues. The consortium also increased its *non-grant* revenues by a year-over-year average of 65%. This is a positive finding, as it suggests that the services it offered stimulated interest in the market (both in terms of membership value and registration fees/sponsorship). However, without grant money, NY-BEST would have likely had to curtail its expenses accordingly and, in particular, curtailed its work with startup companies and economic development (sector building) – in the case of startup companies because the firm is less likely to have the financial resources to fully compensate for this work and in the case of economic development because an individual member firm would unlikely benefit directly from this work.

The proportion of NY-BEST revenue from membership dues and fees decreased from 2010 through 2014, and then increased again in 2015 (see Table 3-1). According to the audited financials in December 31, 2010, membership dues represented 27.7% of total revenue; this number had decreased to 2.3% in December 31, 2014. This drop in percentage was due to an increase in total revenue from other sources over time, because the total value of membership dues and fees since December 31, 2010 steadily increased from $31,000 to $123,833 in December 31, 2014. In 2015, the proportion of dues from members increased to 12.2%. This appears to have been influenced more by the decrease in grant money in 2015 than to an increase in membership dues.

Table 3-1. NY-BEST Revenues

	Dec 31 2010	Dec 31 2011	Dec 31 2012	Dec 31 2013[19]	Dec 31 2014[20]	Dec 31 2015[21]
Total Revenue	$111,845	$724,966	$1,067,174	$2,060,039	$5,500,407	$1,079,966
Membership dues and fees	$31,000	$57,000	$88,332	$106,288	$123,833	$131,750
Proportion of dues from members	27.72%	7.86%	8.28%	5.16%	2.25%	12.2%
Grants	$79,554	$641,098	$899,726	$1,821,233	$5,191,094	$154,786
Registration Fees and Sponsorship	$850	$25,890	$79,116	$132,518	$185,480	$143,109

NY-BEST total expenses increased greatly from 2010 to 2011, and have remained relatively constant since 2012. Similarly, net assets have increased accordingly each year. There was a substantial jump in net assets in 2014, representing a multi-million dollar grant received from NYSERDA that year. NY-BEST expenses and net assets are shown below in Table 3-2.

[19] Revenue in 2013 included funding for the Battery Testing and Commercialization Center.

[20] Revenue in 2014 included funding for the Battery Testing and Commercialization Center.

[21] Audited financial statements were used for the years 2010 through 2014 (inclusive). Audited financials were not available for 2015 at the time this report was written, thus unaudited financial information was used instead.

Table 3-2. NY-BEST Expenses and Net Assets

	Dec 31 2010	Dec 31 2011	Dec 31 2012	Dec 31 2013	Dec 31 2014	Dec 31 2015[22]
Total Expenses	$81,833	$714,451	$951,289	$1,033,471	$956,700	$995,786
Net Assets End of Year	$30,312	$40,527	$156,412	$1,182,980	$5,726,687	$5,736,862
Increase in Net Assets	$30,312	$10,515	$115,885	$1,026,568	$4,543,707	$10,174

3.3 Relationship with Non-Member Organizations

During the period 2010-2015, NY-BEST maintained relationships with energy storage-related organizations that are not members, including companies, industry associations, and government agencies. For example, non-members could receive a version of the newsletter and were allowed to attend NY-BEST events. The evaluation team documented overlapping membership between various industry associations such as the Energy Storage Association (ESA) or California Energy Storage Association (CESA), suggesting there may be benefits for companies operating in multiple jurisdictions to join more than one association. Finally, there was recognition that government agencies (including national labs) were important partners in the advancement of energy storage technologies and markets in the U.S.

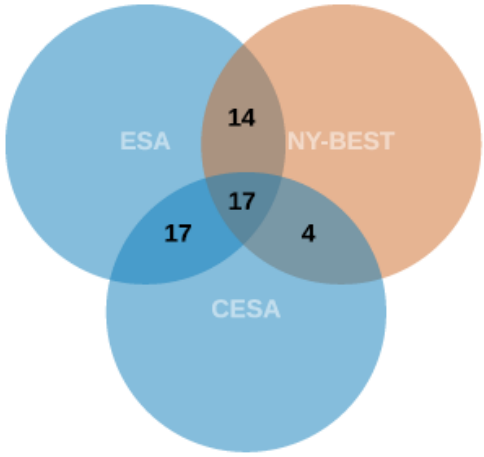
In the evaluation team's assessment, the various industry associations working within the U.S. have targeted slightly different niches within the broader industry. As one interviewee explained:

"The [U.S. Department of Energy] labs are still clearly the leaders in identifying which areas of research testing are necessary. Sandia Labs is working with a group of industry practitioners from across the board in order to work out standards and codes, and to [work] with first responders. At the state levels, NYSERDA & NY-BEST are clearly important examples of both a source and driver of the industry. The California Energy Commission has purse strings, and policies are being set for procurement at the PUC."

It is important for NY-BEST and its members to connect with other national leaders in energy storage to promote consistent energy storage policies and industry standards. Members, non-members, and experts interviewed as part of this study did not mention any difficulties associated with working with other, non-member organizations (such as ESA or CESA). Instead, it appears that that there is substantial overlap in membership among several of the organizations. For example, the evaluation team identified at least 17 organizations that were members of NY-BEST, ESA, and CESA (see Figure 3-2). There were also 14 organizations with membership in both NY-BEST and ESA, and four organizations with membership in both NY-BEST and CESA. The evaluation team interpreted this overlap to mean that members find value in the different agendas addressed by the three organizations.

[22] Ibid.

Figure 3-2. Overlapping 2015 Membership Between ESA, CESA, and NY-BEST



4 Results of NYSERDA-Funded NY-BEST Member Projects

In this section, we provide a brief history of NYSERDA's funding objectives, and discuss the outcomes of NYSERDA-funded NY-BEST member projects.

4.1 History of Funding Projects – Objectives, Changes in Funding Priorities

When NYSERDA decided to expand its focus in Energy Storage to help establish the NY-BEST Consortium, NYSERDA held a series of stakeholder meetings to establish priorities. The results of those meetings included three main priorities, to provide: (1) access to testing facilities, (2) research and development funding, and (3) consortium services to foster growth in the battery storage sector in New York State, including economic development and job growth. NY-BEST's role was to provide these consortium services, notify members about funding opportunities, and promote the testing center to its members. In addition to providing funding through Program Opportunities Notices (PONs), NYSERDA maintained a program management role to support consortium operations and management of testing facilities.

4.2 Status of NY-BEST Projects in 2015

In this section, we discuss the status of NYSERDA-funded NY-BEST R&D projects using data obtained from annual Clean Air Interstate Rule (CAIR) reports submitted by NY-BEST and from data constituting NYSERDA's metrics tracking database.

Annual CAIR reports from 2011 to 2014 and program tracking data provided information on NYSERDA-funded NY-BEST R&D projects:

- **Number of Projects:** There were a total of 56 NYSERDA-funded NY-BEST R&D award contracts dating back to 2010. However, three awards were terminated (because they did not show commercial promise or because key partners withdrew) and three other projects were still in process (i.e., they are not applicable for metrics analysis) as of 2015. Thus, as of 2015 there were a total of 42 organizations that had 50 projects with funds distributed: 20 projects were still ongoing, 22 were complete, and 8 projects were in the process of executing or undergoing contract negotiation. One project closed after failing to show adequate performance improvements while another project was never fully executed.[23] Table 4-1 below summarizes the project status by PON. The three terminated awards fell under PON 2458.

[23] One project investigating advanced separator technologies by Hollingsworth & Vose, Co., was terminated due to lack of performance improvements. One other project was never fully executed.

Table 4-1. NYSERDA-funded NY-BEST R&D Projects

	Total Number of Organizations with Projects	Total Number of Projects	Number of Ongoing Projects	Number of Closed Projects	Number of Projects Not Yet Executed	Amount of Funding Distributed	Amount of Company Co-funding
PON 1704 (March 2010)	14	16	3	13	--	$5,168,527	$6,662,351
PON 2458 (July 2012 to March 2015)	28	34	17	9	8	$8,282,166	$10,744,323
Total	42	50	20	22	8	$13,450,693	$17,406,674

- **Investment in Sector:** In the 2013-2014 Annual CAIR report, 30% of funded projects focused on grid storage, 32% on transportation storage, and 15% on other types (the remaining 23% did not specify a focus). Using the 2016 NY-BEST membership list to categorize the sectors of companies with projects through early 2016, 44% of companies focused on grid storage, 32% on transportation storage, and 28% on other types.[24] A more detailed characterization of the member organizations was not possible using the data available.
- **Follow-on Funding:** At least 21 NYSERDA-funded R&D projects had received follow-on funding (42% of projects with funds distributed) totaling to at least $74M.
- **Number of Conference Presentations:** Among the 50 projects, 64% presented during at least one conference (N = 32) totaling out to at least 133 conference presentations.

4.3 Technology Readiness Level Advancement Trends

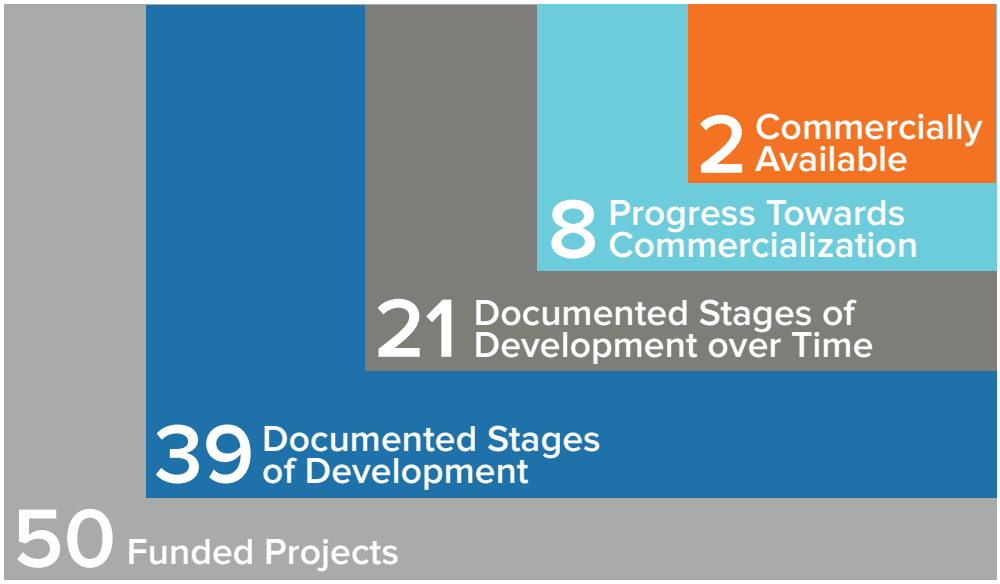
Some NYSERDA-funded NY-BEST projects have demonstrated advances in commercialization, though a large number have not (according to program data). More specifically:

- Out of all 50 projects, 39 projects had information on their stage of development, and 21 of the 39 had information on the stages of development over time.
- In particular, 8 of these 21 projects (38%) indicated commercialization progress (e.g., proof of concept stage in 2014 and initial prototype stage in 2015).
- Of these 21 projects, 2 projects (9.5%) indicated that their product was commercially available.

These numbers are depicted graphically in Figure 4-1.

[24] It is important to note that companies from the member list could represent multiple sectors—they are not mutually exclusive categories—and the sector reported is at the company level, not the project level.

Figure 4-1. Technology Readiness Level Advancement Trends Among NYSERDA-Funded NY-BEST Projects



Four members interviewed as part of this research indicated that NY-BEST played an important role in allowing technologies to advance their TRLs, specifically through the availability of the BPC and BTCC facilities.

- As one member explained: “Thankfully [the BTCC] is there now because the early stages of manufacturing are difficult. This is a critical step in taking the technologies from small startups and giving them a platform. I know two companies and research groups who have benefited from the center already."
- Another member stated that "… NY-BEST helps to fund [us] and provide us support that allowed us to make an extra step towards commercialization of one project line that would have been difficult for me to get financing for from investors. So we would probably be behind in the development stage of our product line without NY-BEST."

4.4 Influence on Other Research and Development

As part of this impact evaluation, a patent analysis was performed to evaluate the technological impact of energy storage research funded by NY-BEST since the program was established (1790 Analytics 2016). This analysis was based primarily on locating scholarly outputs – including patents, scientific journal articles and conference papers – resulting from each of the 50 NY-BEST funded research projects. As part of this analysis, a “forward citation trace” was run on each of these scholarly outputs to determine how frequently they had been cited as prior art (evidence that a similar technology has already been developed or at least described) by subsequent U.S. patents. The number of subsequent citations thus serves as a proxy for the impact that each scholarly output has had on the field. A main conclusion of the analysis is that there is evidence of NY-BEST funded projects influencing developments across a range of energy storage technologies, and that this level of influence will likely increase with time. Key findings from the patent analysis include the following:

- In total, scholarly outputs associated with the 50 NY-BEST funded research projects had been cited as prior art by 140 granted US patents.
- 18 out of the 42 NY-BEST funding recipients had scholarly outputs that have been cited as prior art by at least one subsequent US patent. A small number of organizations had received the bulk of these citations, with the highest number received by CUNY/Columbia (27 citations), Widetronix (23), Hollingsworth & Vose (19), Brookhaven (18), and Eos Energy Storage (16).
- The total citation counts to NY-BEST-funded projects were quite low, particularly for projects funded more recently. However, this mainly indicates that there has not been much time for scholarly outputs resulting from these projects to be referenced by subsequent patents.
- Overall, the results of the analysis show promising signs with regard to the technological impact of the NY-BEST funding program, especially given its relatively recent establishment. Scholarly outputs associated with a number of the projects funded by NY-BEST have been referenced by numerous US patents describing a variety of energy storage technologies. These references can be expected to increase in future years, as more time is available for NY-BEST outputs to be cited.

5 Overview of NY-BEST Indicators of Success

In this section we discuss the ways in which NY-BEST has *intended* to influence the market as described in the logic model developed for this program.[25] We also describe the indicators used to estimate NY-BEST's influence on the market. A copy of the logic model in its entirety is shown below as Figure 5-1.

5.1 Overview of NY-BEST Logic Model

The activities in the logic model can be broken into two categories:

- **Information and recruitment activities,**[26] including distributing information and building membership, hosting conferences and webinars, providing targeted introductions, and providing business support.
- **Technology commercialization,** including promoting and distributing project funding opportunities, providing testing and prototyping capabilities, and promoting policies that support energy storage.

The activities described above are intended to accomplish the several short-, medium-, and long-term outcomes specified in the logic model.[27]

In the short-term, NY-BEST expects to find the following: the information it provides is valued and shared; productive collaborations and partnerships form as a result of facilitated introductions; members' business strategies and product pitches improve; and both members' and non-members' satisfaction with NY-BEST offerings increases. In the broader market, NY-BEST expects to support high-quality, targeted R&D that accelerates development of energy storage solutions, to see energy storage technologies proven in the State, and to make sure policy makers and the public support the energy storage industry.

In the medium-term, NY-BEST expects to evolve into a self-sustaining organization through membership dues, testing, grants and contracts, and fees for events. In the broader market, NY-BEST expects to connect outside investors to NY-BEST members to provide follow-on funding, help energy storage technologies reach commercialization in New York State, and reduce regulatory barriers to energy storage.

In the long-term, NY-BEST efforts to commercialize energy storage technologies are expected to help reduce fossil fuel emissions, contribute to developing a thriving cluster of energy storage researchers and companies in the State, evidenced by an increase in the number of researchers and companies along the energy storage value chain with maturing technologies and increasing sales.[28] This cluster of

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[25] The logic model shows how a program's activities result in immediate outputs and lead to short-, medium-, and long-term outcomes.

[26] It is important to note that activities in each category are not executed independently, but rather are coordinated efforts intended to complement one another. Activities and associated outputs through early 2016 are described in the figures below.

[27] For more details, please see EMI Consulting, Inc.'s "NY-BEST Program Theory and Logic Model Report."

[28] Per the NY-BEST goals described in the *NY-BEST Program Theory and Logic Model,* and in alignment with energy storage goals set forth in the *New York Energy Storage Roadmap* (2012), NY-BEST seeks to "create value chain clusters of companies comprised of suppliers, material and component manufacturers, system integrators, and

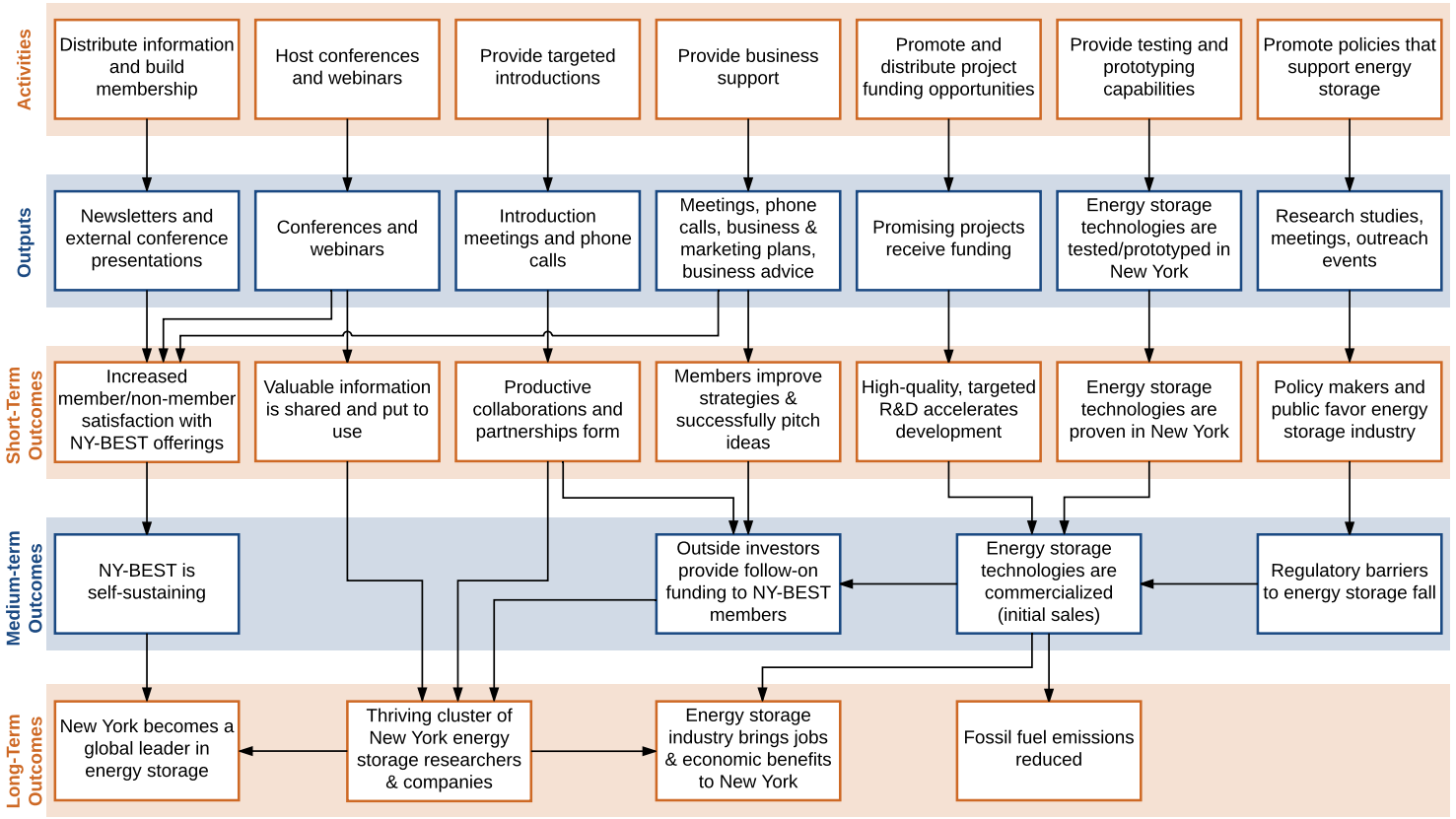
organizations will provide jobs and economic benefits, and encourage others to view the State as a global leader in energy storage.

In the rest of this section we describe indicators that can be used to track progress toward each of the short-, medium-, and long-term outcomes shown in the logic model.

product manufacturers to provide the manufacturing capabilities necessary to grow the sector in New York State and support global markets."

Figure 5-1. NY-BEST Logic Model

Resources/Inputs:
CAIR/NYSERDA funding, other public funding, NYSERDA staff, NY-BEST operations staff, private sector investors, energy storage researchers, universities, trade associations, and intangible resources



External Influences:
Economic conditions, other energy models, utility support, global energy storage development

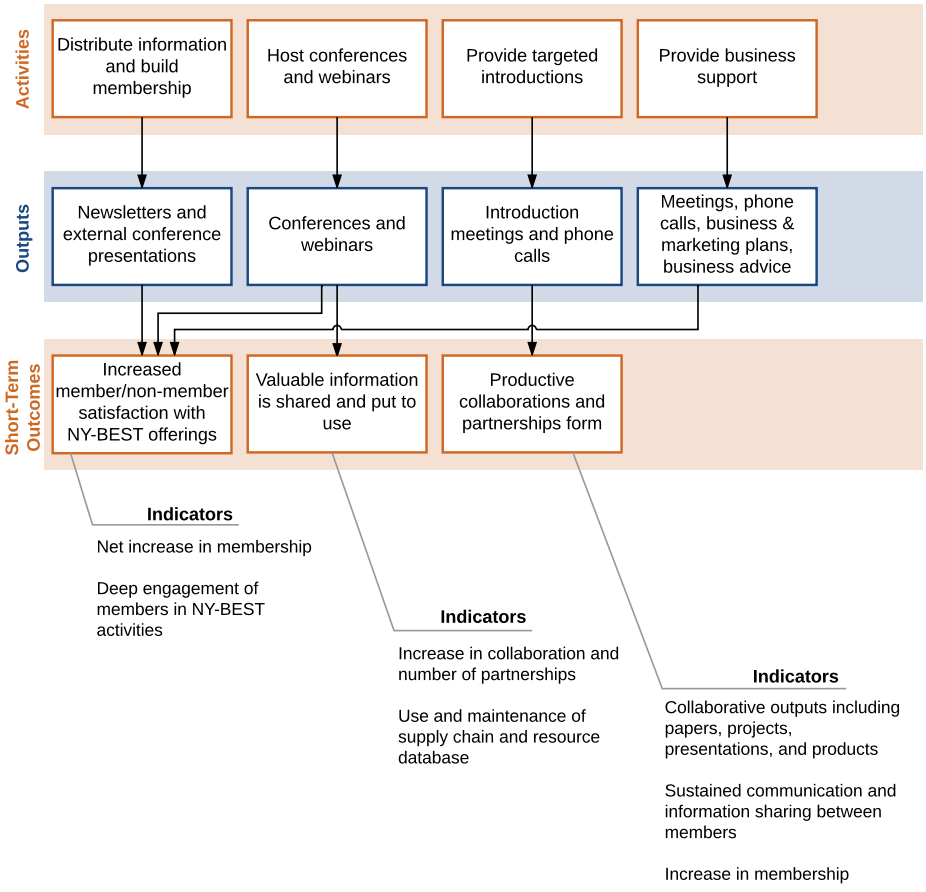
5.2 Logic Model Indicators That Were Measurable in the 2015 Energy Storage Market

Descriptions of measurable indicators for short-, medium-, and long-term outcomes are included in this section. The long-term outcome "Fossil fuel emissions reduced" was not yet measurable given that most projects were not yet deployed and technologies were not yet commercialized by the end of 2015.

5.2.1 Short-Term Outcomes Related to Information and Recruitment Activities

Short-term outcomes related to information and recruitment activities include: (1) increased member and non-member satisfaction with NY-BEST offerings, (2) valuable information being shared and put to use, and (3) the formation of productive collaborations and partnerships. The indicators for these short-term outcomes are shown in Figure 5-2.

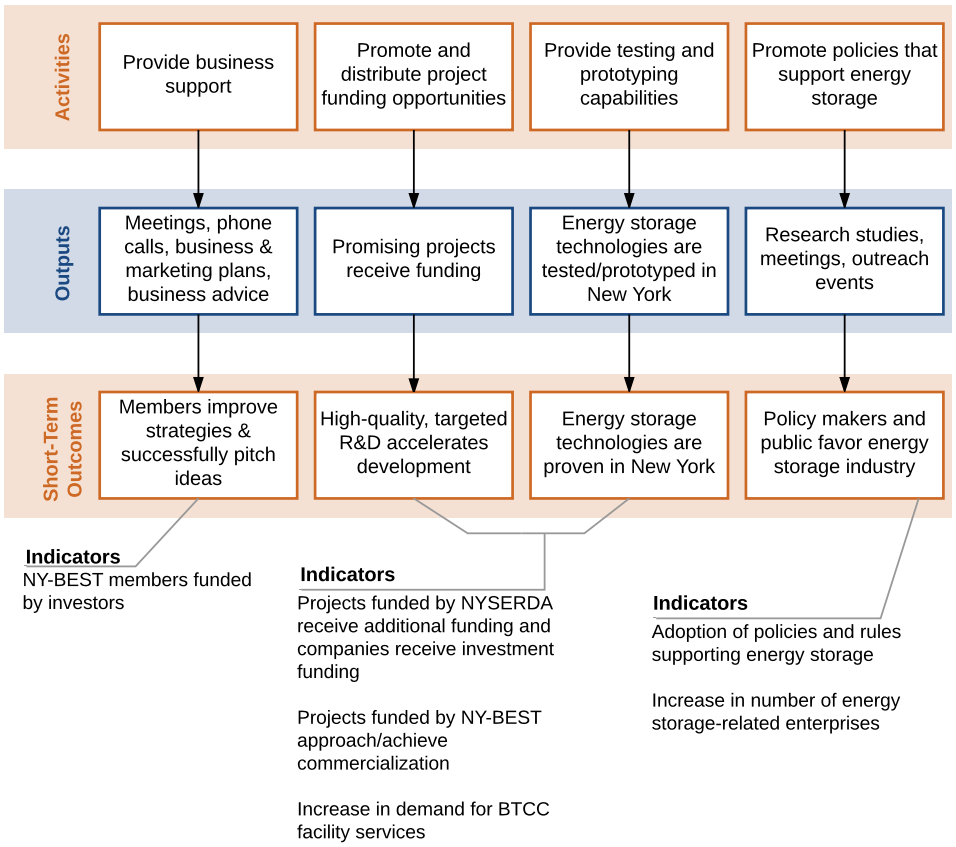
Figure 5-2. Indicators for Short-Term Outcomes Related to Information and Recruitment Activities



5.2.2 Short-Term Outcomes Related to Technology Commercialization Activities[29]

Short-term outcomes related to technology commercialization activities include: (1) members improving business strategies and successfully pitching ideas to investors, (2) the development of technologies resulting from targeted R&D, (3) energy storage technologies are proven in New York State, and (4) policy makers and the public favor the energy storage industry. The indicators for these short-term outcomes are shown below in Figure 5-3.

Figure 5-3. Indicators for Short-Term Outcomes Related to Technology Commercialization Activities

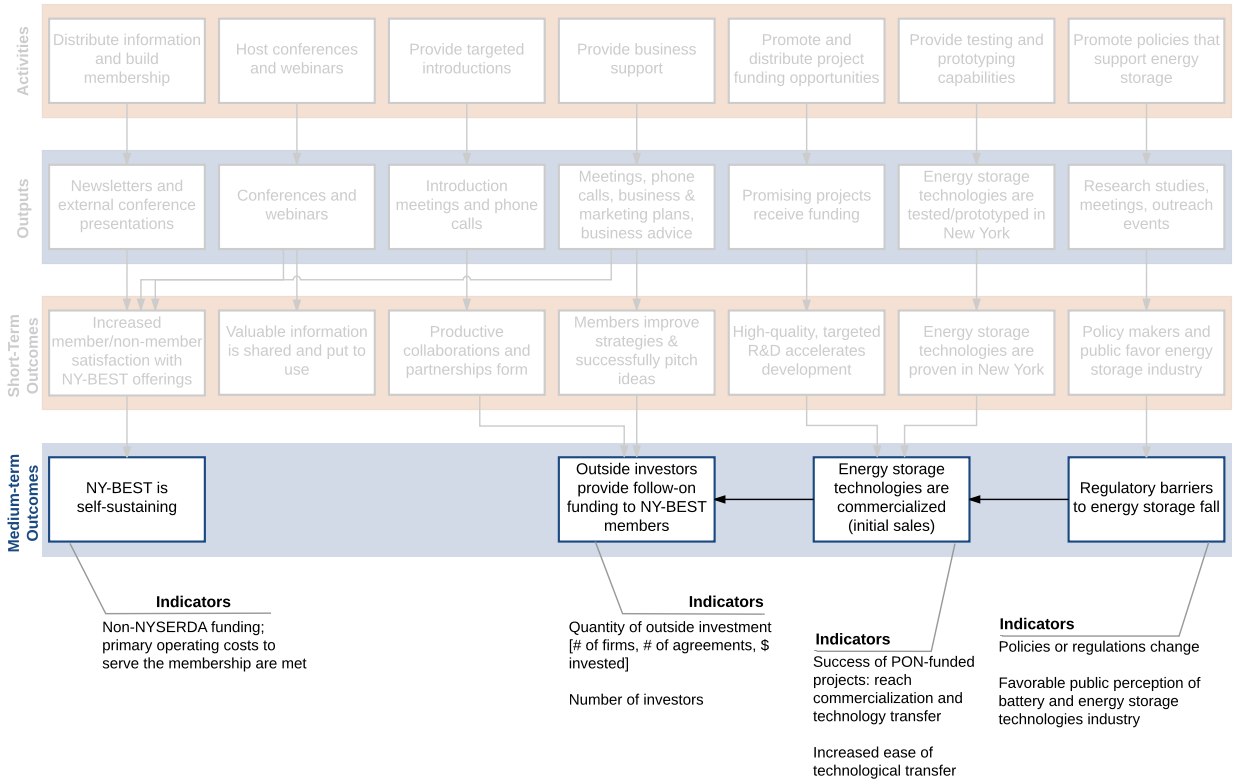


[29] In a future logic model version, outcome descriptions may be further clarified. Specifically, the node "policy makers and public favor energy storage" may be better represented with language that acknowledges awareness as well as positive views towards energy storage.

5.2.3 Medium-term Outcomes

Expected medium-term outcomes of NY-BEST activities include: (1) that NY-BEST will eventually become self-sustaining (financially), (2) outside investors provide follow-on funding to NY-BEST members' projects, (3) energy storage technologies become commercially available, and (4) regulatory barriers to energy storage are removed. The indicators for these medium-term outcomes are shown in Figure 5-4.

Figure 5-4. Indicators for Medium-term Outcomes[30]

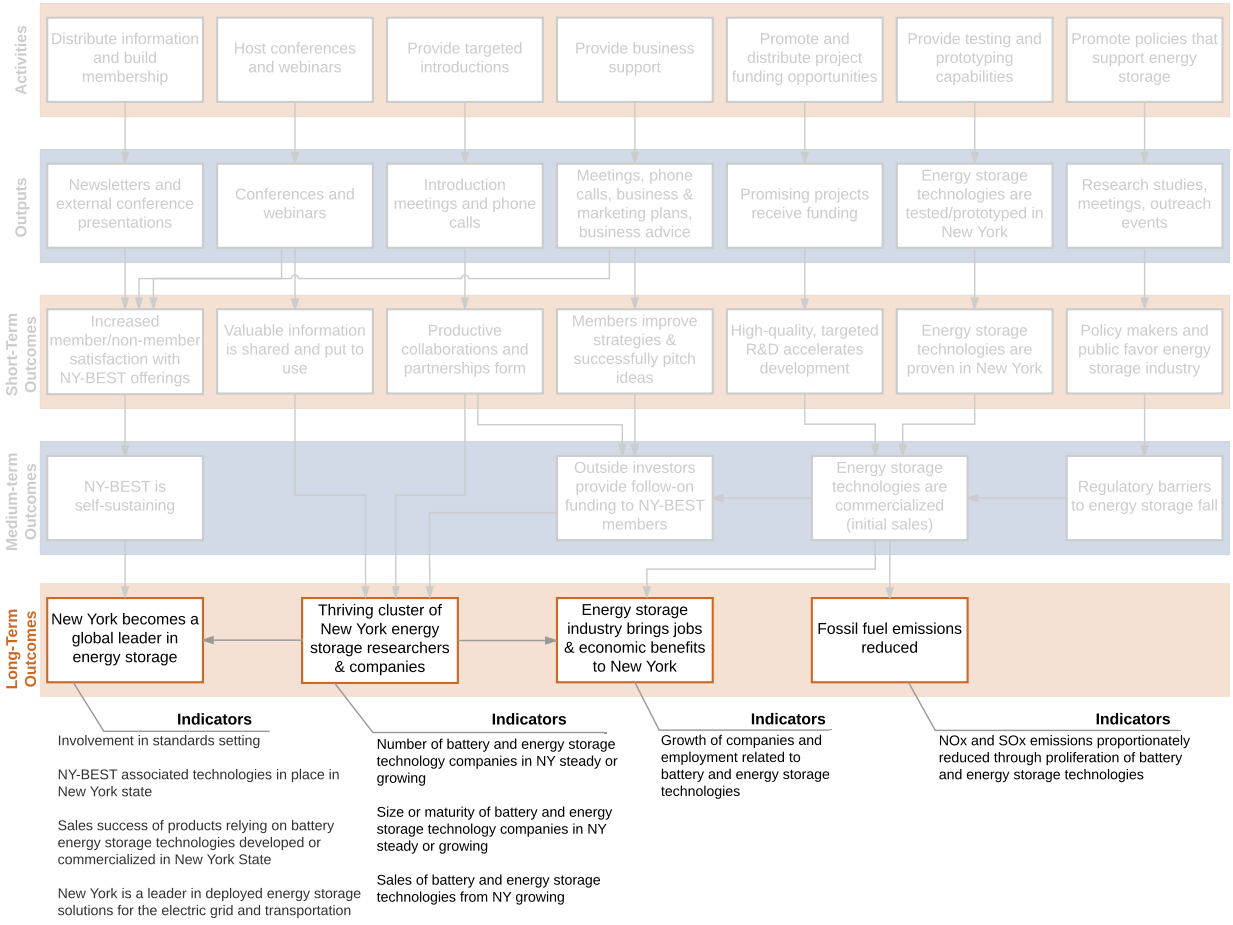


[30] In a future logic model version, outcome descriptions may be further clarified. Specifically, the node "regulatory barriers to energy storage fall" could be changed to focus on policies and regulations that allow storage deployment.

5.2.4 Long-Term Outcomes

Expected long-term outcomes of NY-BEST activities include: (1) New York State becomes a global leader in energy storage, (2) a thriving cluster of energy storage researchers and companies forms in New York State, (3) the energy storage industry brings jobs and economic benefits to New York State, and (4) fossil fuel emissions are reduced. The indicators for these long-term outcomes are shown in Figure 5-5.

Figure 5-5. Indicators for Long-Term Outcomes



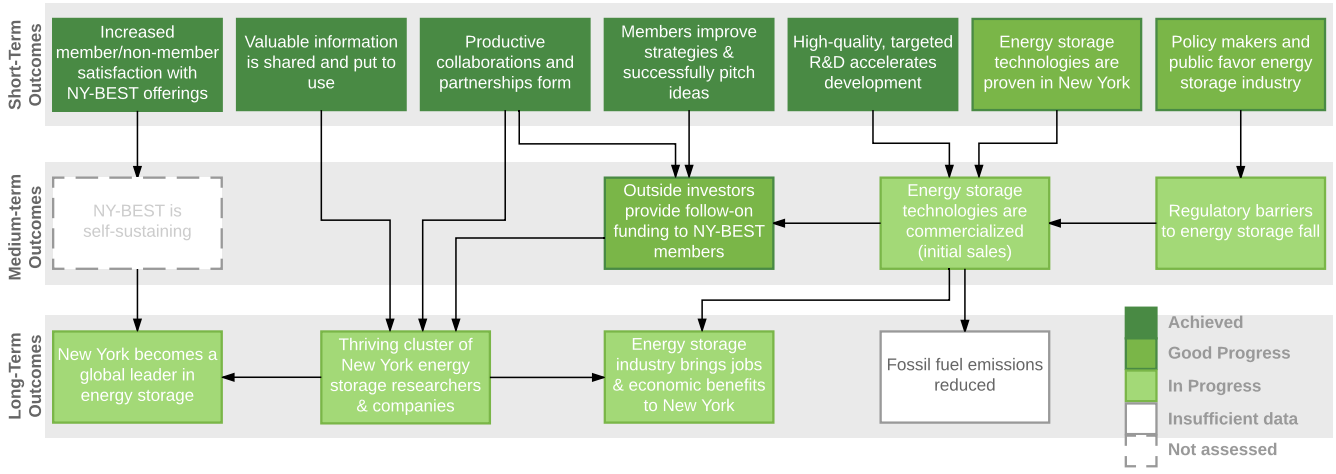
6 Progress Toward Short-Term, Medium-term, and Long-Term Outcomes

The NY-BEST Consortium was created in 2010 to:

- Serve as an expert resource to energy storage-related companies and organizations
- Facilitate financing for new ventures
- Enhance research capabilities
- Act as a connector in establishing a strong energy storage economy within the State.

As summarized in Figure 6-1, by 2015 NY-BEST had achieved or made progress toward all of the short-term outcomes included in the program logic model. The consortium had also made progress on the medium-term and long-term outcomes, though it will be some time before these can be fully assessed. Among the medium-term outcomes represented in the program logic model, good progress was made toward obtaining outside follow-on funding to NY-BEST members. The consortium is currently helping energy storage companies work to commercialize new energy storage technologies, and it continues to work with policy makers and stakeholder groups to mitigate regulatory barriers to energy storage. NY-BEST had also made progress toward long-term outcomes. However, these outcomes will need to be tracked over a longer period of time to assess how well they are achieved.

Figure 6-1. NY-BEST Progress Toward Logic Model Goals[31]



The following points summarize the main types of progress towards short- and medium-term goals in 2015:

- The evaluation team found that NY-BEST was recognized by the industry experts and NY-BEST members interviewed for this study as an advocate for advancing battery and energy

[31] In a future logic model version, outcome descriptions may be further clarified. Specifically, the node "policy makers and public favor energy storage" may be better represented with language that acknowledges awareness as well as positive views towards energy storage. The node "regulatory barriers to energy storage fall" could be changed to focus on policies and regulations that allow storage deployment.

storage markets within the United States, primarily in the area of grid storage and large scale transportation. This research did not investigate the extent to which policy makers and non-US companies view NY-BEST as a leader.

- While it is still early to conduct a full assessment, there was relatively limited commercialization of technologies from projects supported by NY-BEST funding (at the time this report was written, only 2/50 funded projects had produced a commercially-available product). However, at least six other projects had resulted in manufacturing partnerships or licensing agreements, suggesting that more products will ultimately enter the commercial market.
- General perceptions of NY-BEST were very positive, with over 91% of members indicating they were either "satisfied" or "very satisfied" with the organization in 2015. Program data show that membership in the Consortium was stable and represented a number of national and international market actors, ranging from manufacturers to researchers.[32] However, two non-battery storage members indicated benefiting less because of NY-BEST's heavy emphasis on battery technology. The dissatisfaction of these few members demonstrates the trade-off between strategically focusing on specific market segments and casting a wide net.
- Additionally, the Consortium was involved with a number of policy movements in New York State. For example, as part of its *2016 Energy Storage Roadmap for New York's Electric Grid,* the Consortium collaborated with other industry leaders to recommend specific GW targets for the State's energy storage goals, numbers which were absent from the *Reforming the Energy Vision* initiative. These and other technical and standards committee activities helped NY-BEST position itself as an important driver of energy storage in New York State. We do not know if policy makers or legislators will adopt NY-BEST's GW and standards recommendations, and it remains to be seen how effective these actions will be at reducing regulatory barriers preventing greater implementation of energy storage.

NY-BEST made progress toward several of its long-term goals (as described by the program logic model). Namely, NY-BEST helped to develop a thriving cluster[33] of energy storage researchers and companies in New York State; this development appears to have had a positive economic impact on the state's economy. It is too early to fully assess other long-term outcomes, including New York State's status as a global leader in energy storage and a reduction in fossil fuel emissions.

In the remainder of this section, we discuss how NY-BEST carried out the activities described in the logic model and describe the resulting outputs. We provide an assessment of NY-BEST's progress toward each of its short-, medium-, and long-term outcomes as measured by their corresponding indicators.

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[32] Our research indicated that NY-BEST members included 51 national market actors (outside of New York State) and 8 international market actors.

[33] In this report we rely on Michael Porter's definitions of clusters as "… geographic concentrations of interconnected companies and institutions in particular field… [encompassing] an array of linked industries and other entities important to competition." For more information, see: Porter, Michael E. 1998. "Clusters and the New Economics of Competition Harvard Business Review." Harvard Business Review.

6.1 NY-BEST Activities and Outputs

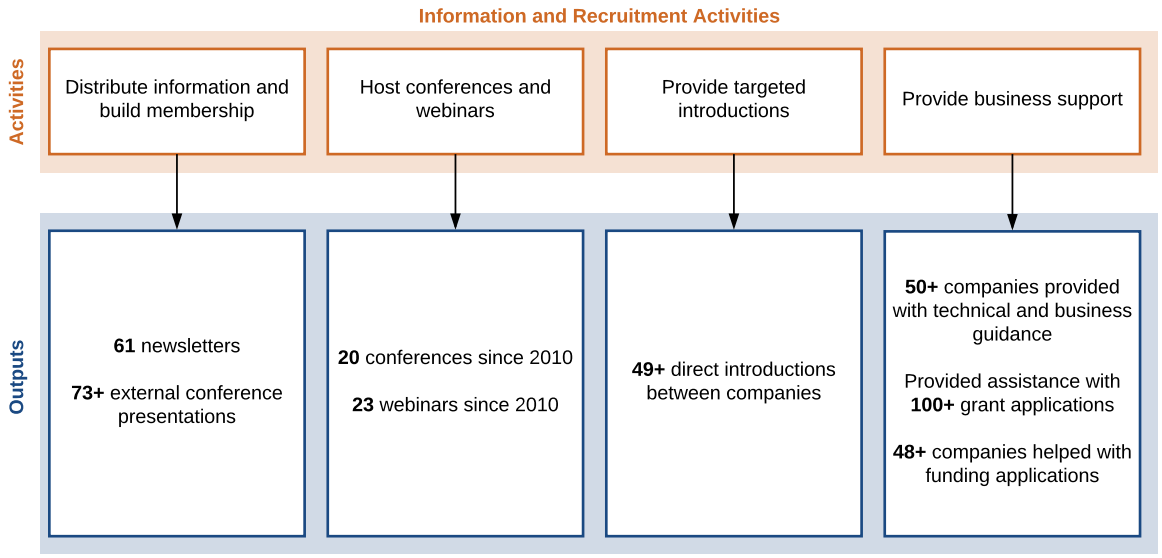
In this section we discuss the activities that NY-BEST has undertaken during the period 2010-2015, and match these to their corresponding outputs as shown in the logic model.

Information and Recruitment Activities

As shown in Figure 6-2, the specific activities related to information and recruitment included:

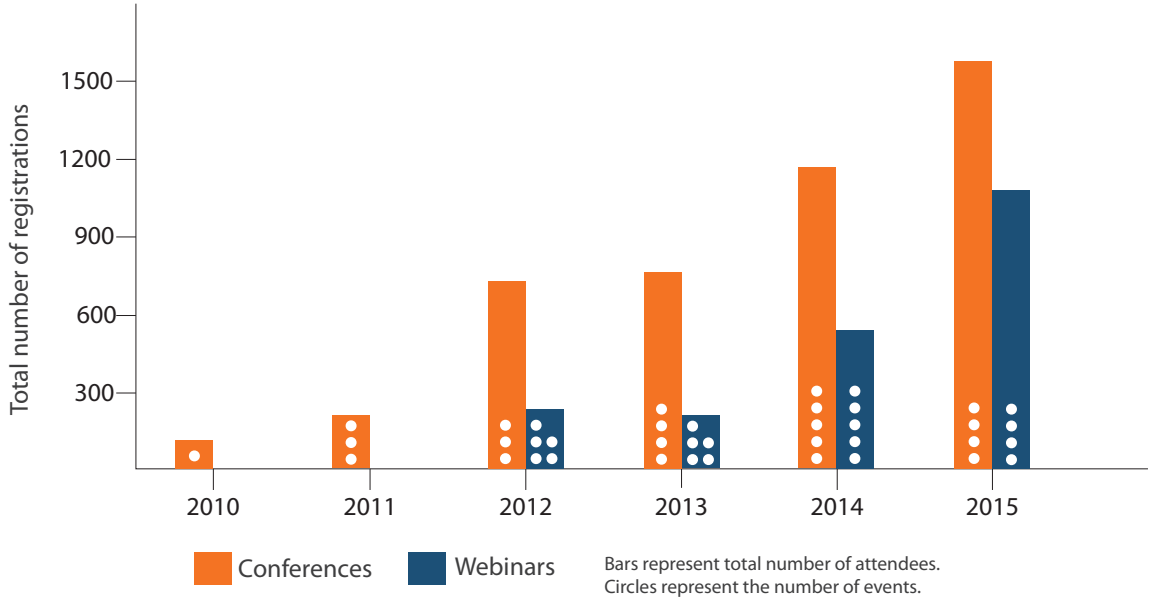
- **Distribute information and build membership**. NY-BEST served its members and recruited additional members by distributing relevant information and providing resources to existing members and, to a limited extent, non-members. Specifically, NY-BEST distributed information by:
  - Implementing a coordinated communication plan that includes a semi-monthly newsletter (including member spotlights), social media, news media, and funding opportunity notices,
  - Maintaining supply chain and resource databases on the NY-BEST website.
  - Helping to facilitate new partnerships between members such as product development, and supplier or research opportunities,
  - Serving as an information clearinghouse for members and policymakers on issues relevant to energy storage deployment,
  - Representing NY-BEST and New York's energy storage sector at national or international conferences,
  - Assessing member needs and opportunities through a member satisfaction survey, and
  - Keeping the NY-BEST website content up-to-date. NY-BEST continually tracked its presence in the news and other media to understand trends and improve its communications.

Figure 6-2. Information and Recruitment Activities and Outputs



- **Host conferences and webinars.** NY-BEST educated members and encouraged collaboration and partnerships through regular conferences and webinars. Through 2015 NY-BEST hosted at least 20 conferences and 19 webinars. This is shown graphically in Figure 6-3.

Figure 6-3. Timeline of NY-BEST Conferences and Webinars[34]



- **Provide targeted introductions**. NY-BEST staff regularly communicated with and introduced members who had the potential to form partnerships. This communication was by phone or in person and resulted in meetings between members to discuss ways in which they may collaborate and partner. NY-BEST also facilitated communication between members and non-members.
    - According to CAIR reports, examples where NY-BEST facilitated introductions include connecting a novel fuel cell developer to a key supplier and manufacturing partner; connecting a system integrator/project developer with an energy services company; and helping an emerging battery maker identify manufacturing partners to provide initial production capability.[35]

[34] NY-BEST also hosted one workshop in 2012, and two forums, one in 2012 and one in 2013 (not depicted on graphic).

[35] While not necessarily a comprehensive list, these are the examples included in annual CAIR reporting by NY-BEST.

- Five interviewed NY-BEST members mentioned benefiting from introductions facilitated by NY-BEST. One member mentioned not needing NY-BEST assistance in this regard.

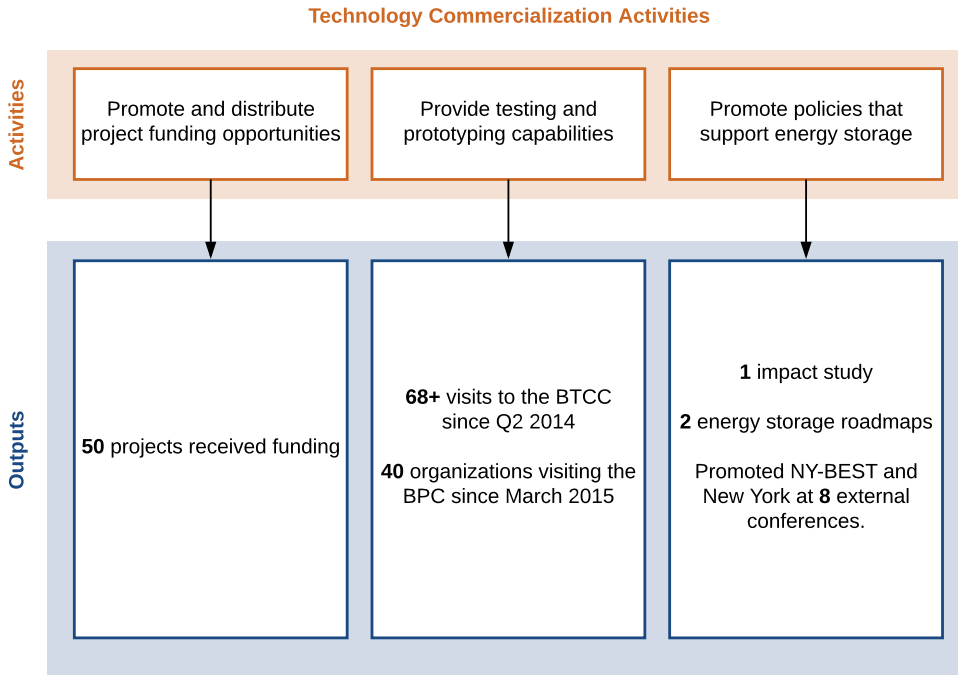
- **Provide business support**. NY-BEST offered business and technical support to member companies, including assistance preparing for grant funding or investor presentations, as well as guidance for beginning or expanding businesses, particularly to improve understanding of the electric regulatory structure in the State. Four interviewed NY-BEST members mentioned using these types of services.
  - CAIR reports show that NY-BEST provided technical and business guidance to at least 50 organizations, provided assistance with 100+ grant applications, and helped at least 48 with funding applications.

Technology Commercialization Activities

As shown in Figure 6-4, the specific activities related to technology commercialization included:

- **Promote and distribute project funding opportunities.** NY-BEST staff directed members to funding opportunities, including regional economic development councils, federal sources, and NYSERDA Program Opportunity Notices (PONs). As part of the $25M NYSERDA investment to seed NY-BEST, projects were funded through NYSERDA and with input from the NY-BEST membership and board of directors through two separate NYSERDA PONs: (1) PON 1704 (March 2010), which included 16 seed stage and development projects, and (2) PON 2458 (2012-2014) – Rounds 1 through 6 commercialization projects from lab to prototype.

Figure 6-4. Technology Commercialization Activities and Outputs



- **Provide testing and prototyping capabilities.** To provide testing and commercialization assistance to its member, NY-BEST collaborated with DNV-GL Energy Power Testing, Inspection, and Certification Group to provide a battery testing facility in Rochester, NY, known as the Battery Test and Commercialization Center (BTCC). This facility opened on April 30, 2014, and offers support for new technologies to be tested to industry standards, including testing for small single cell batteries to larger megawatt systems, product development, performance validation, certification testing, environmental testing and battery lifetime testing, mobile in-field testing and on-site product commissioning. In addition, NY-BEST worked with the Rochester Institute of Technology to provide a battery prototyping facility. Both the BTCC and the BPC are operated by third parties (not NY-BEST).
    - BTCC records show that 33 companies toured the facility in the final three quarters of 2014, while during the first three quarters of 2015 there were documented visits from 35 companies.
    - Since March 2015, the BPC has had over 225 visitors from 45 organizations with interest in collaboration with the center on use of the center's services.
- **Promote policies that support energy storage**. NY-BEST encouraged policies and regulations that are amenable to the growth of the industry in the State. In particular, NY-BEST worked with state and local officials involved in codes and standards development to encourage regulations that are favorable for energy storage implementation. Any NY-BEST lobbying activities (i.e., attempts to influence decisions of government officials) are supported entirely with non-NYSERDA funding. For more details on NY-BEST's policy activities, see Exhibit 6-1.

Exhibit 6-1. NY-BEST's Promotion of Policies that Support Energy Storage

Influencing New York State policy on **several levels**:

- Municipal: NY-BEST worked with officials in New York City in relation to permitting and citing of batteries and energy storage in buildings.
- State: Interactions include the Department of Public Service (DPS), Empire State Development (ESD), Department of Environmental Conservation (DEC), Department of Transportation (DOT), New York Power Authority (NYPA), Long Island Power Authority (LIPA), the Governor's Office, the State Assembly, and the State Senate.
- National: NY-BEST worked with federal officials from the U.S. Department of Energy, several national labs, the U.S. Army, several members of Congress and New York's two U.S. Senators as well as with the Energy Storage Association (ESA).

Leading development of **Energy Storage Roadmap** for New York State in 2012, 2016:

- The roadmaps recommend actions designed to make New York State a preeminent location for research, development, manufacturing and deployment of energy storage technologies.
- The 2016 roadmap established explicit grid storage goals (2 GW of multi-hour storage capacity on New York State's electric grid by 2025 and 4 GW by 2030).

Assisting in development of **codes and standards:**

- Underwriters Laboratories (UL) 1973 - Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications
- UL 9540 - Outline of Investigation for Energy Storage Systems and Equipment
- UL 1741 - Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources.
- UL 1973 and UL 9540 are viewed as industry-defining standards: "UL 9540 addresses key issues associated with energy storage systems, including: battery system safety, functional safety, grid connectivity, interconnection with premise wiring systems, environmental performance, containment and fire detection and suppression. The new standard is intended to safeguard the uses of emerging energy storage system technologies across different types of systems, a variety of usages and functions, and a range of potential system users." (UL 2014)

Participating in **technical committees, GRIDSTOR, stakeholder engagement**:

- International Electrotechnical Commission (IEC) TC 21 – Secondary cells and batteries
- IEC TC 120 – Electrical Energy Storage Systems
- Institute of Electrical and Electronics Engineers (IEEE) Stationary Battery Technical Committee.
- GRIDSTOR contributions
- Work with FDNY, the National Fire Protection Association (NFPA), National Energy Labs on safety-related activities for energy storage system.

6.2 Short-term Outcome Progress

In this section, we discuss the progress that NY-BEST has made toward achieving the expected short-term outcomes shown in the logic model. As described in the logic model short-term outcomes, NY-BEST expects to find that the information it provides is valued and shared; productive collaborations and partnerships form as a result of facilitated introductions; members' business strategies and product pitches improve; and both members' and non-members' satisfaction with NY-BEST offerings increases.

Some short-term outcomes lead directly to long-term outcomes and some lead to medium-term outcomes. Thorough descriptions are provided for short-term outcomes that lead directly to long-term outcomes as we have more evidence of progress at those stages than for the long-term outcomes to which they relate. For those short-term outcomes that lead to medium-term outcomes we provide brief summaries and include references to the more thorough discussions of each medium-term outcome to which they relate. The discussion of the medium-term outcomes in section 6.3 integrates the results of multiple short-term outcomes.

6.2.1 Increased Member/Non-Member Satisfaction with NY-BEST Offerings

As mentioned above, NY-BEST built a membership base that is steadily increasing and was generally satisfied or very satisfied with its offerings. Based on interviews, NY-BEST members were actively engaged with NY-BEST, primarily as a networking tool.

- Many saw NY-BEST conferences as a means to network, connect with others key members in the supply chain, and learn about new opportunities for energy storage. Several interviewees—both members and non-members—made mention of the notion that NY-BEST conferences are well respected for the expertise of the people who attend them.
    - In annual surveys conducted by NY-BEST, satisfaction among members has been consistently high (between 88% and 92% have been "satisfied" or "very satisfied" with NY-BEST).
    - NY-BEST has attracted an increasing number of participants to its conferences and webinars over time, as depicted in Figure 6-3.
    - Nine of the members interviewed as part of this research mentioned the NY-BEST conferences in a positive light. As one interviewee explained, "Their conferences [and webinars] are outstanding. We participate regularly, and we find them forward thinking, inclusive, and effective."
- However, two members and one non-member interviewed as part of this research indicated that they felt NY-BEST offered them limited benefits because the consortium's main focus was only on certain types of batteries.
- NY-BEST staff members, including the executive director (William Acker), director of resource development (John Cerveny), and senior advisor (Denise Sheehan), were widely praised by member interviewees for their passion and depth of industry knowledge (mentioned by five member interviewees).

6.2.2 Valuable supply chain and resource information is shared and put to use among members

NY-BEST was recognized as a valuable information and networking resource. Members report using information from the Consortium to network with others in the energy storage industry, to keep tabs on industry news, and to stay abreast of industry events. Specifically, two-thirds (67%) of NY-BEST members surveyed in 2015 were aware of the services that NY-BEST offers, and just over one quarter (27%) reported using those services.

- In the latest NY-BEST Annual Member Survey (2015), 23 out of 34 participants (68%) were aware of NY-BEST services available to them to connect with others in the energy storage industry. Of these 23 participants who were aware, 9 reported successfully utilizing these services (39%). Industry news (24 out of 32, 75%) and event information (24 out of 32, 75%) are ranked as the most useful information on the NY-BEST website.[36,37]
- Based on the process evaluation findings, over 80% benefited from NY-BEST facilitating connections. The most popular way to connect was through NY-BEST conferences, which were rated 8.5 out of 10 on a scale of 1=not at all valuable to 10=extremely valuable. Members looked to connect with other key members in the supply chain and learn about new opportunities for energy storage. As one member interviewee described NY-BEST's role: "[They] bring elements of the supply chain together that wouldn't happen naturally; [it's a] healthy meeting of market players." Another member interviewee stated: "NY-BEST is doing a great job, bringing together industry players, big companies, utilities, small companies too."
- There is evidence that members' use of the supply chain and resources database has played a role in the development of collaborations between different organizations. As of January 1, 2016, the Supply Chain Database had 1,041 site visits and contained 402 resources, including 72 individuals and 330 organizations and companies. Use of the database, as measured by website traffic, has steadily increased since the database originally launched in spring of 2014.

[36] It was unclear from the data as to whether these numbers were cumulative or not; in either case, however, the increasing trend remains valid.

[37] In the latest Annual CAIR Report (2013-14), NY-BEST helped 8 companies prepare for conference presentations and over 24 companies with funding applications. In addition, NY-BEST provided over 15 direct introductions between companies and over36 companies were provided with ongoing technical and business guidance (e.g., business development, market entry strategies, and connections to resource providers in legal, technical, financial, and manufacturing areas).

Grid Storage Case Study: Eos Energy Storage

Eos Energy Storage (with offices in New Jersey and New York City) is developing a novel zinc battery design for (stationary) electric grid storage applications.

In 2013, Eos received funding for a bench-to-prototype project from NY-BEST, which was aimed at helping the company scale its existing battery technology, rather than to undertake research into brand new technology. Eos has also received additional funding directly from NYSERDA. The company closed a successful round of private investment totaling $23M in 2015.

One of Eos's product lines is the Aurora 1000/4000 system, which is a low-cost DC battery system designed specifically for grid-scale energy storage applications. Eos's Aurora product line is already commercialized, with demonstration projects planned for 2016 and commercial offerings expected to begin in 2017. Currently Eos has partnerships with a number of utilities in the U.S. and around the world, including ConEd in New York State. They are currently working with a contract manufacturer located in New York State to help support these manufacturing operations.

In an interview conducted as part of this research, one representative from Eos mentioned that NY-BEST has had an influence on the energy storage production market by being the "regulatory interface" in statewide legislative proceedings, through supporting small companies, and through hosting events that bring key players together. Eos also commented on the difficulties they have had with permitting and timelines for their projects in New York City.

According to the patent analysis conducted as part of this research, there are a number of other large companies whose patents reference Eos's metal-air battery patents as prior art, including Ford, Hyundai, NGK, and Samsung. Eos's technology thus appears to play an important role in the development of metal-air battery technology.

6.2.3 Formation of productive collaborations and partnerships

Based on our analysis of data from member surveys, from interviews conducted as part of this research, and from program data on conference/webinars, NY-BEST activities led to the formation of collaborations and partnerships between market actors in the energy storage industry.

- In the 2015 NY-BEST Annual Member Survey, 9 out of 34 participants (26.5%) successfully utilized NY-BEST services to help them connect with others in energy storage industry (11 participants, 30.6% were not aware of this service).

- A few NY-BEST members interviewed as part of this research mentioned that the networking opportunities available through NY-BEST have opened the doors for meaningful collaborations with other members, leading to further project work.
    - One member interviewee described his interactions with other NY-BEST members, explaining that during a presentation at NY-BEST, he found a company in another state that was interested in their product, and enabled his company to make their first commercial sale.
- Nine interviewees agreed that workshops, conferences and webinars were valuable offerings, and noted that such events encouraged networking and information sharing between members. Such events thus acted as an important step toward productive collaborations between members. The increases in number of events and average registrations demonstrate a demand for this service and suggest that NY-BEST's network was strong:
    - NY-BEST held substantially more in-person events (e.g., workshops, conferences) and webinars over time since 2011. NY-BEST also steadily increased the number of conferences during this period.
    - NY-BEST event and webinar registrations also increased over time. This does not seem to be simply due to holding more events and webinars, given that the average number of registrations per conference also increased.

Table 6-1. NY-BEST Conference Events and Webinars Held from 2010-2015

Metric	2010	2011	2012	2013	2014	2015
Total events held	1	3	11	10	10	8
Total event registrations	90	235	770	791	1163	1580
Average registration per event	90	78.3	70	79.1	116.3	197.5
Of events, total conferences held	1	3	3	4	5	4
Total conference registrations	90	235	328	453	621	566
Average registration per conference	90	78.3	109.3	113.3	124.2	141.5
Total webinars	0	0	5	5	5	4
Total webinar registrations	--	--	253	232	542	1014
Average registration per webinar	--	--	50.6	46.4	108.4	253.5

6.2.4 Members improve strategies and successfully pitch ideas

As described in section 6.3.1, NY-BEST members have successfully pitched ideas to investors and other organizations, as evidenced by obtaining project co-funding and follow-on funding. Five interviewees mentioned the importance of NY-BEST in helping them secure such funding, citing the ability to attract attention and tap into NY-BEST's network of professionals.

6.2.5 High quality, targeted R&D accelerates product development

Energy storage technologies in New York State developed with the support of NY-BEST during the period 2010-2015. A review of program data showed that 39 of 50 funded projects have information on

their stage of development, and 21 of them had information on the stages of development over time. In particular, eight projects indicate commercialization progress (e.g., proof of concept stage in 2014 and initial prototype stage in 2015). Additional signs of accelerated development included:

- **Project funding for most projects**. At least 50 have received co-funding and follow-on funding, as detailed in section 6.3.1.
- **Increasing demand for testing and prototyping services.** Program records show an increase in demand for BTCC services from 2014 to 2015, and five of six interviewees who used the services expressed positive views, as detailed in section 6.3.2.1.

6.2.6 Energy storage technologies are proven in New York

There was documented commercialization and deployment of NYSERDA-funded technologies in 2015. While many technologies were still in the R&D pipeline and were not yet commercially viable, results of the interviews suggest that the market, as a whole, continues to move forward quickly, and that some number of the supported technologies will begin to have measurable sales in the market in the subsequent 1-2 years. Evidence to support this notion comes from the status of NYSERDA-funded NY-BEST R&D awards, from self-reported TRL advancement of NY-BEST projects, and from demand for BTCC and BPC services:

- **NYSERDA-funded NY-BEST R&D Awards**: A total of 56 NYSERDA-funded NY-BEST R&D contracts were awarded, dating back to 2010. However, three awards were terminated (one applicant decided not to pursue the award and two awards were unable to be contracted)[38] and three other projects are still in the early stages of development (i.e., metrics analysis is not applicable). Thus, as of 2015, there were a total of 50 projects with funds distributed: 20 projects were still ongoing, 22 were closed, and 8 projects were in the process of executing or undergoing contract negotiation. One project closed due to not showing adequate performance improvements.

6.2.7 Policy makers and public favor energy storage industry

As described in detail in section 6.3.3, NY State adopted policies (most notably, the REV initiative) supporting the development of clean energy resources and improving grid resiliency, which energy storage can support. In tandem with these developments, NY-BEST worked between 2010 and 2016 to increase public support for energy storage through its development of the New York State Energy Storage Roadmap, published in 2012 and again in 2016. These efforts are described in detail in section and 6.3.3.1. There is also evidence that such efforts are supported by the general public. In a 2016 poll, 90% of randomly selected New York State voters reported supporting the REV initiative after they were provided with a brief summary of the program (Stein 2016).

[38] The three terminated awards fell under PON 2458.

6.3 Medium-term Outcome Progress

In this section, we discuss the progress that NY-BEST made toward achieving the expected medium-term outcomes shown in the logic model. In the medium-term, NY-BEST expects to evolve into a self-sustaining organization through membership dues, testing, grants and contracts, and fees for events. In the broader market, NY-BEST expects to connect outside investors to NY-BEST members to provide follow-on funding, help energy storage technologies reach commercialization in New York State, and reduce regulatory barriers to energy storage. As mentioned in section 6.2, this section integrates findings demonstrating short-term and medium-term progress. This report did not assess the medium-term outcome "NY-BEST is self-sustaining."[39]

6.3.1 Outside investors provide follow-on funding to NY-BEST members

NY-BEST members and others in New York State have successfully pitched ideas to investors, as judged by the amount of follow-on funding received by NYSERDA-funded R&D projects and by venture capital data on firms in the metro New York city area:

- At least 50 contracts (out of 51 funded projects) received project co-funding, totaling $17,248,627 (including both cash and in-kind). The mean co-funding amount was $218,337.05. At least 21 NYSERDA-funded R&D projects received follow-on funding (42% of projects with funds distributed) totaling to at least $74,245,244.[40]
- According to CB Insights, a venture capital database, investment in energy storage firms located in the New York Metro area has exhibited a positive net growth from 2011 to 2015, with an average deal increase of 5.92%.
- Five member interviewees discussed the importance of NY-BEST and NYSERDA in helping to secure additional funding. As one member explained, without NY-BEST's and NYSERDA's support, his company "never would have made it."

6.3.2 Energy storage technologies are commercialized

While it is still too early to conduct a full assessment of the commercialization results of energy storage projects receiving NY-BEST assistance, as of 2015 there was evidence of progress toward this goal both in terms of (1) commercialized products, and (2) demand for services at the BTCC and BPC (details of which are provided in section 6.3.2.1 below).

Annual CAIR reports from 2011 to 2014 and data from the NYSERDA program provided self-report information on the NYSERDA-funded NY-BEST R&D Projects. A review of program data showed that 39 of 50 funded projects had information on their stage of development and 21 of them had information on the stages of development over time. In particular, eight projects indicated progress on the TRL scale

[39] The medium-term outcome "NY-BEST is self-sustaining" is not addressed in this evaluation. For more information on progress towards this goal, see the *NYSERDA NY-BEST Rapid-Feedback Process Evaluation*.

[40] "Follow-on funding" is defined as funding provided to a company in subsequent funding rounds (i.e., not the initial funding round).

(e.g., proof of concept stage in 2014 and initial prototype stage in 2015).[41] Two projects indicated that their product was commercially available.

Research and Development Case Study: Paper Battery Company

Paper Battery Company in Troy, New York was founded in late 2008 by a team of scientists and entrepreneurs at Rensselaer Polytechnic Institute, and have been members of NY-BEST since 2010. The company develops and commercializes a novel type of flexible ultracapacitor for better power management solutions in energy storage systems.

Paper Battery has benefited from NYSERDA funding, which allowed them to achieve progress toward their first commercialization line. This funding also made it easier for them to secure additional funding from a number of private sector investors. One representative from the company indicated that the NY-BEST conferences have been particularly helpful in facilitating introductions to key people in the industry.

Paper Battery advocated early on for a testing and commercialization center in New York, since product testing and early manufacturing stages can be prohibitively expensive for smaller firms without their own facilities. The company appears to have benefited from access to the BTCC, having obtained at least two U.S. patents and submitted over 20 patent applications to date.

6.3.2.1 Details on Demand for BTCC and BPC Services

Facility reports show an increase in demand for BTCC services from 2014 to 2015. These records show that 33 companies toured the facility in the final three quarters of 2014, while during the first three quarters of 2015 there were documented visits from 35 companies. Anecdotal evidence also supports the notion that the BTCC has contributed to technologies progressing toward more advanced self-reported TRL levels. Results from the 2015 annual member survey indicated that two-thirds of members were interested in learning more about BTCC services and half were interested in learning more about BPC services. While this suggests that these services were not required by all members, five of six interviewees who had used the facilities to test a total of eight products noted positive experiences. Two others noted plans to use the facility. One interviewee called the BPC a "world-class prototyping center" that "tested [the product] in rigorous industry setting conditions" enabling similar comparisons of their product with what is on the market. Staff mentioned the importance of the test center to the commercialization process, as did one interviewee that explained its importance:

"One of the things I pushed for at NY-BEST was the establishment of the commercialization center. Thankfully it is there now because the early stages of manufacturing are difficult. This is a critical step in

[41] Awardees were asked in early 2016 to report on TRL levels for the first time.

taking the technologies from small startups and giving them a platform. I know two companies and research groups who have benefited from the center already."

Table 6-2 describes the BTCC and BPC revenues, tests, visits, and tours completed in 2014 and 2015.

Table 6-2. BTCC and BPC Revenues, Tests, Visits, and Tours

Metric	BTCC Services		BPC Services
	2014	2015	6/2015 – 6/2016
Revenues	$503,000	$586,000	$102,000
Test Programs Completed	8	7	552
Visits/Tours	33	35	225 visitors / 45 tours

Source: NY-BEST Facility Reports

6.3.3 Regulatory and policy barriers to energy storage are reduced

There has been notable progress in New York State policy to support energy storage market development since 2010, as officials and legislators have begun to adopt positions supportive of energy storage in the State. NY-BEST has played a part in this progress, having published energy storage roadmaps in 2012 and 2016, and having advocated for policy improvements at the state level (NY-BEST 2012; NY-BEST 2016).

While not causally related to NY-BEST's activities, New York State adopted *Reforming the Energy Vision* (REV) in 2014, a major initiative aimed at spurring the development of a more efficient, resilient grid. Also in 2014, the New York State Public Service Commission began proceedings to approve a 10-year, $5 billion Clean Energy Fund that will also leverage an expected $29 billion in private sector funding to advance New York's clean energy economy as a whole. Grid energy storage is integral to these two initiatives, as it provides the actual mechanism that allows the grid to become more efficient and resilient, especially with the incorporation of additional intermittent clean energy sources.

However, while the State has made progress toward reducing regulatory and policy barriers, it has not eliminated them. Two members, one non-member, and one expert all mentioned the fact that certain barriers still exist. One expert described it this way: "There is still some hesitation in New York State and New York City to supporting lithium-ion batteries because of safety concerns. This is an issue that must be solved quickly."

6.3.3.1 Details on Energy Storage Roadmap and NY-BEST Policy Goals

In 2012, NYSERDA and NY-BEST collaborated with a diverse set of energy storage industry stakeholders, including a group of 45 experts from various organizations, National Grid, and the NYS Public Service Commission to produce the 2012 New York State Energy Storage Roadmap. The 2012 Roadmap focused on the grid storage and transportation sectors. Its stated objective was to "identify the state's specific needs and to recommend potential strategies to meet the challenges of expanding the development, manufacturing and deployment of energy storage in New York." To this end, the roadmap established three major goals:

- Establishing robust New York markets through the use of appropriate technologies, policies and incentives.
- Creating value chain clusters of companies that will provide the manufacturing capability to grow the energy storage industry in support of New York and global markets.
- Continuing technology leadership and stimulating commercialization of advanced technologies through R&D funding, collaboration and leveraging of resources.

NY-BEST and NYSERDA collaborated again to produce the 2016 New York State Energy Storage Roadmap, which focused primarily on grid storage. The 2016 Roadmap was based on input from a number of NY-BEST member organizations collected through a series of stakeholder workshops. The 2016 Roadmap established goals of "having 2 GW of multi-hour storage capacity on New York's electric grid by 2025 and 4 GW by 2030." Given that the most common focus for NY-BEST members (roughly 63%) is grid storage technologies, it appears that projects are generally in alignment with the 2016 Roadmap and with program goals. As shown below in Table 6-3, there appears to be general alignment between the stated goals of the 2016 Roadmap and NY-BEST expected outcomes included in the logic model.

Table 6-3. Mapping Between 2016 New York State Energy Storage Roadmap Goals and NY-BEST Logic Model Components

2016 New York State Energy Storage Roadmap Goal	NY-BEST Logic Model Component
Create new regulatory and market mechanisms to monetize the full value of energy storage.	Regulatory barriers to energy storage fall (medium-term outcome)
Create common financing vehicles that help provide access to capital, simplify project finances and reduce perceived project risks.	Productive collaborations and partnerships form (short-term outcome) Outside investors provide follow-on funding to NY-BEST members (medium-term outcome)
Reduce soft costs of energy storage installations related to siting, permitting, interconnection and other transactional costs.	Promising projects receive funding (output)
Create standardized methodologies, codes, and regulations that are recognized by all jurisdictions to increase commercial confidence in energy storage solutions and reduce soft costs.	High-quality, targeted R&D accelerates development
Perform a study to evaluate options and assess requirements for storage and other assets needed to support the State's renewable energy and greenhouse gas emissions goals.	No direct analog
Increase the availability of information related to electric grid system needs and capabilities in order to enhance industry decision-making.	Valuable energy storage information is shared and put to use (short-term outcome)
Implement a declining bridge incentive for storage that monetizes the value energy storage delivers to the electric system and provides long term revenue confidence to investors.	Thriving cluster of New York energy storage researchers and companies (medium-term outcome)

6.4 Long-term Economic Impacts

In the long-term, NY-BEST's efforts to commercialize energy storage technologies are expected to help reduce fossil fuel emissions, contribute to developing a thriving cluster of energy storage researchers and companies in the State that provides jobs and economic benefits, and encourage others to view the State as a global leader in energy storage.

Long-term outcomes are not expected to manifest at the same time. Instead, there is an anticipated cascading order, beginning with the development of a thriving cluster of researchers and companies in New York State that will in turn foster the creation of jobs and economic benefits, and lead to the recognition of New York State as a global energy storage leader, and finally to a reduction in fossil fuel emissions. Currently, there is evidence of the formation of a thriving cluster of energy storage researchers and companies in New York. There is also evidence that this industry is bringing jobs and other economic benefits to New York State. It is too early to gauge NY-BEST's progress toward achieving recognition of New York State as a global leader in energy storage—though as discussed below, there are specific events which would help signal progress toward this goal. The final long-term outcome—a reduction in fossil fuel emissions—will likely require even more time and empirical data before an accurate assessment can be performed.

In this section we discuss indicators related to each of the four long-term economic impacts from the logic model.

6.4.1 Thriving cluster of energy storage researchers and companies in New York

Federal census data support the notion that as of 2015, a thriving cluster of researchers and companies had begun developing in New York State. If we assume that the "other electrical equipment and component manufacturing" industry (NAICS code 3359) is a reasonable proxy for the energy storage industry in New York, then federal data sources also suggest that the energy storage industry in New York State has increased since 2010. County Business Pattern data from the U.S. Census shows a 20% increase in the number of paid employees and annual payroll for NAICS code 3359 for the period 2010-2014 (shown in Table 6-4). During this same time period the number of total establishments progressed from 105 in 2010, peaked at 115 in 2012, and decreased to 107 in 2014.[42]

Table 6-4. County Business Patterns Data for NAICS Code 3359, 2010-2014

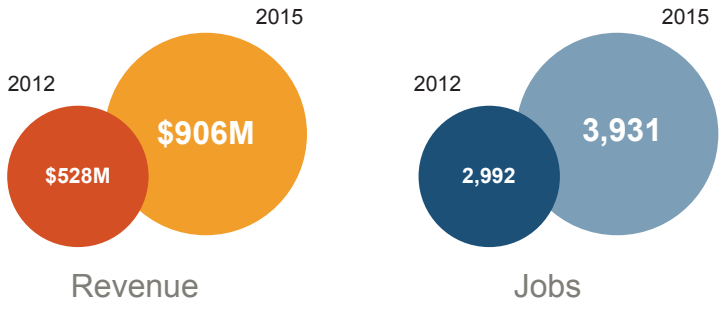
Year	Paid employees for pay period including March 12 (number)	Annual payroll ($1,000)	Total establishments
2010	5,981	$315,546	105
2011	5,904	$321,476	106
2012	6,348	$354,612	115
2013	6,577	$389,365	106
2014	7,203	$435,557	107

[42] Because clusters will often span multiple NAICS codes, this analysis cannot capture the entire picture of cluster development in New York State. However, it should serve as a reasonable proxy, assuming that NAICS code 3359 is a core contributor to this development.

6.4.2 Energy storage industry brings jobs and other economic benefits to New York

As described in the economic analysis report included as part of this study, the energy storage market in New York State steadily increased both in terms of revenue and employment from 2012 through 2015, with revenues increasing from $598M in 2012 to $906M in 2015 (estimated). Similarly, the State experienced an increase in energy storage industry employment from 2,992 jobs in 2012 to 3,931 jobs in 2015 (estimated). This trend was present in both the emerging and traditional market sectors (depicted graphically in Figure 6-5). These figures are roughly consistent with the "base case" estimated in the 2012 market report, which assumed that New York State would continue to cultivate a strong economic development program focused on the emerging electricity storage and transportation battery sectors and implement incentives to help develop existing New York State companies and attract new companies to the state.

Figure 6-5. New York State Trends in Energy Storage Revenue and Employment, 2012-2015



Transportation Case Study: Raymond Corporation

Raymond Corporation (based in Greene, NY) has been a NY-BEST member since the consortium's inception. In 2014, Raymond received NY-BEST funding (along with their partner Navitas Systems) to develop and test an advanced lithium-ion energy storage system for electric lift trucks. Designed to provide an alternative to more traditional lead acid technology currently in place, this new energy storage system could serve as a more reliable, more efficient way to power lift trucks.

Although the Raymond Corporation is a wholly-owned subsidiary of Toyota, the company produces roughly half of its electric forklift units in New York State (roughly 75,000 units annually). Because all of these units have a battery or storage system of some type, the company has the potential to impact the energy storage production market within New York State.

In an interview conducted as part of this research, a representative from the Raymond Corporation indicated that he believed NY-BEST is doing a good job of addressing "multiple issues on multiple fronts" to further the market for energy storage within New York State. Raymond has benefited from access to both the BTCC and BPC, which they have used for testing new prototypes. They have also used the supply chain database in order to find components vendors.

6.4.3 New York becomes a global leader in energy storage

Findings from the interviews suggest that in 2015 many in the industry viewed New York State, and NY-BEST in particular, as being a leader in promoting energy storage markets, particularly in terms of research and policies supporting the production and adoption of energy storage technologies.[43] One member interviewee described NY-BEST's role by explaining that "Without NY-BEST, the dialogue would not be what it is today."

In 2015, New York was commonly mentioned along with California and Hawaii as being on the leading edge of the energy storage market. Interviewees mentioned that the current leadership of NY-BEST are highly respected and have been instrumental in the organization's success thus far. As one expert interviewee mentioned: "I think [NY-BEST]is considered to speak for the industry in New York, and I know that the Energy Storage Association (ESA)… defers to NY-BEST when working in New York State. And I think that when they talk to regulators, they are viewed as speaking to everyone in the industry. So I think they are very powerful in that way."

[43] It is important to note that all interviewees represented organizations with a presence in the U.S.

Actual deployment in New York State in 2015 was present but limited, at least in the grid storage market. Department of Energy data shows that within the United States, New York State accounted for approximately 5% of all deployed projects by rated power capacity (KW), including pumped hydro and compressed air storage in 2015. New York State did not have the same level of deployed energy storage as many other regions in the world. At that time, China, Japan, India, Germany, and Australia had emerged as leaders for the deployment of energy storage technologies.

One path to success for this outcome is the establishment of mandatory energy storage procurement goals for utilities operating within New York State. NY-BEST, in their 2016 roadmap, called for such goals. However, if this does not materialize, it may also be possible to attain "global leadership" status through the deployment of a substantial capacity of energy storage within the State.

6.4.4 Fossil fuel emissions decline as a result of energy storage technologies commercialized and in use

It is too early to generate estimates for this long-term outcome. Such estimates of emissions reductions require that technologies are commercially available and have been adopted by at least some portion of the population. Thus it will be important to review progress toward this long-term outcome once new energy storage technologies have been commercialized and deployed.

7 Conclusions

This impact evaluation focused on documenting the influence the NY-BEST Consortium has had on the energy storage market in New York State in the period 2010-2015 (using data from early 2016). This section summarizes the conclusions the EMI Consulting team has regarding the specific research questions for this evaluation.

7.1 What was the state of the energy storage market when NY-BEST launched in 2010?

In 2010, energy storage was still considered an "emerging technology" by those outside the industry.[44] Grid storage batteries, for example, were not viewed as a commercially ready technology that could be trusted to last 10 years and perform as needed. Costs were also significantly higher. Electric vehicle batteries cost 40% more than today, for example (also see Table 7-1 for a summary of the market in 2010).

The global energy storage market experienced substantial growth in the period from 2010 to 2015, as new technologies became available, awareness of these technologies increased, and costs improved. This growth was present in multiple sectors, including grid energy storage, transportation, and portable devices. To put this in perspective:

- Growth of the global grid storage market segment during this time grew from roughly 125 GW in 2010 to roughly 185 GW (including planned projects, based on the DOE's Energy Storage Database) in 2015 (International Energy Agency 2014). While the bulk of this storage capacity was accounted for by pump storage hydro, with less than 5% of capacity held by more advanced energy storage technologies (battery storage, flywheels, etc.), it is these more advanced types of energy storage technologies that grew most rapidly (on a relative basis). For example, from 2014 to 2015 alone, it is estimated that U.S. energy storage capacity increased from 65 MW to 221 MW, a 243% increase. (GTM Research 2016)
- In the emerging transportation storage market segment, demand for electric vehicles was relatively weak in 2010 – about 2.37% market share of sales. In 2015, this number had increased slightly to 2.87% market share of sales (Electric Drive Transportation Association 2016). While this growth has been more modest than grid storage growth, it is estimated that demand for electric vehicles in the coming decades will be bullish, with one source estimating that EV sales will grow to represent roughly one-third of global annual new car sales by 2040. (Bloomberg New Energy Finance 2016)

Within the U.S., New York State was among at least 10 states[45] aggressively pursuing the development of energy storage markets and infrastructure in 2015. Other states included in this group were early leaders such as California, Massachusetts, Texas, and Hawaii as well as Washington, Oregon, New Mexico,

[44] An exception to this statement may be for conventional forms of energy storage such as pumped hydropower storage.

[45] A 2014 NREL brief indicated that since 2011, about 10 states have introduced legislation intended to support energy storage, though this number will likely continue to grow. The NREL brief is available at: http://www.nrel.gov/docs/fy14osti/62726.pdf

Iowa, Wisconsin, and New Jersey. In 2015, New York state had less energy storage deployed than California, but posted similar numbers from an employment perspective, per capita.[46]

From an international perspective, the energy storage market within New York State followed a growth pattern quite similar to the broader global market. As described in the economic analysis report included as part of this study, the energy storage industry in New York State steadily increased both in terms of revenue and employment from 2012-2015,[47] with revenues increasing from $598M in 2012 to $906M in 2015 (estimated). Similarly, the State experienced an increase in energy storage industry employment from 2,992 jobs in 2012 to 3,931 jobs in 2015 (estimated).[48]

Table 7-1. State of the Energy Storage Market When NY-BEST Launched in 2010

Metrics	Data Source	Results
State of energy storage policies in 2010	Secondary literature, including reports by US DOE, IEA, and others	• Grid storage was mainly focused on FOM applications; BTM storage was just beginning to emerge in places like Germany • In the US, there was roughly 125 GW of grid energy storage deployed, the vast majority of which was pumped storage hydro. The market for BTM storage for residential and commercial applications was virtually nonexistent.
Key energy storage market actors in 2010	NY-BEST staff interviews Secondary literature, media sources	• In 2010, key market actors with a presence across multiple parts of the supply chain included large, established companies like ABB, Bosch, GE and Schneider Electric. But a number of other major companies had not yet entered the energy storage market (e.g., Johnson Controls). • In the transportation segment, Tesla was just beginning to make greater inroads into the electric vehicles market. • Fewer grid storage systems integrators and controls vendors existed in 2010 compared to 2015. Of those that did exist, some were just starting to get involved with utility-scale grid storage (e.g., Greensmith).
Types of energy storage technologies available in 2010	NY-BEST staff interviews Secondary literature, media sources	• There were few mass-market BTM commercial, utility, or residential grid storage units available in 2010.
Number of energy storage jobs in 2010	Economic analysis report	• 2010 energy storage jobs not found.[49] • 2012 jobs: 2,992
Energy storage sales in 2010	Economic analysis report	• 2010 energy storage sales not found.[50] • 2012 revenues: $598M

[46] For a more detailed analysis, please see the corresponding market characterization and assessment report included in this research.

[47] Employment and revenue data was not available for the energy storage industry in New York State in 2010 in a form that was directly comparable to data from later years.

[48] Industrial Economics, Inc. The Energy Storage Industry in New York: Recent Growth and Projections, 2015 Update.

49 Employment and revenue data was not available for the energy storage industry in New York State in 2010 in a form that was directly comparable to data from later years.

50 Ibid.

7.2 In 2015, to what extent and in what ways was NY-BEST viewed as a domestic and/or international leader in supporting the energy storage industry? How had this changed, if at all, since 2010?

While actual grid storage and large-scale transportation storage deployment was limited as of 2015 – New York represented an estimated 5% of national energy storage capacity – experts and members viewed NY-BEST as a leader in supporting energy storage in New York and in national conversations. Evidence from interviews conducted as part of this research suggests that NY-BEST is respected within the energy storage field as having a positive influence on promoting policies and markets favorable to energy storage technologies within New York State. To this end, interviewees generally agreed that while New York State's *Reforming the Energy Vision* (REV) initiative was an important step towards supporting energy storage, it has not gone far enough. Similar to California's approach, they support NY-BEST's call for a mandated specific grid storage goal in its 2016 *Energy Storage Roadmap for New York's Electric Grid* as a way to establish certainty around the demand for energy storage technology.

That said, NY-BEST is recognized for its leadership more so in grid storage and large-scale transportation – its intended areas of focus – than in electric vehicles or portables. It is also seen as a very helpful network for securing partnerships and financial assistance as emerging technologies develop commercially-viable products. Table 7-2 describes metrics used to assess progress towards being viewed as an energy storage industry leader.

Table 7-2: Extent to Which NY-BEST Had Become Leader in Energy Storage Industry

Metrics	Data Source	Results
Involvement in standards setting	Records of battery and energy storage technologies-related activities in NY state Interviews with NY-BEST members	• Interviewed members and experts generally view NY-BEST as leader in energy storage research and policy • There is a general consensus from the secondary literature that CA, HI and NY are viewed as energy storage leaders • NY-BEST authored energy storage policy recommendations in "New York Energy Storage Roadmap" (2012) and "Energy Storage Roadmap for the New York Electric Grid" (2016)
NY-BEST associated technologies in place in New York State	Record of technology demonstration and use in NY	• Limited data available due to early stages of NYSERDA-funded projects; only 2 commercially-available products.
Sales success of products relying on battery energy storage technologies developed or commercialized in New York State	Interviews with NY-BEST members Sales data Comparative sales and use data for other states/nations	• Limited sales data available due to lack of response from interviewees and due to early stages of NYSERDA-funded projects; only 2 commercially-available products as of 2015.
New York is a leader in deployed energy storage solutions for the electric grid and transportation	DOE Global Energy Storage Database Interviews with NY-BEST members	• Grid storage deployment is limited; 5% of U.S. deployed projects by rated power capacity (KW), including pumped hydro and compressed air storage • Most members and industry experts view NY-BEST as a grid and large-scale transportation energy storage leader

7.3 As of 2015, what were the outcomes of projects that received awards through NY-BEST?

Although it is still too early to assess the final outcomes, as of 2015, the NYSERDA-funded NY-BEST member projects had begun to demonstrate an influence on the market. Of the 50 projects, 44% were complete and 42% of the projects with funds distributed secured a total of at least $74M in additional funding for their technologies. Only one project was closed due to inadequate performance. Of the 21 projects with information on developmental stages over time, eight had begun to report TRL progress towards commercialization, of which two were commercially viable in 2015. Furthermore, there is evidence that the projects were beginning to influence other research given that 18 of the funding recipients were cited as prior art by at least one subsequent patent.

To help fulfill its mission of leading the "development and deployment" of energy storage technologies, it is important that NY-BEST provide support at all levels of the technology readiness scale. This includes support of technologies that are market-ready but not yet necessarily ready for widespread market uptake. As more and more technologies advance along the technology readiness scale, it will be increasingly important to help these technologies bridge the gap between development and deployment.

Table 7-3 describes the projects' progress by TRL level, funding, citation, and patent metrics.

Table 7-3. NY-BEST NYSERDA-funded Project Outcomes

Metrics	Data Source	Results
Increase in TRL level	Project records Member interviews	• 39 of 50 projects reported stage of development; 21 of 39 report on stages of development over time • 8 of 21 showed commercialization progress; 2 of 21 have commercially available products
Follow-on funding	Program records Member interviews	• Total follow-on funding across at least 21 projects: $74M
Presentations and citations	Program records Patent analysis	• 32 of 50 projects presented at least one conference • 18 of 42 funding recipients have at least one scholarly output cited as prior art in at least one subsequent patent
Patent applications filed		• 7 of 42 funding recipients reporting to NY-BEST indicated filing for a total of 19 patents • 2 of 19 patents were granted • 38 papers reported to NY-BEST by funding recipients • Funded projects received 140 citations as prior art

7.4 In 2015, how did the program stand relative to its definition of success?

As defined in its program logic model, by 2015 NY-BEST had achieved or made progress toward all the short- and medium-term outcomes and has made progress towards several of its long-term goals. Significant growth in membership (from 49 members in 2010 to 151 in early 2016) — including national and international market actors — and non-grant revenue (from $32K in 2010 to just over 275K in 2015), along with consistently high member satisfaction scores (low of 84%, high of 94%) suggest the

organization was valued by most for the services it provides. NY-BEST also increased the number, variety, and size of conferences, webinars, and other networking opportunities for members, including personal meetings to foster collaborative relationships within the energy storage industry.

One of NY-BEST's key differentiators among other industry groups—and a core strength—is its ability to leverage its substantial networking resources and successful information sharing machine to help propel lesser-known, promising research efforts, technologies, and companies forward along their journey towards yielding commercially-adopted technologies and services. That said, some members felt left out. Two members and one non-member interviewed as part of this research indicated NY-BEST offered them limited benefits because the consortium's main focus was only on certain types of batteries. While NY-BEST must carefully allocate its time and resources and cannot serve everyone equally all the time in this emerging market, there is an ever-present tension between honing a strategic focus and becoming too narrow and thus missing opportunities to support worthwhile niches or lesser-known technologies.

The positive net growth between 2011 and 2015 and the progress exhibited by NYSERDA-funded NY-BEST member projects indicates that a thriving cluster of energy storage researchers and companies had begun to develop in New York State and that this development may have had a positive economic impact on the state's economy. While the evaluation team did not found evidence that NY-BEST had attracted major new manufacturing activity to the State for many types of more established energy storage technologies, it did provide services and testing facility access to companies involved in the research, testing, and commercialization of emerging technologies (as evidenced by test facility records and use of NY-BEST services).

Additionally, the Consortium was involved with a number of policy movements in New York State. In addition to the 2012 and 2016 energy storage roadmaps, NY-BEST has been active in standard-setting and technical committee work, as well as work with ancillary groups affected by energy storage technology developments, such as the Fire Department of the City of New York (FDNY). These and other activities have helped NY-BEST position itself as an important driver of energy storage in New York State.

Several areas in which NY-BEST may be able to improve its operations have become apparent as a result of this research:

- As previously discussed, NY-BEST has been involved in several important policy efforts aimed at improving market conditions for energy storage in New York State. However, substantial uncertainty around business and ownership models continues to hinder market development in the State (particularly for the deployment of energy storage technologies).
- Though it is too early to make a full assessment, to date relatively few projects assisted by NY-BEST have produced commercially available products. It remains to be seen if more products will bridge the gap between R&D and commercial markets in time.
- NY-BEST has a strong focus on battery-related projects and companies, but may be able to engage more actively with companies producing non-battery technologies (such as ultracapacitors).

Appendix B provides a synopsis of the progress towards logic model outcomes. A summary is shown in Table 7-4.

Table 7-4: NY-BEST Progress Towards Short- and Medium-term Goals Described in the Logic Model

Logic Model Short- and Medium-term Outcomes	Data Source	Results
Increased member/non-member satisfaction with NY-BEST offerings	Member and non-member interviews and surveys Program records NY-BEST Financial statements	• 308% membership increase from 2010-2016 • 82%-100% retention rate • 88%-94% satisfaction rating • 86% likelihood of recommending NY-BEST • 8.6-fold increase in non-grant revenues from 2010-2015
Valuable information is shared and put to use	Program records, reports Member interviews Annual member survey	• 67% of members aware of NY-BEST services; 39% of those who are aware also use services. • 36% increase in average conference attendance from 2010 to 2015 • 402 resources existed in the Supply Chain Database • Business guidance for 36 companies in 2010-2015
Productive collaborations and partnerships form	Program records, reports Member interviews Annual member survey	• NY-BEST facilitated 49 personal introductions among members • 26.5% members used NY-BEST services to connect with others in energy storage industry
Outside investors provide follow-on funding to NY-BEST members	NYSERDA financial records CB Insights	• At least 21 NYSERDA-funded projects received follow-on funding (42% of projects with funds distributed), totaling at least $74,245,244 • Investment in energy storage firms located in New York metro area had positive net growth from 2010-2015; average deal increase of 5.92%
Energy storage technologies are commercialized	Program records Member interviews	• Of 56 NYSERDA-funded NY-BEST award contracts between 2010-2015, 3 terminated (PON 2458), 3 were in process, and 50 had funds distributed. • Among 50 projects with funds distributed, 20 were ongoing, 22 were closed, 8 were in contract negotiations, 1 closed due to lack of performance improvement.
Regulatory barriers to energy storage fall	Legislation/regulation review Media coverage Process evaluation peer interview notes Expert interviews Energy storage association policy-related activities	• NY-BEST published energy storage roadmaps in 2012 and 2016 • REV supports grid improvement • Recognition of city code challenges to installing storage in New York City • Standards development: UL 1973, 9540, and 1741 • Technical committee participation: IEC TC 21 and 120 • Work with GRIDSTOR, FDNY, and NFPA

7.5 As of 2015, what impact had the Battery and Energy Storage Technology Test and Commercialization Center (BTCC) and Battery Prototyping Center (BPC) had on NY-BEST members' organizations and technologies tested at the BTCC and BPC labs?

The BTCC and BPC facilities seek to fill a gap for energy storage product developers who need the space, financial support, and/or the third-party review of their products to move them towards commercial viability. As of 2015, these facilities were relatively new and, thus, there was not a lot of data available

yet on the role the BTCC and BPC played in members' use of the services. That said, eight products had been tested and the facilities had earned $503,000 in revenue (based on CAIR reporting). Several members interviewed as part of this research indicated that NY-BEST has played an important role in allowing technologies to advance their TRLs, specifically through the availability of the BPC and BTCC facilities. While there are other facilities that offer these services, one member mentioned that had the BTCC not been available, he would have had to go to Florida to complete the work.[51] A summary is shown in Table 7-5.

Table 7-5. Impact of BTCC and BPC on NY-BEST Member Organizations and Technologies

Metric	Data Source	Results
Increase in demand for BTCC and BPC facility services	Facility usage records (aggregated) Member interviews	• 33 BTCC visits in 2014; 47visits in 2015 • 8 BTCC test programs completed • $503,000 in revenue earned in 2014; $586,000 revenue earned in 2015, corresponding to a $83,000increase • 225 BPC visits from 45 organizations since March 2015 • 552 BPC tests completed • $102K in BPC revenue (June 2015 through June 2016)

[51] As of 2013, at least four such facilities existed in the United States, according to the Sandia National Labs 2013 report *DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA.*

8 Recommendations

Based on the findings of this research, we provide several high-level recommendations meant to build on NY-BEST's current activities.

8.1 Recommendation 1

Leverage existing connections with New York State government entities to provide additional policy support to stakeholders as the State implements the *Reforming the Energy Vision* initiative and other efforts. A key role for NY-BEST might be to identify actions that would increase market certainty around supply of and demand for energy storage in New York State. To date, NY-BEST has focused on disseminating information, fostering business networks, and promoting R&D. Through these efforts, NY-BEST has attained a position of influence within the industry. Experts and members interviewed as part of this research support the notion that, going forward, NY-BEST might use its position to more actively advance the policy priorities. This type of action may include:

- Focusing on educating key legislative stakeholders about the benefits of energy storage in New York State and the status of energy storage policies in competitor states (like Massachusetts and California).
- Continuing to work on codes and standards development to facilitate technology adoption and integration for complex applications, particularly those in grid storage.

8.2 Recommendation 2

In instances where outside investment is lacking, offer a service to formally facilitate small-scale demonstration or pilot projects by connecting commercially viable technologies with end users who may stand to benefit from such technologies. NY-BEST has already provided prototyping, testing, and commercialization facilities. The facilitation of in-field demonstration projects goes one step beyond this, and may be particularly helpful for novel technologies with a limited track record of performance outside the lab or for technologies that face concern regarding their interactions in a field environment. Beyond connecting technologies with test subjects, such a strategy may seek to help member organizations set up a good demonstration project and draw investors' attention to those projects that are successful. While NYSERDA may be able to assist with facilitating funding for demonstration projects, NY-BEST could leverage its network to connect willing partners, including electric utilities.

8.3 Recommendation 3

Formulate a strategy to increase engagement with organizations not solely focused on battery technologies (e.g., those focused on flywheels, fuel cells, thermal energy, compressed air, flow batteries, etc.). While NY-BEST intends to remain focused on grid and large scale transportation energy storage, other market segments can benefit from and contribute to NY-BEST's network. To guard against the risk of losing potentially valuable non-battery members, NY-BEST could carve out and promote some dedicated space (e.g., newsletter section, conference agenda category, webinar series) to ensure that members with non-battery technologies have room to participate in and benefit from NY-BEST's network.

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