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2015 Clean Air Interstate Rule Annual Report on the New York Battery and Energy Storage Technology Consortium

July 2016

NYSERDA's Promise to New Yorkers:

NYSERDA provides resources, expertise, and objective information so New Yorkers can make confident, informed energy decisions.

Mission Statement:

Advance innovative energy solutions in ways that improve New York's economy and environment.

Vision Statement:

Serve as a catalyst – advancing energy innovation, technology, and investment; transforming New York's economy; and empowering people to choose clean and efficient energy as part of their everyday lives.

2015 Clean Air Interstate Rule Annual Report on the New York Battery and Energy Storage Technology Consortium

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Albany, NY

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Summary

Energy storage can play an important role in the reduction of nitrogen oxide (NO_x) and greenhouse gases in two critical sectors: transportation and the electric grid. For example, energy storage can capture and then deploy energy lost during braking in vehicles, including in electrified rail and subway, and store electricity until it is needed on the electric grid. Storage distributed throughout the electric system can also reduce the intermittency of solar electric and wind generated energy, helping these resources to serve as flexible assets when needed. Energy storage capacity can avoid the need for new transmission and distribution infrastructure, increase system efficiency and resiliency, and reduce the requirement for additional fossil fuel plants to meet periods of peak electric demand, which occurs sporadically. It can integrate with demand response and energy efficiency measures within buildings to achieve greater energy savings without sacrificing occupant comfort. It can enable distributed generation to operate independently or "island" from the electric grid during an outage providing greater resiliency. Energy storage will help meet New York's Clean Energy Standard for 50% renewable electric generation by 2030 while achieving the State's greenhouse gas reduction goals, and will be an integral component to enabling the future electric system envisioned under the Public Service Commission's Reforming the Energy Vision.

The New York Battery and Energy Storage Technology Consortium™ (NY-BEST) was established in 2009-2010 to help position New York State as a global leader in energy storage technology for electric grid, transportation, and other large-scale storage applications. NYSERDA was charged with working with industry and academic partners to establish this industry-driven consortium, which is being seeded by NYSERDA with approximately $26 million total through Clean Air Interstate Rule (CAIR) proceeds.

NY-BEST is a New York State not-for-profit corporation and is managed by a 17-member Board elected by the NY-BEST membership. In 2010, the Board hired Bill Acker as executive director and Capitol Hill Management Services to provide association management services to NY-BEST. These services continued in 2015.

S.1 Strategies

NY-BEST uses four primary strategies to build the energy storage industry in New York State:

- Serve as an authoritative resource on energy storage, proactively communicating energy storage related news and information, and facilitating connections amongst stakeholders.
- Advance and accelerate the commercialization process for energy storage technologies, from research and development, to products and widespread deployment.
- Educate policymakers and stakeholders about energy storage and advocating on behalf of the energy storage industry.[1]
- Promote New York's world-class intellectual and manufacturing capabilities and providing access to markets to grow the energy storage industry in New York.

This annual report is prepared pursuant to the Program Plan developed with stakeholder input in 2009 and adopted by the NYSERDA Board and provides an update on NY-BEST progress, expenditures, and results for the year. NYSERDA priorities for NY-BEST during the next year are also presented.

Metrics used to assess the progress of NY-BEST are included for NY-BEST operations; testing, characterization, and prototyping capabilities; and research and development. Commercialization progress related to NY-BEST's activities is also presented. Funds are also budgeted for three independent, external evaluations of the NY-BEST initiative. The first evaluation, a process evaluation, was completed in 2015. This evaluation was designed to provide feedback to support NY-BEST program planning. The evaluation documented NY-BEST program activities and progress toward the consortium's short- and mid-term outcomes. It also benchmarked NY-BEST in comparison to peer organizations and identified lessons about the consortium model that other groups may consider. This evaluation found that NY-BEST is making good progress in delivering valued services to its members and achieving its objectives. Visit nyserda.ny.gov/publications for the report. The second evaluation (a market characterization) began in 2015 and will be completed in 2016-2017. A market impact evaluation will be conducted in 2016.

[1] Any NY-BEST lobbying activities (i.e., attempts to influence decisions of government officials) are funded entirely with non-NYSERDA funding.

S.2 Accomplishments

Highlights of NY-BEST major accomplishments during 2015 include:

- NY-BEST membership remained strong with over 150 companies and research institutions. Approximately 25 percent are from outside of New York State, which presents an excellent opportunity to attract new firms to the State.
- NY-BEST held three conferences and an investor conference with 555 participants in total. In addition, four informational webinars were presented spanning policy and markets with more than 1,000 individuals participating.
- NY-BEST helped members with introductions to potential customers, facilitated product development and commercialization partnerships, helped members with funding applications and investor pitches, and assisted members with understanding and navigating financial and regulatory requirements for energy storage.
- Although relationships and negotiations with investors take time to solidify, numerous NY-BEST members who have presented at a NY-BEST investor conference have subsequently raised significant funding totaling more than $200 million.
- NY-BEST released its Energy Storage Roadmap for New York's electric grid, which illustrates the role that energy storage can play in enabling a cleaner, more efficient, more cost-effective electric grid and includes recommendations for the energy storage industry, policymakers, and stakeholders to consider.
- 96 percent of the $26.2 million in CAIR funds budgeted within the CAIR Program Plan have been expended or committed. This number includes a $4.35 million contract with NY-BEST to partially support operations and management as the consortium becomes operationally self-sufficient; 85 percent of this operations contract has been expended as of December 31, 2015. NY-BEST earned $340,000 in non-NYSERDA funds. Through earned revenue, NY-BEST has expanded its financial reserves to approximately five months of operations to enable a smoother transition when NYSERDA core operation funding is exhausted in 2017.
- In total, 49 NY-BEST research and development projects have been awarded and are in varying stages of completion. These projects include $13.25 million in CAIR funding and $17.1 million in award recipient co-funding.
- A $1.5 million Battery Prototyping Center affiliated with NY-BEST opened at Rochester Institute of Technology with a semi-automated battery pouch cell line for prototyping battery cells.
- NY-BEST was awarded an additional $2 million in State funding through the Regional Economic Development Council to expand new product development activities at the Battery Prototyping Center and BEST Test and Commercialization Center at Eastman Business Park.
- NY-BEST served as an active participant in the Reforming the Energy Vision (REV) proceeding to fundamentally transform the way electricity is distributed and used in New York State and promote a clean, resilient, and affordable energy infrastructure.

1 CAIR Financial Information

Financial data through December 31, 2015 is presented in Table 1, and details are provided in the remainder of this section.

1.1 NY-BEST Operations and Management

NY-BEST operations and management includes a $4.35 million operations contract between NYSERDA and NY-BEST to partially support NY-BEST's operations as the consortium works toward self-sufficiency for its core member services. As of December 31, 2015, 85 percent of this operations contract has been expended with NYSERDA's proportion of total consortium expenditures continuing to decrease. The remaining funds under this contract are anticipated to partially support NY-BEST operations through 2017, at which time the consortium is expected to fund its core member services through non-NYSERDA funding. Some of the activities performed by NY-BEST are economic development in nature, such as recruiting companies to the State and expanding visibility into the energy storage supply chain. These activities do not naturally align with the types of services an individual member would find sufficient value to support. In these cases, grant funding including from NYSERDA may continue to support targeted economic development and sector building efforts.

Table 1. Budgeted and Committed CAIR Funds as of December 31, 2015

Source: NYSERDA

	Budgeted	Expended/Committed [a]
NY-BEST Operations and Management	$4,548,000	$4,396,477
Research and Development Awards	14,609,441	13,962,109
Testing and Characterization Capabilities	3,445,114	3,445,114
NYSERDA Administration	2,211,000	2,202,900
Program Evaluation and Accountability	500,000	475,001
Brokerage Fees for NO_x Allowance Sales	296,105	296,105
New York State Cost Recovery Fee	618,000	429,911
Total	**$26,227,660**	**$25,207,617**

[a] "Committed" includes funds already expended and those that have been committed for specific initiatives.

1.2 Research and Development

Research and development awards have been committed through two Program Opportunity Notices. These opportunities sought seed-stage projects and projects that transition promising storage technologies from proven technical feasibility into working prototypes. Funds are also supporting initial investment in battery safety testing to begin removing uncertainty within fire and building departments, which is delaying consideration of energy storage systems for building energy management.

1.3 Testing and Characterization

Testing and characterization capabilities funding has been fully utilized for the BEST Test and Commercialization Center (BTCC), which allows companies, researchers, and customers to test and validate new energy storage technologies for electric grid, transportation, and other applications.

1.4 NYSERDA Administration

NYSERDA administration covers staffing and direct costs associated with managing the program including the research and development projects, as well as serving in a formative role during the first 21 months of NY-BEST's development until an executive director and staff were hired by the NY-BEST Board.

1.5 Program Evaluation and Accountability

Program evaluation and accountability includes three independent, external evaluations of the NY-BEST initiative with a process evaluation completed in 2015, a market characterization scheduled to be completed in 2016, and an impact evaluation scheduled for 2016-2017.

1.6 Brokerage Fees

Brokerage fees for nitrogen oxides (NO_x) allowance sales represents fees charged by Amerex in selling the CAIR allowances provided to NYSERDA. New York State's regulations that implemented the federal CAIR program are set forth at 6 NYCRR Parts 243 and 244. Ten percent of the NO_x emission allowances allocated to New York under these regulations were directed by the New York State Department of Environmental Conservation to the Energy Efficiency and Renewable Energy Technology Account and

used to establish NY-BEST. During 2015, $227,328 in gross receipts was received from selling additional CAIR allowances and, along with interest earnings, are included in the budget presented. No additional CAIR allowances are expected as a result of CAIR transitioning into the U.S. Environmental Protection Agency's Cross-State Air Pollution Rule during 2015.

1.7 New York State Cost Recovery Fee

New York State Cost Recovery Fee is a shared services fee assessed by the New York State Division of the Budget and billed to NYSERDA.

2 NY-BEST Operations

In December 2010, the NY-BEST Board hired Bill Acker to serve as executive director. The Board selected Capitol Hill Management Services to provide association management services and office space for NY-BEST in January 2011.

John Cerveny was subsequently hired as director of resource development in March 2011. These services continued during the year.

NY-BEST's objective is to build a vibrant energy storage sector in New York State. Reaching this objective involves providing support at various stages of the product development and commercialization pipeline and proactively helping to form partnerships. NY-BEST is helping to facilitate commercial introduction of energy storage technologies in New York State, building the human capital and expertise needed to sustain a vibrant commercial energy storage industry, and leveraging NYSERDA's seed resources to create a sustainable organization that provides value to its members and to New York State.

NY-BEST's operational measures and progress during the year are presented in this section.

2.1 Increased Membership

NY-BEST membership exceeds 150 members, a 200 percent growth since its inception in 2010. Members represent all aspects of the energy storage sector, with academic institutions, research organizations, start-up companies, nonprofit organizations, small- and mid-sized enterprises, and large multinational corporations all well-represented. During the year, the member retention rate remained at over 80 percent, primarily reflecting startup companies discontinuing operations and service providers not renewing. Appendix A lists all members of NY-BEST. During the year, the annual membership fee in NY-BEST remained unchanged at $1,500 for corporate organizational members; $1,000 for academic institutions, nonprofit, and government organizations; and $500 for start-up companies (defined as a company in the energy storage business having 25 or fewer employees). Table 2 presents total revenue earned by NY-BEST including from membership fees.

Table 2. NY-BEST Financial Summary

Accrual Basis; 2015 is unaudited; for the years ended December 31.

Source: NY-BEST Financial Reports

	2015	2014	2013
SOURCES OF FUNDS			
Membership Dues	$131,750	$123,833	$106,288
Conferences	$74,109	$81,155	$41,023
Sponsorships	$69,000	$104,325	$91,945
Non-NYSERDA Grants	$35,312	$31,932	$127,380
NYSERDA Funds	$695,614	$757,540	$778,033
BEST Test Center Revenue Share from Testing Fees	$30,491	$0	$0
TOTAL REVENUE	**$1,036,276**	**$1,098,785**	**$1,144,669**
USES OF FUNDS			
Contracted Services	$677,709	$643,003	$648,394
Professional Services	$71,771	$67,449	$161,747
Conferences	$108,584	$118,411	$103,551
Travel	$29,690	$35,552	$40,742
Marketing	$15,380	$2,315	$2,070
Other Expenses	$48,963	$69,939	$64,670
TOTAL EXPENSES	**$952,097**	**$936,669**	**$1,021,174**
CHANGE IN NET ASSETS	**$84,179**	**$162,116**	**$123,495**

2.2 Progress Toward Reaching Self-Sufficiency

Table 2 presents sources and uses of funds by NY-BEST during the year. In total, 85 percent of the $4.35 million operating support contract between NYSERDA and NY-BEST has been expended. The remaining funds are expected to support a portion of NY-BEST's operations through 2017, with NYSERDA's contribution continuing to decline as earned revenue increases. Non-NYSERDA funds earned by NY-BEST has increased and is used to cover a portion of operating costs and build a reserve fund to enable a smooth transition to sustainability after NYSERDA funding is exhausted. During the

year, non-NYSERDA funds earned by NY-BEST was $340,000. The goal is for NY-BEST to have close to one year's worth of operating cash on hand as reserves when the NYSERDA operating funds are exhausted to support its core member operations. As of December 31, 2015, NY-BEST had approximately five months of operations in reserves.

2.3 NY-BEST Technology Transfer Activities during 2015

During the past year, NY-BEST continued to facilitate connections among energy storage supply chain and manufacturing resources. The first phase in populating the NY-BEST Energy Storage Supply Chain database was completed and the searchable web-based tool allows interested companies and organizations to search and locate resources, assets, and suppliers in New York State. This tool has potential for much greater use in the future.

NY-BEST also continues to work with the New York City buildings and fire departments, as well as with NYSERDA and Con Edison staff, to address challenges in siting energy storage systems in New York City.

Additional technology transfer highlights from the year included:

- Working with the U.S. Department of Energy and Pacific Northwest National Lab to participate in national efforts to summarize existing testing and evaluation guidelines for energy storage technologies.
- Holding NY-BEST's annual conference (Capture the Energy 2015), which was attended by more than 225 participants during two days of presentations and discussions examining energy storage related policies, markets, and technologies. Attendees gave the conference high marks in quality of presentations and networking opportunities.
- In addition to the Capture the Energy conference, NY-BEST held three regional conferences: an Energy Storage Markets Conference in Melville, an Energy Storage Technology Conference in Rochester, and an Investment Conference in New York City. More than 330 individuals attended these events.
- NY-BEST presented four informational webinars covering a market outlook, alternative business models for distributed energy resources, electric and hybrid buses, and energy storage applications on the electric grid. More than 1,000 individuals participated in the webinars and several more viewed the recordings.
- NY-BEST also attended, exhibited, and/or presented at numerous industry conferences, including the ARPA-E Innovation Summit, Energy Storage Alliance's Annual Conference, Intersolar, the Battery Show, and Energy Storage North America.
- In an effort to keep members informed and continue to raise NY-BEST's profile, NY-BEST also provided ongoing electronic communications including the NY-BEST website, e-newsletters, blogs, press releases, and social media.

3 Testing, Characterization, and Prototyping Capabilities

One of NY-BEST's key initiatives is helping companies and researchers access testing, characterization, and prototyping capabilities. These capabilities include leveraging existing assets throughout New York State and establishing a product commercialization center, known as the BEST Test and Commercialization Center (BTCC), to allow companies, researchers, and customers to test and validate new energy storage technologies for electric grid, transportation, and other applications. These capabilities are typically cost-prohibitive for any single entity to procure and maintain, and are not available in close geographic proximity.

In 2011, NY-BEST was awarded $3.5 million through the Finger Lakes Regional Economic Development Council to establish the BTCC at Eastman Business Park in Rochester. This award included $1 million from Empire State Development and $2.5 million from NYSERDA, and is in addition to $3.4 million in CAIR funds. The BTCC opened in April 2014 and is providing unique testing and validation capabilities to evaluate new energy storage technologies from individual cells to megawatt sized systems in operation.

The BTCC is a wholly owned subsidiary of NY-BEST and comprises 17,000 square feet of space. NY-BEST competitively selected DNV GL to operate the lab under an arrangement where DNV GL will staff and operate the BTCC, relocated an existing energy storage testing operation from Pennsylvania to Rochester, and will invest in the BTCC over five years. The initial five-year contract term is renewable based upon performance and provides for revenue sharing back to NY-BEST based on gross revenues beginning in April 2015.

The BTCC's services include a suite of test, validation, and independent certification capabilities that are necessary to introduce new energy storage technologies into the marketplace and accelerate integration of renewable and distributed energy resources. It includes equipment for testing secondary (rechargeable) battery cells and battery packs, as well as temperature test chambers and modular walk-in temperature test chambers. Offering testing from single cells to megawatt systems, the BTCC's services include product development, performance validation and certification testing, and a wide range of environmental testing and battery lifetime testing, including the ability to conduct on-site testing in the field. These services are designed to accelerate the adoption and growth of energy storage technologies.

3.1 BTCC Evaluation Metrics

Metrics used to evaluate the BTCC include:

- Use by members of NY-BEST and by non-members, and fees generated.
- Jobs at the BTCC such as technicians and equipment operators.
- Changes in Technology Readiness Levels and Manufacturing Readiness Levels for technologies examined at the BTCC.
- Commercialization success of products tested at the BTCC.

The lab's grand opening occurred on April 30, 2014, and the first test was conducted on May 28, 2014. The director and two test engineers staff the lab full time. They are supported by five other off-site staff members (business development, operations, health and safety, and finance). During 2015, 15 test programs were completed and five test programs were in progress at year-end, primarily for members of NY-BEST.

Several of the tested products are approaching commercialization and were tested for pre-field installation. This included Eos Energy Storage and Urban Electric Power. A total of $586,000 in testing revenue was earned and DNV GL incurred $983,000 in total expenses operating the center. Revenue sharing back to NY-BEST from the BTCC began in April 2015. In March 2015, the BTCC received American Association for Laboratory Accreditation for International Organization for Standardization (ISO) 17025 Lab Quality.

3.2 Battery Prototyping Center

Recognizing the need for battery and energy storage prototyping, a semi-automated pouch cell line and dry room was established at Rochester Institute of Technology (RIT) to provide prototyping capabilities to companies, researchers, and entrepreneurs. These capabilities were necessary to enable new materials and cell components to be validated in an industry-accepted battery or ultracapacitor cell "form factor." In particular, potential customers want to test new materials, electrolytes, and electrodes in a cell that resembles a commercial product. The center opened during the first quarter of 2015. New York State committed $1.1 million for the center, which was comprised of $750,000 in NYSERDA funding through NY-BEST and $350,000 in funding from Empire State Development (ESD).

Through agreements with New York State and NY-BEST, RIT will operate and own the facility with the input and guidance of an advisory board, and will provide staffing and additional investments in the facility. In addition, RIT will leverage its status as a research university to seek competitive grants and funding to use and expand the expertise and research capabilities of the Battery Prototyping Center. This facility is available on a discounted fee basis to NY-BEST members, RIT faculty and researchers, as well as to other companies and entities with battery prototyping needs.

In 2015, NY-BEST submitted an application to New York State's Finger Lakes Regional Economic Development Council seeking funding to expand the capabilities and offerings at both the Test Center and Battery Prototyping Center. NY-BEST was awarded $2 million in State funding to support new product development activities at these facilities and is prioritizing necessary capabilities for action in 2016.

Metrics used to evaluate research and development awards include publications, presentations at technical and business conferences, invention disclosures and patents, licensing agreements executed and licensing revenue, additional research funding received, research and development jobs supported, recognition awards and significant research accomplishments, and commercialization progress.

4 NY-BEST Research and Development

NYSERDA awards and manages all research and development funding using NYSERDA's established solicitation process with input from the energy storage community and NY-BEST. These awards complement NYSERDA's existing energy storage programs by focusing on transitioning new energy storage technologies with proven technical feasibility into working prototypes.

In total, 49 NY-BEST research and development projects have been awarded and are in varying stages of completion. Figure 1 shows these projects by underlying energy storage technology. Figure 2 shows intended applications and reflects the composition of the NY-BEST membership, which primarily focuses on electric grid and transportation applications. A wide range of chemistries and systems, each possessing unique attributes best suited to a specific use case have been supported.

Figure 1. Research Projects by Underlying Chemistry

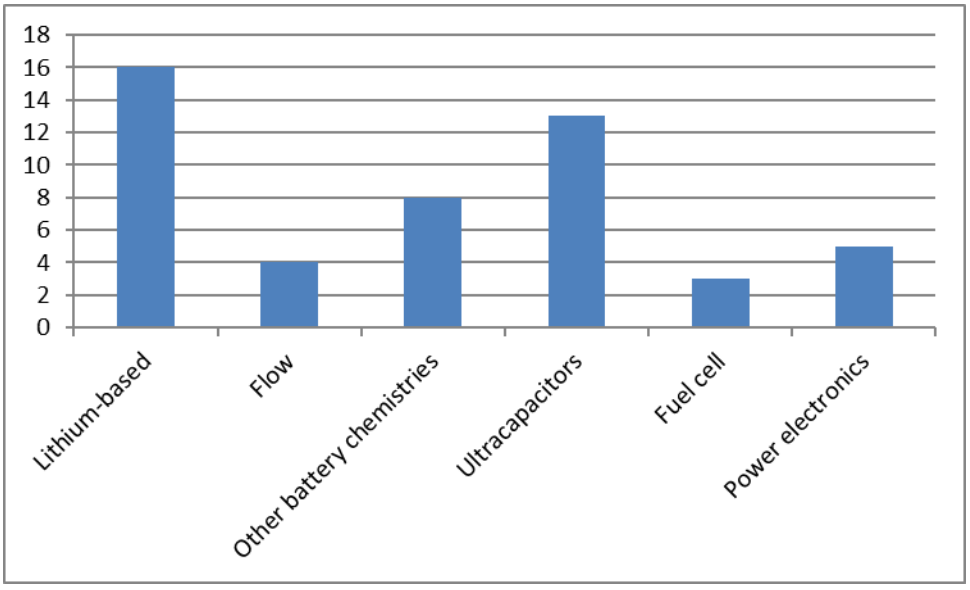
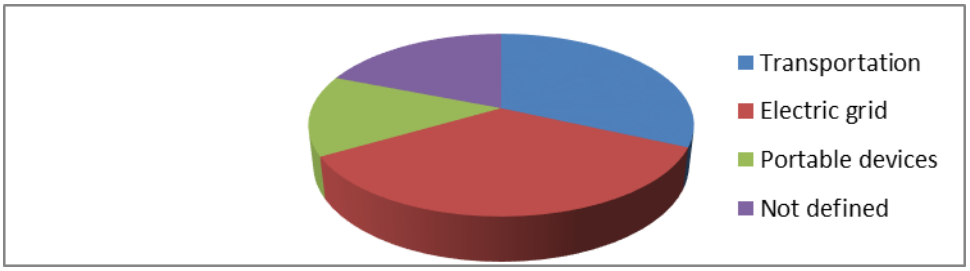


Figure 2. Intended End Use Applications



4.1 Program Opportunity Notice 1704

The following 16 projects were awarded in March 2010 under Program Opportunity Notice 1704, which supported seed and product development projects:

- Binghamton University (Binghamton): Dr. Stan Whittingham pursued a lithium air energy storage system for vehicles and stationary applications.

  NYSERDA: $200,000; Co-funding: $78,410

  Status: completed; work has been presented at 20 conferences and included in 5 publications

- Brookhaven National Laboratory (Upton): Dr. Feng Wang is examining lithium-titanate batteries for lower cost electric grid storage.

  NYSERDA: $200,000; Co-funding: $100,000

  Status: ongoing; work was presented at one conference and included in three publications

- Binghamton University (Binghamton): Dr. Stan Whittingham partnered with Brookhaven National Lab and Stony Brook University to develop improved batteries for lower cost electric grid storage examining lithium-ion batteries.

  NYSERDA: $152,890; Co-funding: $147,000

  Status: completed; work was presented at five conferences and included in three publications

- Stony Brook University (Stony Brook): Dr. Esther Takeuchi is examining new materials for lithium-ion batteries with improved performance and lower cost for electric grid storage.

  NYSERDA: $200,000; Co-funding: $200,000

  Status: ongoing; work was presented at seven conferences and included in six publications

- Cerion Enterprises (Rochester): Researchers explored nanoparticle materials for next-generation lithium-ion batteries, which could make the batteries smaller and lighter, which are important characteristics for transportation applications.

  NYSERDA: $200,000; Co-funding: $151,072

  Status: completed; work has been presented at four conferences, included in two publications, and resulted in five patent filings

- City University of New York (New York City): Pursuing a low-cost nickel-zinc flow battery that could be used in hybrid electric vehicles.

  NYSERDA: $200,000; Co-funding: $50,000

  Status: ongoing; this work leveraged almost $2 million in ARPA-E and National Science Foundation funding and the technology has been licensed to Urban Electric Power, a startup company

- City University of New York worked with Columbia University (New York City): Pursuing metacapacitors using a printable material to create high voltage, high energy, and high power density capacitors for energy storage.

  NYSERDA: $149,597; Co-funding: $1,649,865 including an ARPA-E award

  Status: completed; a $1.6 million ARPA-E award was received; the technology was presented at six conferences and included in nine publications

- SUNY Polytechnic (Albany): Dr. Pradeep Haldar and Dr. Manisha Rane-Fondacaro developed new electrolytes to improve performance of ultracapacitors.

  NYSERDA: $200,000; Co-funding: $116,263

  Status: completed; Eonics, a startup company, was formed to commercialize this technology and has attracted over $3.5 million in grants and investments; six presentations were made and the technology was described in two publications

- Cornell University (Ithaca): Dr. Emmanuel Giannelis developed nonflammable battery electrolytes with improved safety and performance.

  NYSERDA: $200,000; Co-funding: $213,652

  Status: completed; results were presented at five conferences and included in two publications

- General Electric Co. (Schenectady): Under the largest NY-BEST R&D award made under this first funding round, GE partnered with Alfred University (Alfred), Clarkson University (Potsdam), Columbia University (New York City) and Stony Brook University (Long Island) to explore enhancements to the next generation of its sodium metal halide batteries for uninterruptible power backup systems, electric grid applications and heavy-duty transportation.

  NYSERDA: $2,500,000; Co-funding: $2,994,063

  Status: completed; the company decided not to pursue commercialization of this battery chemistry

- General Motors (previously in Honeoye Falls, NY, and now in Detroit, MI), in conjunction with Cornell University (Ithaca): Evaluated new materials for improved lithium-ion battery electrodes for automotive applications to increase performance and reduce cost.

  NYSERDA: $150,922; Co-funding: $67,581

  Status: completed; a provisional patent was filed for the underlying technology and was transferred to Cornell University

- Hollingsworth & Vose, Co. (Easton): Explored a new advanced separator for more efficient valve-regulated lead-acid batteries used in start-stop hybrid electric vehicles.

  NYSERDA: $119,965; Co-funding: $85,951

  Status: completed; the new separators did not show adequate performance improvements to justify their cost and the project was terminated; the company is exploring other separator formulations

- Impact Technologies (Rochester): Explored a novel method to increase the lifetime of batteries by assessing battery health through in-cell measurement techniques.

  NYSERDA: $99,766; Co-funding: $27,115

  Status; ongoing; the company has received over $3 million in outside investment and the work has been presented at two conferences

- Ioxus (Oneonta): Exploring enhancements to its ultracapacitors by developing a novel electrode-electrolyte interface in conjunction with the City University of New York.

  NYSERDA: $200,000; Co-funding: $200,000

  Status: completed; Ioxus continues to grow, now employing almost 100 staff at its manufacturing facility in Oneonta and having raised over $21 million in venture capital.

- Rensselaer Polytechnic Institute (Troy): Dr. Nikhil Koratkar developed nanoengineered silicon based electrodes that could enable greater power and energy density and reduce the cost of lithium-ion batteries.

  NYSERDA: $200,000; Co-funding: $424,179

  Status: completed; received a $396,000 National Science Foundation grant to support follow-on work; project was presented at one conference and included in two publications; the technology was part of the underlying basis for spinning out Enermat Technologies to commercialize this technology

- Rochester Institute of Technology (Rochester): Dr. Gabrielle Gaustad evaluated methods that can help recycle and reuse lithium-ion batteries to minimize landfill waste and maximize reclamation.

  NYSERDA: $195,387; Co-funding: $157,200

  Status: completed; the project was presented at five conferences and included in four publications

4.2 Program Opportunity Notice 2458 Round 1

The second research and development solicitation issued by NYSERDA (PON 2458) focused on transitioning energy storage technologies with proven technical feasibility at the lab scale into working prototypes to assess whether the technology has commercial potential. Demonstrating a working prototype is an important stage that can interest additional funders including private capital. Five rounds were included.

Seven awards were made in July 2012 under Round 1 of PON 2458:

- Custom Electronics Inc. (Oneonta): Explored a graphene electrolytic capacitor that could provide extra energy to ride through momentary electric fluctuations or interruptions on the electric grid.

  NYSERDA: $250,000; Co-funding: $421,032

  Status: completed; patent applications have been submitted and the work was presented at one conference

- SUNY Polytechnic (Albany): Explored an ionic liquid electrolyte to enhance lithium-ion capacitors for improved short-term energy storage in hybrid vehicles and power electronics.

  NYSERDA: $249,979; Co-funding: $251,170

  Status: completed; a research agreement is being explored with a company partner

- Graphenix Development (formerly Graphene Devices Ltd.) (Williamsville/Rochester): Developed a graphene-based high energy ultracapacitor with up to three times the energy density of current commercial devices at similar cost, which can be used in smart grid devices and hybrid vehicles.

  NYSERDA: $300,000; Co-funding: $330,000

  Status: completed; several patent applications were submitted; a $1 million joint development agreement was executed with a capacitor manufacturer worth potentially several million dollars per year in electrode sales

- Ioxus (Oneonta): Developing thermally optimized ultracapacitors for hybrid vehicle applications.

  NYSERDA: $250,000; Co-funding: $250,000

  Status: completed; initial results showed some promising incremental improvements to enable better heat dissipation from the cells, and better cycling; work continues beyond the scope of this agreement for those areas most promising

- Paper Battery Co. (Troy): Developed a production prototype of its thin and flexible ultracapacitor to provide temporary backup power systems.

  NYSERDA: $250,000; Co-funding: $353,000

  Status: completed; the company has raised $6.4 million in funding including a $3 million Series A financing to move toward commercial production of their ultracapacitor technology for mobile electronics; three patents have been issued

- Primet Precision Materials (Ithaca): Sought to develop a production process that could lower the manufacturing cost of key raw materials used in lithium-ion batteries.

  NYSERDA: $250,000; Co-funding: $365,835

  Status: completed; the work has been presented at two conferences and published in one scientific journal

- Urban Electric Power (New York City): Developing a megawatt-hour battery for peak power reduction using a novel "flow-assisted" zinc anode battery with an advanced battery management system.

  NYSERDA: $249,847; Co-funding: $249,847

  Status: ongoing; the company has raised over $2 million from investors

4.3 Program Opportunity Notice 2458 Round 2

Seven awards were made in February 2013 under Round 2 of PON 2458:

- Battery Energy Storage Systems (BESS) Technologies (Albany): Collaborated with SUNY Polytechnic Institute and Rensselaer Polytechnic Institute to evaluate a graphene-based electrode for lithium-ion batteries that can store more energy and charge faster than those currently deployed.

  NYSERDA: $218,000; Co-funding: $218,000

  Status: completed; results were presented at one conference and joint development partnerships are being pursued; company has received a $250,000 angel investment

- Bettergy Corp. (Peekskill): Pursuing improvements to a low-cost zinc air-flow battery that could be used for grid storage applications.

  NYSERDA: $189,000; Co-funding: $189,000

  Status: ongoing; results were presented at three conferences; work is continuing under a $385,000 grant from ARPA-E

- Custom Electronics (Oneonta): Developing an ultracapacitor with increased energy storage potential to provide shorts bursts of power over very long lifetimes for industrial power electronic applications and hybrid vehicles.

  NYSERDA: $250,000; Co-funding: $257,300

  Status: ongoing; work has been presented at one conference

- Eos Energy Storage (New York City): Scaling a novel zinc battery with low-cost, high energy-density and an inherently safe design for electric grid storage applications.

  NYSERDA: $250,000; Co-funding: $386,149

  Status: ongoing; the company is contracting with a New York State manufacturer to produce its batteries; prototype units have been tested by utilities; company recently raised $15 million in private capital; results were presented at three conferences; the product is approaching initial commercial sales

- NOHMS Technologies (Ithaca and Rochester): Developing and testing a new prototype for longer-lasting batteries for mobile phones and power electronics.

  NYSERDA: $250,000; Co-funding: $250,000

  Status: ongoing; one patent application was submitted; $600,000 in federal/industry research and development grants were previously obtained, $1.35 million in private capital has been raised, and the company recently received a $750,000 NASA award

- UTS Engineering (formerly Electromotive Designs) (Ronkonkoma): Pursuing a low-cost, easily installed, hybrid-electric, add-on system to recapture braking energy in buses and trucks using ultracapacitors manufactured by Ioxus in Oneonta, NY. Verizon will test the system.

  NYSERDA: $249,980; Co-funding: $315,740

  Status: ongoing; a patent application has been submitted

- Watt Fuel Cell Corp. (Port Washington): Building a prototype capable of providing electricity and heat from a portable solid-oxide fuel cell for military applications and backup power during electric grid outages.

  NYSERDA: $249,704; Co-funding: $812,696

  Status: ongoing; the work has been presented at three conferences

4.4 Program Opportunity Notice 2458 Round 3

Six awards were made in January 2014 under Round 3 of PON 2458.

- Custom Electronics, Inc. (Oneonta, NY): Working with Binghamton University to develop a new electric capacitor for power conditioning applications. This new capacitor will incorporate a flexible roll-to-roll manufacturing process and could provide high energy density, greater tolerance to temperature, and graceful aging characteristics.

  NYSERDA: $250,000; Co-funding: $269,406

  Status: ongoing; results have been presented at one conference

- Cornell University (Ithaca, NY): Working with company partner Proton to develop and demonstrate a regenerative fuel cell energy storage system based on an anion exchange membrane designed at Cornell to produce hydrogen. This technology will seek to address a key obstacle in renewable hydrogen production from electrolysis by reducing the cost of expensive platinum catalysts.

  NYSERDA: $250,000; Co-funding: $250,000

  Status: ongoing

- Ambri (Cambridge, MA): Will work with Consolidated Edison (NYC) and the BEST Test and Commercialization Center (Rochester, NY) to develop and test a working prototype of Ambri's novel Liquid Metal Battery comprising 6.25 kW and 25 kWh. Initial system development was funded by ARPA-E through a $6.9 million award that helped form the underlying technology licensed by MIT to Ambri in 2010.

  NYSERDA: $250,000; Co-funding: $627,900

  Status: ongoing; patent applications have been submitted; the project has been presented at two conferences and submitted to one publication

- Columbia University (New York, NY): Will scale an electrochemical technology coupled with a bioreactor, which was successfully developed under a $1.5 million ARPA-E award, to convert electricity into energy stored in a liquid fuel. The technology, if successful, will produce biofuels from electricity and from CO_2 with minimal land and environmental burdens.

  NYSERDA: $249,367; Co-funding: $271,621

  Status: ongoing; a patent application has been submitted

- Widetronix (Ithaca, NY): Worked with the Cornell Nanoscale Facility to enhance the power density of the Widetronix betavoltaic platform, which is a millimeter-scale semiconductor chip that converts an embedded isotope into very small amounts of DC electricity for decades of use, such as would be used in sensors. Target markets include those where the longevity, high power density, and robustness in harsh environmental conditions are important characteristics for critical monitoring needs.

  NYSERDA: $249,067; Co-funding: $442,937

  Status: completed; company received an $800,000 angel investment and is pursuing joint development agreements

- Rensselaer Polytechnic Institute (Troy, NY): Working with Finch Paper (Glens Falls) and JNC (Rye) to explore high-energy density cathode materials for lithium-sulfur batteries using a green chemistry approach that uses a low-cost byproduct from the paper industry.

  NYSERDA: $122,009; Co-funding: $122,026

  Status: ongoing; results have been presented at two conferences

4.5 Program Opportunity Notice 2458 Round 4

Seven awards were made in August 2014 under Round 4 of PON 2458.

- Bettergy (Peekskill, NY): Developing a low-cost rechargeable Zn-MnO_2 battery (similar to a primary alkaline battery) for a projected sale price of less than $100/kWh, a point at which widespread adoption for electric grid applications would be practical.

  NYSERDA: $249,852; Co-funding: $249,852

  Status: ongoing; project has been presented at one conference

- Graphenix Development (Williamsville, NY): Working to commercialize a nanostructured graphene-based electrode for high power, high energy ultracapacitors for applications including hybrid vehicles (start/stop) and hybridized batteries. The company is also leveraging the roll-to- roll manufacturing capabilities at Eastman Business Park in Rochester.

  NYSERDA: $249,998; Co-funding: $249,998

  Status: completed and results incorporated into status of Graphenix project presented in PON 2458 Round 1 above

- Combined Energies (Latham, NY): Partnering with UTS Engineering (Ronkonkoma, NY) to develop a low-cost power conversion device to increase the life of electrochemical batteries in stationary and mobile applications. The team will initially target the airport ground support equipment market and then materials handling equipment and specialty mining vehicles and will field test the system under this project at a Southwest Airlines hub in New York State.

  NYSERDA: $299,495; Co-funding: $299,495

  Status: ongoing; one patent has been received and the work has been presented at one conference; company is moving to next phases of work with potential customers testing the system and has been selected by a battery manufacturer to provide power conditioning equipment

- Lionano (Ithaca, NY): Seeking to commercialize a high-performance nanoengineered anode material for the lithium-ion battery sector.

  NYSERDA: $250,000; Co-funding: $282,177

  Status: ongoing; a patent application has been submitted

- Eonix (Colonie, NY): Developing next-generation electrolytes that increase energy storage capabilities of ultracapacitors with increased voltage and a wider temperature range.

  NYSERDA: $250,000; Co-funding: $250,000

  Status: ongoing

- Custom Electronics (Oneonta, NY): Partnering with UTS Engineering (Ronkonkoma, NY) to construct prototype devices for field-testing and develop a detailed commercialization plan for a high voltage graphene-based electrolytic capacitor for power-conditioning applications such as servers and electrical equipment.

  NYSERDA: $250,000; Co-funding: $369,834

  Status: ongoing

- Raymond Corporation (Greene, NY): Working with Navitas Systems (a lithium-ion manufacturer) to develop and test an advanced lithium-ion energy storage system for electric lift trucks. Compared to existing lead acid technology, this energy storage system could enable improved cold temperature performance, lower operating costs, more efficient opportunity charging during operator breaks, and increased productivity.

  NYSERDA: $250,000; Co-funding: $434,617

  Status: ongoing; the work has been presented at two conferences

4.6 Program Opportunity Notice 2458 Round 5

Six awards were made in March 2015 under Round 5 of PON 2458, and projects are beginning:

- Urban Electric Power (New York City): Will demonstrate a rechargeable Zn-MnO_2 battery chemistry developed by City University of New York with ARPA-E funds, and move toward a target sale price of less than $100/kWh for grid applications.

  NYSERDA: $249,898; Co-funding: $249,898

  Status: in contract negotiation

- Applied Power Systems (Hicksville, NY): Developing a multi-chemistry battery charger / low voltage power supply for use on commuter rail cars to improve the functionality and efficiency of a charger originally designed exclusively for lead acid batteries.

  NYSERDA: $205,686; Co-funding: $205,686

- Varta Microbattery (Rye, NY): Developing a backup power system for residential solar electric systems by leveraging the solar inverter and developing an island interconnection device to serve as the interface between the building's microgrid and the electric grid.

  NYSERDA: $250,000; Co-funding: $405,000

- Enermat Technologies (Clifton Park, NY): Commercializing high performance graphene anodes for li-ion batteries with increased energy and power densities, and excellent cycle life with target markets in the electric grid and transportation sectors.

  NYSERDA: $249,859; Co-funding: $249,859

- American Fuel Cell (Rochester, NY): Demonstrating the manufacturing scale up of fuel cell membrane electrode assemblies using high volume, roll-to-roll equipment and evaluating performance metrics to assess superiority of the company's membranes in targeted applications including transportation.

  NYSERDA: $250,000; Co-funding: $320,625

- PowerHub Systems (Blacksburg, VA) and Applied Power Systems (Hicksville, NY): Developing a high-density silicon-carbide-based power inverter for grid interfaced small footprint energy storage systems with better performance, higher efficiency, and potentially lower cost than alternative products.

  NYSERDA: $249,925; Co-funding: $249,953

5 Commercialization Progress

Commercialization progress for members of NY-BEST is measured by outside funding received including grants and private investment, product sales and new products launched, licenses executed and licensing revenue, cost savings, capital expenditures, and jobs created and retained. Energy, economic, and environmental benefits realized by utilizing energy storage will also be assessed as part of the independent evaluations conducted.

This section presents commercialization progress of NY-BEST members who were assisted by NY-BEST's staff during the year. This assistance included introductions to new partners, facilitating product development and commercialization partnerships, helping with investor pitches, identifying funding opportunities, and helping members understand and navigate financial and regulatory requirements for energy storage. NY-BEST members have achieved the following results, in part, as a result of these activities. Commercialization progress related to research and development awards is included in the NY-BEST Research and Development section.

Investor Funding: In addition to advising and providing introductions and coaching throughout the year, NY-BEST continued its annual Energy Storage Investment Conference where selected NY-BEST members present to leading venture capital, angel, and institutional investor firms including GE's investment arm, Kleiner Perkins, and Braemar Energy Ventures. NY-BEST coached and helped seven member companies prepare for presentations at the 2015 NY-BEST Investor Conference in New York City. Although many of these relationships and negotiations take time to solidify, numerous NY-BEST members who have presented at a NY-BEST investor conference have subsequently raised significant funding totaling more than $200 million, including Green Charge Networks ($56 million), Eos ($40 million), Ambri ($50 million), Ioxus ($69 million), Paper Battery ($4 million), NOHMs ($1.8 million), Widetronix ($2.2 million), Graphenix ($1.5 million), and EnStorage ($17 million). Other funding efforts are in due diligence and/or not publicly disclosed.

Grant Funding: NY-BEST routinely provides advice and guidance for member companies in their funding applications and worked closely with over two dozen members to identify specific grant funding opportunities and help them prepare, edit, review, and submit more than four dozen applications to federal, New York State, and nonprofit organizations during the year. A number of these were subsequently selected for funding totaling over $10 million from organizations including NASA, U.S. Department of Energy, ARPA-E, the U.S. Advanced Battery Consortium, and the U.S. Navy. NY-BEST members receiving awards included Bren-Tronics, Applied Power Systems, Varta Microbattery, Enermat Technologies, American Fuel Cell, PowerHub Systems, Applied Power, Urban Electric Power, NOHMs, Bettergy, Cadenza, and Eos.

Facilitating R&D and Product Development Partnerships: NY-BEST plays an active role forging new partnerships among members through direct introductions and by providing numerous face-to-face networking opportunities throughout the year. Direct introductions between companies related to product development and R&D occurred 13 times over the past year. Important introductions were made for battery developers to companies in the supply chain to provide key materials, processing and/or expertise needed to move their products from the prototype stage into production. Examples where NY-BEST facilitated introductions include connecting a battery developer to a customer; 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.

Technical and Business Guidance/Early Stage Mentoring: In the past year, NY-BEST provided more than three dozen established and start-up companies with substantive and, often, ongoing technical and business guidance. These companies included Bettergy, Viridity, Demand Energy, Lionano, NOHMs, Eos, Standard Hydrogen, Xallent, Tumalow, Tesla, Stasis, Navigant, OSW Power, Vizn Energy, Tabuchi, Schneider Electric, Stem, Brammo, Cadenza, Phillips Lytle, Effen Systems, Bollinger Motors, NTEA, EverOn24, Greenwich Energy, Innovari, SolarCity, C4V, Constellation, ABB, BYD, Vionx, Stem, Fluidic, Wildan, Convergent Energy, Stasis Energy, Nextera Energy, and BYD. These advising and services spanned areas as diverse as business development and market entry strategies (including siting requirements for energy storage in buildings in New York City) to connections to resource providers in legal, financial, technical and manufacturing arenas. Evidence of the outcomes is best measured in the continued growth of the NY-BEST membership and success of individual companies through product sales and new jobs that will be evaluated as part of the impact analysis scheduled in 2016-2017.

6 Priorities During the Next Year

NYSERDA's priorities for NY-BEST during 2016 include:

- Continue to build a self-sustaining organization delivering core member services without the need for additional NYSERDA operational funding beyond 2017 to support these core activities.
- Contribute to a thriving energy storage industry in New York State measured by employment and sales growth at members, and greater numbers of companies participating in the energy storage value chain in New York State.
- Successfully grow the BTCC, maintaining a high level of facility utilization, and helping members bring new profitable energy storage products to market; expand the center's offerings as member needs evolve including adding battery safety testing.
- Help to forge new product development and commercialization partnerships between members including expanding and leveraging the energy storage supply chain database.
- Play an active role in helping to transition New York State's electric system under Reforming the Energy Vision and the Clean Energy Standard.

Appendix A: NY-BEST Members

1. Advanced Energy Center at Stony Brook University
2. AES Energy Storage
3. Alfred University
4. alpha-En Corporation
5. Ambri
6. American Fuel Cell
7. American Renewable Energy Associates, Inc.
8. American Vanadium Corp.
9. Apogee Power USA
10. Applied Power Systems
11. AppliedLogix LLC
12. Arnold Magnetic Technologies
13. Ascension Industries Inc.
14. BAE Systems Controls
15. Bess-Tech
16. Bettergy Corp.
17. Binghamton University, SUNY
18. Bond, Schoeneck & King PLLC
19. Braemar Energy Ventures
20. Bren-Tronics Inc.
21. Brookhaven National Laboratory
22. Cadenza Innovation
23. CEC Energy
24. Center for Economic Growth
25. Central Hudson Gas & Electric
26. Charge CCCV LLC
27. City University of New York (CUNY)
28. Clarkson University
29. CODA Energy
30. Columbia University
31. Combined Energies LLC
32. Conamix Inc.
33. Consolidate Energy Solutions LLC
34. Consolidated Edison Company of New York, Inc.
35. Constellation (An Exelon Company)
36. CooperHill
37. Cornell University
38. Corning Incorporated
39. CQuest Partners LLC
40. CSA Group
41. Curtis Instruments, Inc
42. Custom Electronics, Inc.
43. Customized Energy Solutions
44. Delta Products Corporation
45. Demand Energy Networks
46. DNV GL
47. EaglePicher Technologies, LLC
48. Eastman Business Park
49. ECG Consulting Group Inc.
50. Elco Motor Yachts, LLC
51. Electron Storage, Inc.
52. Energy Technology Savings, LLC
53. Enerlogic LLC
54. EnerMat Technologies
55. EnStorage Inc.
56. EnSync Energy Systems
57. Eonix
58. EOS Energy Storage
59. EWI
60. Expansion Energy LLC
61. Fire & Risk Alliance, LLC
62. Fluidic Energy
63. G4 Synergetics, Inc.
64. General Electric
65. Genesis Energy Systems LLC
66. Graphenix Development
67. Green Charge Networks
68. Grid Energy
69. Harris Beach PLLC
70. Hecate Energy LLC
71. Helix Power Corporation
72. Heslin Rothenberg Farley & Mesiti PC
73. Hitachi America Ltd.
74. Hollingsworth & Vose
75. Hydrogenics Corporation
76. Hylie Products, Inc.
77. ICF International
78. ICL-IP America Inc
79. Ideal Power Converters
80. Innovation Core SEI, Inc.(Sumitomo Electric)
81. Intertek Testing Services NA, Inc
82. Invenergy Storage Development LLC
83. IPLAN Access
84. ITM Power Inc
85. Johnson Controls, Inc.
86. JuiceBox Energy, Inc.
87. Landis+Gyr
88. LeChase Construction Services

89. LG Chem ltd.
90. LG CNS America Inc.
91. Lionano
92. Lumens Energy
93. Lux Research Inc.
94. MeOH Power, Inc.
95. Mesha, LLC
96. MGA Research
97. MPEG LA
98. National Grid
99. Navitas Systems
100. NEC Energy Solutions
101. New York Institute of Technology
102. New York Power Authority
103. New York State Electric & Gas
104. NextEra Energy
105. NGK-Locke, Inc.
106. NOHMs Technologies, Inc
107. Northeast Transportation Electrification Alliance
108. Northern Power Systems
109. Novorocs Technologies
110. NRG Energy
111. O'Brien & Gere
112. O'Connell Electric
113. OneD Material LLC
114. Pacific Northwest National Laboratory
115. Paper Battery Company
116. Peak Power Energy Corp
117. Phillips Lytle LLP
118. PowerHub Systems
119. PowerPHASE LLC
120. Primet Precision Materials, Inc.
121. Primus Power
122. Renewable Energy Systems
123. Rensselaer Polytechnic Institute
124. River Road Research, Inc.
125. Rochester Gas and Electric
126. Rochester Institute of Technology
127. S&C Electric Company
128. Saft America, Inc.
129. Samsung SDI
130. Sendyne Corp
131. Sharp SEC – ESSG
132. Skyview Ventures LLC
133. SolarCity
134. Solid Cell Inc.
135. Stem, Inc.
136. SUDANO Consulting Inc.
137. Sustainable Innovations
138. Syracuse University
139. Tesla Motors
140. The Raymond Corporation, Division of Toyota Industries
141. Third Power
142. Ultralife Corporation
143. UniEnergy Technologies, LLC
144. Unique Technical Services LLC
145. University of Rochester
146. Urban Electric Power Incorporated
147. Valence Technology
148. VARTA Microbattery Inc.
149. VIONX Energy Corporation
150. Voltaiq
151. Watt Fuel Cell
152. Widetronix Inc.
153. Xcogen Energy, LLC

Appendix B: NY-BEST Board of Directors

The 17 member NY-BEST Board of Directors, elected by the membership, represent industry, the research community, end users, and government partners. Terms are staggered so that half of the Board seats are elected each year. The Board meets approximately five times each year with the Executive Committee meeting monthly. Officers and board members during 2015 are listed below. Those whose seats changed in 2015 after this reporting period are noted with an asterisk.

Michael Field, Raymond Corporation
Chair of the Board

Cathy Hill, CooperHill and Skidmore College
Vice Chair, At Large

Glen Merfeld, GE Global Research*
Vice Chair, Industry

Stan Whittingham, Binghamton University, SUNY
Vice Chair, Academia

Paul Mutolo, Cornell University and Center for Future Energy Systems
Treasurer/Secretary

Fernando Gomez Baquero, BESS Technologies

Victor Cardona, Heslin Rothenberg, Farley & Mesiti PC

Rick Fioravanti, ICF International *

Alex Fraenkel, NextEra Energy Resources

Matt Fronk, Matt Fronk and Associates

Robert Hull, RPI

Patrick McHugh, Consolidated Edison Co.

Jim Misewich, Brookhaven National Laboratory

Ryne Raffaelle, RIT

John Rhodes, NYSERDA (the President and CEO of NYSERDA serves as a permanent director)

Barry Watkins, Alfred University

Matthew Watson, Empire State Development (the Executive Director of NYSTAR serves as a permanent director)

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975.

To learn more about NYSERDA's programs and funding opportunities, visit nyserda.ny.gov or follow us on Twitter, Facebook, YouTube, or Instagram.

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State of New York
Andrew M. Cuomo, Governor

New York State Energy Research and Development Authority
Richard L. Kauffman, Chair | John B. Rhodes, President and CEO

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