NYSERDA ENERGY STORAGE AND NY-BEST PROGRAM: IMPACT EVALUATION

Appendices

Prepared For:

New York State Energy Research and Development Authority (NYSERDA)
Albany, NY

Jennifer Phelps
NYSERDA Project Manager

Prepared By:

EMI CONSULTING

83 Columbia Street
Seattle, WA 98104
206/621-1160

Todd Malinick, Project Manager

Kara Crohn, Senior Technical Lead

Michael Hamilton, Lead Analyst

INDUSTRIAL ECONOMICS, INCORPORATED (IEc)

2067 Massachusetts Avenue
Cambridge, Massachusetts 02140
617/354-0074

Cynthia Manson, Principal

NYSERDA Contract 32883 March 2017

Notice

This report was prepared by EMI Consulting in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority (hereafter "NYSERDA"). The opinions expressed in this report do not necessarily reflect those of NYSERDA or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, NYSERDA, the State of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. NYSERDA, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

NYSERDA makes every effort to provide accurate information about copyright owners and related matters in the reports we publish. Contractors are responsible for determining and satisfying copyright or other use restrictions regarding the content of reports that they write, in compliance with NYSERDA's policies and federal law. If you are the copyright owner and believe a NYSERDA report has not properly attributed your work to you or has used it without permission, please email print@nyserda.ny.gov.

Appendices

Appendix A: Detailed Methods

The primary objective of this task, the impact evaluation, was to document the influence the NY-BEST Consortium had through early 2016 on the energy storage market in New York State. 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.

The evaluators applied a mixed-methods design to address the research questions and gather metrics used to assess NY-BEST progress towards its goals. 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 member survey; 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: *An Analysis of the Technological Impact of NY-BEST Funded Energy Storage Research (Finalized June 2016).*

Table A-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 BTCC and BPC had on NY-BEST members' organizations and technologies tested at the BTCC and BPC labs?	X		X	

Program Data Review

The evaluation team reviewed the following program data as part of this research. In all cases, documents were reviewed and key data were summarized in a single spreadsheet. Where appropriate, data were color-coded by theme.

- NY-BEST member lists
- NY-BEST non-members lists
- NY-BEST annual member survey responses
- Annual CAIR reports
- Audited financial statements for 2010-2014
- Unaudited financial statement for 2015
- NYSERDA program documentation on events/webinars
- Facility reports for the Battery and Energy Storage Test and Commercialization Center
- Facility reports for the Battery Prototyping Center
- NYSERDA program documentation on funded projects
- Federal Census data for New York State
- Project patent applications
- A list of project-related publications provided by NYSERDA
- Program data on project co-funding and follow-on funding
- Data on the number of visits to the NY-BEST supply chain web database

Secondary Data Review

The evaluation team referenced a number of secondary and media sources, such as GreenTech Media and Bloomberg New Energy Finance, as shown in the References section of this report. These secondary sources were compiled into a single Mendeley database and used to develop an understanding of the energy storage market developments since 2010.

In-Depth Interviews

EMI Consulting conducted in-depth interviews to understand the broader context in which market actors experienced their work and the influence NY-BEST had on their work. Table A-2 provides a summary of the number of interviews conducted by interviewee group.

Table A-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	11
Energy Storage Industry Experts	5

EMI Consulting first conducted 60-minute interviews with key NYSERDA Energy Storage program staff and NY-BEST staff to record their perspectives on the market and NY-BEST's impact. Following the staff interviews and a comprehensive data review, EMI Consulting conducted interviews with NY-BEST members and non-members, and energy storage experts. All member, non-member, and expert interviews were conducted by phone and lasted approximately 30-45 minutes per person. Interviews were recorded for those interviewees who gave permission to do so.

The evaluation team adhered to the following sampling methods to obtain interviews with NY-BEST members:

1. The list of NY-BEST member organizations was used as a starting point.
2. Project status information was matched to member organizations. Bench-to-prototype projects have the most recent R&D metrics database development stage of "initial prototype" or "proof of concept." Other projects have the most recent R&D metrics database development stage of "commercial prototype" or "refined prototype."
3. The list was randomized using a random number generator in Excel.
4. Members were placed in the appropriate category in the sample frame according to focus (e.g., "grid").
5. The list was reviewed by NYSERDA to ensure that the list (1) represented the diversity of the membership and included a sufficient number of key market actors; and (2) excluded companies that did not want to be contacted.
6. Interviewers called companies in each section (e.g., "grid") until the required number of interviews were completed.

Table A-3: Member Sample Targets and Completed Interviews

	Project - bench to prototype		Project - other		No Project		Total	
Categories (not mutually exclusive)	**Target**	**Completes**	**Target**	**Completes**	**Target**	**Completes**	**Target**	**Completes**
Grid	3	1	3	3	2	3	8-10	7
Transportation	2	1	2	1	2	1	6	3
Portable	2	N/A	2	3	2		4-6	3
Other	0	2	0		0	5	0	7
Total	**7**	**4**	**7**	**7**	**6**	**9**	**20**	**20**

The evaluation team followed the following sampling methods to obtain interviews with NY-BEST non-members:

1. The list of non-members from the NY-BEST newsletter email distribution list was used as a starting point.
2. This list was combined (merged) with membership lists from ESA and CESA to develop a single combined list of organizations involved in the battery storage industry.
3. Priority for recruitment of organizations went to organizations that are not currently members of NY-BEST but are members of ESA and/or CESA. Major or key players based on secondary market data review were also prioritized.
4. To the degree possible, organizations were classified into the appropriate category (e.g., "grid").

5. The initial sample list was reviewed by NYSERDA to ensure it (1) represented the diversity of the membership and included a sufficient number of key market actors; and (2) excluded companies that do not want to be contacted.
6. Interviewers called companies in each section (e.g., "grid") until the required number of interviews were completed.

Table A-4: Non-Member Sample Targets and Completed Interviews

Categories (not mutually exclusive)	Target	Total Completes
Grid	4-5	8
Transportation	3	1
Portable	1-2	-
Other	1	1
Total	**10**	**10**

The evaluation team followed the following sampling methods to obtain interviews with industry experts:

1. The list of experts previously interviewed for the process evaluation was used as a starting point.
2. The list was reviewed by NY-BEST. They added additional contacts whom they felt were highly respected and knowledgeable.
3. The list was categorized into area of focus: policy, research and development, and industry.
4. A calling order was established that included a mix of area of foci and a mix of NY-BEST recommendations and experts who participated in the process evaluation.
5. Interviewers called the first five companies in the call order, contacting each individual at least three times before moving to the sixth individual on the list.

Table A-5: Expert Sample Targets and Completed Interviews

Categories	Target	Total Completes
Policy	1	1
Research & Development	1	1
Industry	3	3
Total	**5**	**5**

Incorporation of Concurrent Research Reports

To assess the influence of NY-BEST in relation to the broader energy storage market, the evaluation team referenced and included relevant data from the other studies completed as part of this evaluation, including:

- A market characterization report: *NYSERDA Energy Storage and NY-BEST Program Market Characterization and Assessment*
- An economic analysis: *The Energy Storage Industry in New York: Recent Growth and Projections, 2015 Update*

- A patent analysis: *An Analysis of the Technological Impact of NY-BEST Funded Energy Storage Research*

Appendix B: Mapping Data to Logic Model

Logic Model Outcomes	Logic Model Indicators Addressed in Evaluation	Evaluation Questions	Data Sources and Potential Collection Approaches	Data Summary
	Short-term Outcomes from Information and Recruitment Activities			
Increased satisfaction of members and non-members with NY-BEST offerings	Net increase in membership Deep engagement of members in NY-BEST activities	In 2015, was the membership base stable or growing? How had this changed since 2010? How engaged were NY-BEST members with NY-BEST services?	Program records Interviews with NY-BEST members	During the period 2010-2015, NY-BEST membership continued to grow and most NY-BEST members renewed their memberships. Retention from year to year ranged from 82% to 100%. Membership steadily increased from February 2010 (49 members) to February 2016 (151 members). This represents an average increase of about 20 members per year from 2010 to 2015. 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 indirection mention of the notion that NY-BEST conferences are well respected
Valuable supply-chain and resource information is shared and put to use among members	Increase in collaboration and number of partnerships Use and maintenance of supply chain and resource database	In 2015, what was the level of connectedness between members? How had this changed since 2010? What role did the consortium play in building relationships between 2010-2015? Have members' use of the supply chain and resources database	Supply chain/resource database usage information Interviews with NY-BEST members	In the 2015 NY-BEST Annual Member Survey, 23 out of 34 participants (67.6%) 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. In the 2013-2014 Annual CAIR Report, NY-BEST reported helping 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 over 36 companies were provided with ongoing technical and business guidance (e.g., business development,

Logic Model Outcomes	Logic Model Indicators Addressed in Evaluation	Evaluation Questions	Data Sources and Potential Collection Approaches	Data Summary
		resulted in collaborations?		market entry strategies, and connections to resource providers in legal, technical, financial, and manufacturing areas). 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. It appears 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 visits and contained 402 resources, including 72 individuals and 330 organization and companies. Use of the database, as measured by website traffic had steadily increased since the database originally launched in spring of 2014.
Increased number and quality of productive collaborations and partnerships	Collaborative outputs including papers, projects, presentations, and products Sustained communication and information sharing between members Increase in membership	What types of information sharing have NY-BEST members engaged in as a result of NY-BEST services between 2010-2015? Between 2010-2015, how many collaborative outputs have NY-BEST members generated as a result of NY-BEST services?	Number of member publications and presence at conferences and events Interviews with NY-BEST members	Anecdotal evidence from interviews conducted as part of this research suggested that for some NY-BEST members, the networking opportunities available through NY-BEST opened the doors for meaningful collaborations with other members, leading to further project work. Workshops, conferences and webinars can reflect communications and information sharing between members, and may thus act an important step toward productive collaborations between members. NY-BEST increased the number of in-person events (e.g., workshops, conferences) and webinars during the period 2010-2015. NY-BEST event and webinar registrations also appeared to increase over this time; this increase did not seem to be simply due to holding more events and webinars because the average number of registrations per conference increased. Furthermore, anecdotal evidence from interviewees suggests that the conferences – and in particular the people at the conferences – were highly respected.

Logic Model Outcomes	Logic Model Indicators Addressed in Evaluation	Evaluation Questions	Data Sources and Potential Collection Approaches	Data Summary
	Short-term Outcomes of Technology Commercialization Activities			
Members improve strategies; successfully pitch ideas to potential investors	NY-BEST members funded by investors	In 2015, to what extent were outside investors providing follow-on funding to NY-BEST members who received awards from NYSERDA? How had this changed since 2010? What was the global reach (sales) of the energy storage industry in New York in 2015?	Program records of outside investment in projects Venture capital data	At least 21 NYSERDA-funded R&D projects received follow-on funding (42% of projects with funds distributed) totaling to at least $74M. According to CB Insights, a venture capital database, investment in energy storage firms located in the New York Metro area exhibited a positive net growth from 2011-2015, with an average deal increase of 5.92%.
High quality, targeted R&D accelerates product development	NY-BEST member projects funded by NYSERDA approach/achieve commercialization NY-BEST member projects funded by NYSERDA receive additional funding Increase in demand for BTCC facility services	As of fall 2015: How had these projects moved towards commercialization? Technology absorbed? Technology transferred? How did projects completed under the prototyping portion of PON 2458 fair? Had the testing facilities contributed to technologies being able to progress through the Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL) scales? Had demand increased for BTCC facility services	Facility usage records (aggregated) Program records on funded projects Interviews with NY-BEST members Program records of outside investment in projects Patent research Media coverage of project successes	A review of program data showed that 39 of 50 funded projects have information on their stage of development and 21 of them have information on the stages of development over time. In particular, 8 projects indicated commercialization progress (e.g., proof of concept stage in 2014 and initial prototype stage in 2015). Two projects indicated that their product is commercially available. At least 21 NYSERDA-funded R&D projects received follow-on funding (42% of projects with funds distributed) totaling to at least $74M. At least 50 contracts received project co-funding, totaling $17M (including both cash and in-kind). The mean co-funding amount was approximately $218K. It appears there was an increase in demand for BTCC services from 2014 to 2015. 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. Anecdotal evidence also supports the notion that the BTCC has contributed to technologies progressing toward more advanced TRL levels. Interviewees mentioned that use of the BTCC has allowed their technologies to progress, particularly by lowering cost and access barriers for smaller start-ups that may not have access to other testing facilities. Staff also mentioned the importance of the test center to the commercialization process.

Logic Model Outcomes	Logic Model Indicators Addressed in Evaluation	Evaluation Questions	Data Sources and Potential Collection Approaches	Data Summary
		between the launch of BTC in 2014 and 2015?		
New technologies are tested and proven in New York	Projects funded by NY-BEST approach/achieve commercialization Projects funded by NYSERDA receive additional funding and companies receive investment funding	In 2015, were energy storage installations from NY-BEST funded or supported research in place in New York? In 2015, to what extent were outside investors providing follow-on funding to NY-BEST members who received awards from NYSERDA? How has this changed since 2010?	Facility usage records (aggregated) Program records on funded projects Interviews with NY-BEST members Program records of outside investment in projects Media coverage of project successes	There is documented commercialization and deployment of NYSERDA-funded technologies in 2015. While many technologies were still in the R&D pipeline and are 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 these technologies will begin having an impact on the market in the subsequent 1-2 years. At least 21 NYSERDA-funded R&D projects received follow-on funding (42% of projects with funds distributed) totaling to at least $74M. At least 50 contracts received project co-funding, totaling $17M (including both cash and in-kind). The mean co-funding amount was $218K; the median co-funding amount was $151K.
Officials and legislators adopt positions supportive of energy storage industry	Adoption of policies and rules supporting energy storage Increase in number of energy storage-related enterprises	Between 2010-2015, how had NY-BEST and NYSERDA affected energy storage policy in NYS compared with influences of broader energy storage associations?	Media coverage of activity in energy storage industry Member and/or expert feedback regarding regulatory and legislative climate for energy-storage technology development Program records of outside investment in projects and NY-BEST	There was notable progress in New York State policy to support energy storage market development between 2010-2015. 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. Concurrent with but not causally related to NY-BEST's activities, during this time New York State also adopted *Reforming the Energy Vision*, a major initiative aimed at spurring the development of a more efficient, resilient grid. More recently, the New York State Public Service Commission approved 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. A recent poll found broad support among New York State voters for the REV initiative—90% of those polled indicated support for the initiative after hearing a brief description.

Logic Model Outcomes	Logic Model Indicators Addressed in Evaluation	Evaluation Questions	Data Sources and Potential Collection Approaches	Data Summary
	Medium-term Outcomes			
NY-BEST is self-sustaining	Non-NYSERDA funding; primary operating costs to serve the membership are met	As of 2015, was the organization self-sustaining? Was the membership base stable or growing? What was the level of connectedness between members? For how many years does the organization have sufficient funding?	Program financial records	*Note: This particular outcome is not a focus of this research. For more information on this topic, please see the corresponding process evaluation report. The information given below is for context only.* NY-BEST financial records showed a consistent year-to-year increase in their revenue from membership fees, from $31,000 in 2010 to $131,750 in 2015. During this time period, NY-BEST posted a net increase in assets each year. The average expense-to-revenue ratio is 0.70 for all five years of financial data. Looking at all years except 2014 (when NY-BEST received a large grant), the average expense-to-revenue ratio is 0.81. At the end of 2015, unaudited financial records show total assets of $5,736,861.94.
Outside investors provide follow-on funding to NY-BEST members	Quantity of outside investment [# of firms, # of agreements, $ invested] Number of investors	In 2015, to what extent were outside investors providing follow-on funding to NY-BEST members who received awards from NYSERDA? How has this changed since 2010?	Project records	At least 21 NYSERDA-funded R&D projects received follow-on funding (42% of projects with funds distributed) totaling to at least $74M. Note that information on where this funding came from was very limited. 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 2011-2015, with an average deal increase of 5.92%.
Energy storage technologies are proven and commercialized	Success of PON-funded projects: reach commercialization and technology transfer Increased ease of technological transfer	As of fall 2015, what were the outcomes of projects that received awards through NY-BEST?	Program records on funded projects Interviews with NY-BEST members	There were a total of 56 NYSERDA-funded NY-BEST R&D award contracts dating back to 2010. However, three awards were terminated (one decided not to pursue and no explanation for the other two) and three other projects are still in process (i.e., they are not applicable for metrics analysis). Thus, there are a total of 50 projects with funds distributed: 20 projects are still ongoing, 22 are closed, and 8 projects are in the process of executing or undergoing contract negotiation. One project closed due to not showing adequate performance improvements. The three terminated awards fell under PON 2458.
Regulatory and policy barriers to energy storage are reduced	Policies or regulations change Favorable public perception of battery	Between 2010 and 2015, how had NY-BEST and NYSERDA affected energy storage policy in NYS compared with	Passed and implemented regulations or legislation Media coverage	There was notable progress in New York State policy to support energy storage market development between 2010-2015. NY-BEST published energy storage roadmaps in 2012 and 2016. New York State has also adopted *Reforming the Energy Vision*, a major initiative aimed at spurring the development of a more efficient, resilient grid. Additionally, interviewees

Logic Model Outcomes	Logic Model Indicators Addressed in Evaluation	Evaluation Questions	Data Sources and Potential Collection Approaches	Data Summary
	and energy storage technologies industry	influences of broader energy storage associations?	Process evaluation peer interview notes Expert interviews Energy storage association policy-related activities	discussed the fact that there is recognition of the barriers that remain in place (for instance, city code preventing the installation of energy storage units in New York City), even if they have yet to be addressed.
	Long-Term Outcomes of NY-BEST Activities			
Thriving cluster of energy storage researchers and companies in New York	Number of battery and energy storage technology companies in NY steady or growing Size or maturity of battery and energy storage technology companies in NY steady or growing Sales of battery and energy storage technologies from NY growing	In 2015, was there a strong cluster of energy storage companies in New York State? What was the global reach (sales) of the energy storage industry in New York in 2015? How has this changed since 2010?	Program records on funded projects Interviews with NY-BEST members US Census data (NAICS 3359)	Sales data specific to New York State is limited. However, according to CB Insights, a venture capital database, investment in energy storage firms in the New York Metro area experienced a positive net growth from 2011-2015, with an average deal increase of 5.92%. Compared to other regions in the U.S., this average deal growth ranked second highest (behind Massachusetts, at +8.45%). The New York Metro area also ranked highly in terms of number of deals, securing 9.73% of all the deals recorded (the only regions with a greater percentage of deals were Silicon Valley with 17.3% and Massachusetts with 11.3%). County Business Pattern data from the U.S. Census showed a 20% increase in the number of paid employees and annual payroll for NAICS code 3359 ("Other electrical equipment and component manufacturing") for the period 2010-2014.
Energy storage industry brings jobs and other economic benefits to New York	Growth of companies and employment related to battery and energy storage technologies	How many jobs were in the energy storage industry in New York in 2015? How had this changed since 2010?	Job and sales records from industry Interviews with NY-BEST members	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 to 2015, with revenues increasing from $598M in 2012 to $906M in 2015 (estimated). Similarly, the State has experienced an increase in energy storage industry employment from an estimated 3,000 jobs in 2012 to 3,900 jobs in 2015. This trend was present in both the emerging and traditional market sectors, though a direct comparison between the two is difficult as of limited data from 2012.
New York becomes a global leader in energy storage	Involvement in standards setting NY-BEST associated technologies in place in New York state	In 2015, to what extent and in what ways was NY-BEST viewed as a domestic and/or international leader in	Records of battery and energy storage technologies-related activities in NY state	Findings from the interviews suggest that many in the industry view New York State, and NY-BEST in particular, as being a leader in the field, particularly in terms of research and policies supporting energy storage. New York was commonly mentioned along with California and Hawaii as being on the leading edge of the energy storage market. Interviewees mentioned that

Logic Model Outcomes	Logic Model Indicators Addressed in Evaluation	Evaluation Questions	Data Sources and Potential Collection Approaches	Data Summary
	Sales success of products relying on battery energy storage technologies developed or commercialized in New York State New York is a leader in deployed energy storage solutions for the electric grid and transportation	supporting the energy storage industry? How had this changed, if at all, since 2010? In 2015, were energy storage installations from NY-BEST funded or supported research in place in New York? In 2015, was there a strong cluster of energy storage companies in New York? What was the global reach (sales) of the energy storage industry in New York in 2015? How has this changed since 2010?	Record of technology demonstration and use in NY Sales data Comparative sales and use data for other states/nations DOE Global Energy Storage Database Interviews with NY-BEST members	the current leadership of NY-BEST are highly respected and have been instrumental in the organization's success thus far. Actual deployment in New York State was present but limited in 2015, at least in the grid storage sector. 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. New York State did not have the same level of deployed energy storage as many other regions in the world. In particular, China, Japan, India, Germany, and Australia have emerged as leaders for the deployment of energy storage technologies. 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 ("Other electrical equipment and component manufacturing") for the period 2010-2014.
Fossil fuel emissions decline as a result of energy-storage technologies commercialized and in use	NOx and SOx emissions proportionately reduced through proliferation of battery and energy storage technologies	Have projects supported by NY-BEST resulted in longer battery life, improved energy density, or decreased manufacturing costs? How have projects supported by NY-BEST decreased greenhouse gas emissions? Have NY-BEST supported projects resulted in quantifiable Energy Security Benefits?	Interviews with NY-BEST members Market share information Sales data Engineering calculations of NOx and SOx offset	It is too early to generate estimates for this long-term outcome.

APPENDIX C: Patent Analysis

Note: This appendix presents the report "An Analysis of the Technological Impact of NY-BEST Funded Energy Storage Research" by 1790 Analytics. This patent analysis, which was finalized in May of 2016, examined the influence of NYSERDA-funded NY-BEST projects on research and patent development. The patent analysis used historical tracing algorithms to locate relevant patent and publication data and assess scholarly outputs associated with NY-BEST projects and researchers.

An Analysis of the Technological Impact of NY-BEST Funded Energy Storage Research

Report prepared for:

Kara Crohn
Managing Consultant
EMI Consulting Inc.
83 Columbia Street, Suite 400
Seattle, WA 98104

Cynthia Manson
Principal
Industrial Economics Inc.
2067 Massachusetts Avenue
Cambridge, MA 02140

Report prepared by:

Patrick Thomas Ph.D.
Founding Partner
1790 Analytics LLC
130 North Haddon Avenue
Haddonfield, NJ 08033

May 12, 2016

1790 Project Number: IEC/NY-BEST/1

Table of Contents

Executive Summary

The New York Battery and Energy Storage Technology Consortium (NY-BEST) was established in 2010, with the purpose of advancing energy storage technology in New York State. This report outlines the results of an analysis designed to evaluate the technological impact of energy storage research funded by NY-BEST since the program was established.

The main findings of this report are:

Project Design

- To date, NY-BEST has funded 50 energy storage research projects across six different funding rounds. These funding rounds occurred in March 2010, July 2012, February 2013, January 2014, August 2014 and January 2015. The 50 awards have been made to 42 different recipients.

- Our analysis is based primarily on locating scholarly outputs – notably patents, scientific journal articles and conference papers – resulting from each of the 50 NY-BEST funded research projects. We then trace forward from these scholarly outputs to determine how frequently they have been cited as prior art by subsequent US patents.

- The idea behind this analysis is that these subsequent patents have built in some way on the previous NY-BEST funded energy storage research. By determining the extent of these citation links, it is thus possible to evaluate the degree to which NY-BEST funded energy storage research forms a foundation for technological developments both within and beyond energy storage.

Methodology

- As part of their funding awards, recipients may submit to NY-BEST scholarly outputs that have resulted from these awards, such as scientific papers, patents, reports etc. Out of the 42 award recipients, only 18 have submitted a patent, paper or report as being NY-BEST funded. In addition, for most of these 18 recipients, the number of scholarly outputs they associated with NY-BEST funding was very low.

- These low numbers of scholarly outputs may result from NY-BEST funding recipients neglecting to submit relevant outputs to the program. We therefore collated complete lists of scholarly outputs (journal articles, conferences papers, patent applications/grants etc) generated by recipients of NY-BEST funding since they received this funding.

- In total, we identified 587 scientific papers authored by NY-BEST funding recipients since they received this funding; plus 155 published US patent applications, of which 46 have been granted. We recognize that many of these outputs will not be related to NY-

BEST funding, since the recipients may have research interests beyond just those funded by NY-BEST.

- We thus ran our citation tracing algorithms on this superset of documents associated with NY-BEST funding recipients, and then removed irrelevant results. These irrelevant results occur where a document cited as prior art by a US patent was written by a NY-BEST funded organization or researcher, but describes a subject very different to their NY-BEST funded project.

Results

- In total, scholarly outputs associated with the 50 NY-BEST funded research projects have been cited as prior art by 140 granted US patents. Out of these 140 citations, 135 are to scholarly outputs located through our additional searches, rather than outputs submitted to NY-BEST by funding recipients.

- 18 out of the 42 NY-BEST funding recipients have scholarly outputs that have been cited as prior art by at least one subsequent US patent. A small number of organizations have 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).

- Individual citation profiles of NY-BEST funded organizations reveal interesting details of their impact on subsequent technological developments. Examples include CUNY/Columbia's influence on thin film technology; Widetronix's impact in the development of betavoltaic cells; Eos's role in the development of grid storage technology; General Electric's influence related to renewable energy power networks; and Custom Electronics' presence as part of the technical foundation for NASA technology related to ultracapacitor electrodes.

- The total citation counts to NY-BEST funded projects are quite low, but this is not particularly surprising, since NY-BEST is a relatively new program. Hence, there has not been much time for scholarly outputs resulting from these projects to be referenced by subsequent patents. This is especially true for projects funded in the most recent rounds. Also, the time lags associated with the patenting process mean that many patents filed in the most recent years have yet to be granted, so any prior art references from them to NY-BEST funded scholarly outputs are yet to appear.

- Overall, the results of our 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. There is thus evidence of NY-BEST funded projects influencing developments across a range of energy storage technologies.

Introduction

This report outlines the results of an analysis designed to evaluate the technological impact of the New York Battery and Energy Storage Technology Consortium (NY-BEST). This program was established in 2010, with the purpose of advancing energy storage technology in New York State. NY-BEST currently has more than 150 members, most of which are based in New York. They include energy storage manufacturers and materials developers; academic institutions and government entities; and engineering firms and systems integrators.

NY-BEST's mission is to be a central resource for energy storage companies and researchers in New York. To this end, it undertakes a variety of activities, including helping its members identify potential research partners and technology developers, access financing, and locate other private sector and government resources.

In addition to these activities as a 'connector' for energy storage organizations in New York, NY-BEST also provides funding for specific research and development projects related to energy storage. Thus far, it has funded 50 such projects carried out by a range of companies, academic institutions, and non-profit organizations.

The analysis presented in this report focuses on these 50 research projects funded by NY-BEST. The purpose of the analysis is to evaluate the impact of these 50 projects upon subsequent technological developments in energy storage. This evaluation is based primarily on locating scholarly outputs – notably patents, scientific journal articles and conference papers – resulting from each of the 50 projects. We then trace forward from these scholarly outputs to determine how they have influenced developments in energy storage technology, specifically those developments described in subsequent patents.

This report contains three further sections. The first of these sections provides an overview of the project design, and the evaluation techniques used in the analysis. The second section outlines the methodology used to carry out the analysis, including how the various data sets were constructed. Finally, the third section contains the results of the analysis, examining the impact of NY-BEST funded projects on subsequent technological developments in energy storage.

Project Design

This section of the report outlines the project design used to trace the technological impact of NY-BEST funded energy storage research. We start by providing an overview of the patent system, since our analysis makes extensive use of patent data, which may be unfamiliar to some readers. We then describe an evaluation technique known as patent citation analysis. This technique forms the basis for much of the analysis presented in this report. Specifically, it is used to take patents and papers resulting from NY-BEST funded projects, and connect these NY-BEST patents and papers to subsequent patents, both within and beyond energy storage technology.

Overview of US Patent System

This project makes extensive use of data covering both published literature and patent documents. We anticipate that readers will be familiar with the systems and processes associated with published literature, such as journal articles and conference papers. However, readers may be less familiar with the patent system, and its various features. Below is a brief overview of the US patent system, focusing on those elements of the system that are relevant to the analysis presented in this report.

We focus our discussion on the US patent system, since this is the system used in our analysis. Note that this does not mean that our analysis is restricted to innovations produced within the US. The US patent system is widely used by inventors worldwide, and half of all US patents are produced by inventors based overseas. Also, note that the discussion below is designed to be a basic overview of the patent system, not a detailed legal summary.

Patent Prosecution – in its most basic form, the patenting process in the US consists of two steps. In the first step, an applicant files a patent application describing an invention for which they would like to obtain patent protection. In the second step, the patent examiner decides whether to grant patent protection for the invention. This decision is based on the invention described in the application meeting three criteria – it must be novel, useful, and non-obvious to somebody who is skilled in the field.

The process involved in moving from the first step to the second step is known as *patent prosecution*. In practice, this process can take a significant amount of time. Currently, the mean *patent pendency* (the time from patent application to patent issuance) in the US is 26 months. Often, much of this time is taken up by a form of negotiation between the applicant and the patent examiner. This negotiation generally focuses on the claims of the patent application. It is these claims that will define the breadth of coverage provided by the patent application, if it is granted.

Typically, an applicant will submit an initial patent application with broad claims, with the objective of gaining as much coverage as possible. The examiner then either accepts the claims, and grants the patent; or rejects the claims, stating the reasons for the rejection. The applicant may then amend the claims – normally with the effect of making them less broad – and resubmit them for the examiner to consider. This to-and-fro process continues until either the examiner accepts the claims and grants the patent, or until the applicant abandons the application. The applicant may make this abandonment explicitly, or by failing to respond to the examiner within the allotted time period.

In terms of the analysis presented in this report, there are two main features of patent prosecution that are particularly relevant. The first is the time lag between when a patent application is filed, and when the resulting patent is granted. NY-BEST is a relatively new program, having only started in 2010. There has thus been little time for scholarly outputs from this program to be referenced by subsequent patents. This is exacerbated by the time lags associated with patent prosecution, since patents applied for in the most recent years are unlikely to have been granted, so any references from them to NY-BEST outputs will be yet to appear (since, as outlined below, only granted patents contain prior art references).

The second feature of note from patent prosecution is the concept of abandoned patent applications. There are a number of NY-BEST funding recipients who have filed and then abandoned patent applications, as outlined in the narratives contained in the results section of this report. These are applications that the funding recipients chose not to pursue, typically in the face of rejection by the patent examiner.

Types of Patent Documents – there are various types of documents generated by the US patent system, which are described here because they are referenced in subsequent sections of the report. In particular, there are references to *provisional applications*, *published patent applications* and *granted patents*.

As noted above, the first step in the patenting process is for an applicant to file a patent application. There are two options available to the applicant – a provisional application, or a standard patent application. Provisional applications are simpler to prepare (notably, they contain no claims) and less expensive to file. They are typically used as a quick, inexpensive to establish an early filing date for an invention. However, they cannot themselves result in a granted patent covering the invention. Instead, a provisional application has a lifetime of one year, during which time the applicant must file a standard patent application covering the invention in order to be able to claim protection back to the filing date of the provisional application.

Standard patent applications enter the full prosecution process described earlier, and can result in granted patents if they are accepted by the patent examiner. Historically, patent applications in

the US remained confidential until they were granted. Since 2001, the US has used a 'fast publishing' system to bring itself into line with other major patent systems worldwide. In this system, most patent applications are published – i.e. made public – within a certain time after they are filed, generally within 18 months. These are referred to as published patent applications. They remain in the public domain, irrespective of whether they are ultimately granted.

If the patent examiner rules that a standard patent application meets the criteria for acceptance, a patent is granted. This granted patent then provides protection for the claimed invention, currently for 20 years from the initial application date.

Prior Art References – as noted above, the analysis presented in this report centers upon connections made between generations of research by prior art references listed on patent documents. The purpose of these prior art references is to detail the state of the art at the time of the patent application, and to demonstrate how the new invention is original over and above this prior art. These references may consist of many different types of documents. A large number of the references are to earlier patents and published patent applications; while others are to scientific journal articles and conference proceedings; and others are to standards, technical reports, magazines and newspapers.

The responsibility for adding prior art references differs across patent systems. In the US system, it is the duty of patent applicants to reference (or 'cite') all prior art of which they are aware that may affect the patentability of their invention. Patent examiners may then reference additional prior art that limits the claims of the patent for which an application is being filed.

It should be noted that, while granted patents contain lists of prior art references, provisional applications and published patent applications do not, because the final list of prior art references is not completed until the examiner has allowed the application. This has an important impact on the analysis presented here, due to the time lags associated with patent prosecution, as discussed earlier. Specifically, only when a patent is granted (an average of 26 months after it is filed) will any of its prior art references to NY-BEST scholarly outputs appear.

Overview of Patent Citation Analysis

Patent citation analysis centers upon the links between generations of research that are made by the prior art references outlined above. In basic terms, this type of analysis is based upon the idea that the prior art referenced by patents has had some influence, however slight, upon the development of these patents. The prior art is thus regarded as part of the technical foundation for the later inventions.

In assessing the influence of individual patents and papers, citation analysis centers on the idea that highly cited patents and papers (i.e. those cited by many later patents) tend to contain

technological information of particular interest or importance. As such, they form the basis for many new innovations and research efforts, and so are cited frequently by later patents. While it is not true to say that every highly cited patent/paper is important, or that every infrequently cited patent/paper is trivial, many research studies have shown a correlation between patent citations and measures of technological and scientific importance. For background on the use of patent citation analysis, including a summary of validation studies supporting its use, see Breitzman A. & Mogee M. "The many applications of patent analysis", *Journal of Information Science*, 28(3), 2002, 187-205. For a comprehensive study on various hypotheses surrounding the motivations of inventors in citing non-patent references, see Branstetter, L. and Oguara, Y. "Is Academic Science Driving a Surge in Industrial Innovation? Evidence from Patent Citations", NBER Working Paper 11561, August 2005.

Patent citation analysis has also been used extensively to trace technological developments. In this type of analysis, a reference from a patent to a previous patent/paper is regarded as recognition that some aspect of the earlier patent/paper has had an impact on the development of the later patent. For example, in the analysis presented in this report, we use citations from patents to earlier patents and papers resulting from NY-BEST funded research projects to trace the technological influence of these projects.

The idea behind this analysis is that the later patents have built in some way on the previous NY-BEST funded energy storage research. By determining how frequently NY-BEST funded patents and papers have been cited by subsequent patents, it is thus possible to evaluate the extent to which NY-BEST funded energy storage research forms a foundation for various technologies both within and beyond energy storage.

It should be noted that, as described above, the analysis presented in this report is based on prior art references from US patents to NY-BEST funded patents and papers. The analysis does not consider references from scientific papers to NY-BEST funded papers (or from scientific papers to NY-BEST patents, although references from papers to earlier patents are very rare). This is purposeful, since our primary focus is on how NY-BEST research has influenced innovations developed in the energy storage industry. Such innovations are particularly likely to be protected by patents. Conversely, scientific papers may describe more early-stage and exploratory research, so references from them to NY-BEST papers may be mainly a reflection of the scientific, rather than technological, impact of this program.

Methodology

While the previous section outlines the general idea behind the analysis described in this report – i.e. tracing citation links from patents to earlier NY-BEST funded patents and papers – this section describes the methodology used to implement the analysis. There are two major steps in this methodology: (1) identifying NY-BEST funded patents and papers; and (2) identifying prior art references from patents to these NY-BEST patents and papers. These two steps are described in more detail below.

Identifying NY-BEST Patents and Papers

To date, NY-BEST has made a total of 50 awards across six different funding rounds. These funding rounds occurred in March 2010, July 2012, February 2013, January 2014, August 2014 and January 2015. These 50 awards have been made to 42 different recipients, which are listed in Table 1. As shown in this table, some organizations have been funded in multiple rounds. For example, Ioxus was funded in both March 2010 (Round 1) and July 2012 (Round 2), while Custom Electronics was funded in each round from the second (July 2012) through the fifth (August 2014). In addition, there are organizations that received funding for more than one project in a given round. For example, Binghamton University received two separate awards in Round 1, the first to research lithium air energy storage devices, and the second to develop lithium ion batteries for grid storage.

As part of their funding awards, recipients may submit to NY-BEST scholarly outputs that have resulted from these awards, such as scientific papers, patents, reports etc. A list of these scholarly outputs was provided to us as a starting point in collating our set of NY-BEST funded outputs. We found that, out of the 42 award recipients, only 18 had submitted a patent, paper or report as being NY-BEST funded. In addition, for most of these 18 recipients, the number of scholarly outputs they associated with NY-BEST funding was very low.

There could be two reasons for the lack of scholarly outputs submitted to NY-BEST by a given funding recipient. The first is that no such outputs have resulted from NY-BEST funding. This is certainly possible, especially for recipients of awards in the most recent funding rounds, who may be in the early stages of their projects.

The second possibility is that NY-BEST funded outputs do exist, but the recipients have not submitted them to the program. In order to address this second possibility, we collated lists of scholarly outputs (journal articles, conferences papers, patent applications/grants etc) generated by recipients of NY-BEST funding since they received this funding. We recognize that many of these outputs will not be related to NY-BEST funding, since the recipients may have research interests beyond just those funded by NY-BEST. However, as discussed in the next section of the report, our citation tracing algorithms are quite time-consuming, but the time is not linear

with the size of the starting set of scholarly outputs. It was thus more efficient for us to run the citation tracing a single time starting with a superset of all outputs associated with NY-BEST funding recipients, and then remove results unrelated to NY-BEST funding (rather than having to run the tracing multiple times if any relevant documents were absent from the initial list).

Generating the list of scholarly outputs for each funding recipient involved two steps. The first step was to identify the key researchers associated with each NY-BEST funded project. In a few cases, these researchers were listed in the project descriptions contained in the NY-BEST annual reports. However, these annual reports did not attach individual researcher names to most of the projects. We therefore searched news reports and press releases announcing the funding awards, and also searched company and university websites for information on key researchers. Through this process, we were able to locate key researchers for almost all of the NY-BEST funded projects. These researchers are listed in Table 2.

Having located key researchers for each project, we then put together bibliographies and patent lists for each of these researchers, covering the period since they received NY-BEST funding. To generate bibliographies, we consulted multiple data sources, such as Google Scholar (including individual researcher profiles where available), ResearchGate, and company/lab websites. For patents, we matched researcher names against the inventor names listed on granted patents and published patent applications. In some cases, this process required further name disambiguation, especially where organization names were missing (since organization names are sometimes not listed on published patent applications).

Table 3 shows the number of scholarly outputs used as a starting point for the tracing analysis for each NY-BEST funded project. The numbers in the left-hand side of the table show the count of outputs submitted by funding recipients to NY-BEST. The numbers in the right-hand side of the table show the total count of outputs used in the tracing, including those identified via our additional searches (recognizing, as outlined above, that most of these outputs will not be related to NY-BEST funding).

In both the left and right half of the table, the document counts are divided into two columns. The first column shows the number of scientific papers, which includes both journal articles and conference papers. The second column shows the number of published patent applications, along with how many of these applications have been granted to date (see the earlier discussion of the patenting process for more details on these different types of patent documents). In total, the tracing included 587 scientific papers and 155 published patent applications, of which 46 have been granted.

Table 1 – Recipients of NY-BEST Funding

Funding Round	Recipient	Funded Technology
1	Binghamton University	Lithium air energy storage/Li-ion batteries for grid storage
1	Brookhaven National Lab	Lithium titanate batteries
1	Stony Brook University	New materials for lithium ion batteries
1	Cerion Enterprises	Nanoparticles for lithium ion batteries
1	City Univ of New York	Nickel zinc flow battery for HEVs
1	City Univ of NY/Columbia Univ	Metacapacitors using printable material
1, 2	SUNY Polytechnic (Albany)	Electrolytes for ultracapacitors
1	Cornell University	Non-flammable battery electrolytes
1	General Electric + Univ partners	Sodium metal halide batteries
1	General Motors / Cornell Univ	Lithium ion battery electrodes for automotive applications
1	Hollingsworth & Vose Co.	Separator for valve-regulated lead-acid batteries
1	Impact Technologies	In-cell battery measurement to increase battery lifetime
1, 2	Ioxus / City Univ of New York	Electrode-electrolyte interface for ultracapacitors
1	Rensselaer Polytechnic Univ	Nanoengineered silicon electrodes for lithium ion batteries
1	Rochester Inst of Technology	Recycling and reusing lithium ion batteries
2, 3, 4, 5	Custom Electronics Inc	Graphene electrolytic capacitor
2	Graphene Devices Ltd	Graphene based ultracapacitor
2	Paper Battery Co	Thin, flexible ultracapacitors
2	Primet Precision Materials	Producing low cost raw materials for lithium ion batteries
2, 6	Urban Electric Power	Zinc anode battery with advanced battery mgt system
3	BESS; SUNY Poly; RPI	Graphene based electrode for lithium ion batteries
3, 5	Bettergy Corp	Zinc air-flow battery
3	Eos Energy Storage	Zinc battery
3	NOHMS Technologies	Longer lasting mobile phones
3	UTS Engineering	Recapturing vehicle braking energy using ultracapacitors
3	Watt Fuel Cell Corp	Solid oxide fuel cell
4	Cornell University / Proton	Fuel cell based on anion exchange membrane (AEM)
4	Ambri / Consolidated Edison	Liquid metal battery
4	Columbia University	Producing biofuels from electricity
4	Widetronix	Betavoltaic platform based on semiconductor chip
4	RPI / Finch Paper / JNC	Cathode materials from paper byproducts
5	Graphenix Development	Nanostructured graphene electrode for ultracapacitors
5	Combined Energies / UTS	Power conversion device to increase battery life
5	Lionano	Nano-engineered anode material for Li-ion batteries
5	Eonix	Next generation electrolytes for ultracapacitors
5	Raymond Corp / Navitas	Lithium ion energy storage for electric lift trucks
6	Bren-Tronics	Anti-idling battery system for rescue vehicles
6	Applied Power Systems	Battery charger and power supply for commuter rail cars
6	Varta Microbattery	AC-integrated backup system for PV
6	Enermat Technologies	Graphene anodes for Li-ion batteries
6	American Fuel Cell	Fuel cell membrane electrode assemblies
6	PowerHub /Applied Power Syst	Silicon-carbide (SiC) based power inverter

Funding Rounds: 1=March 2010; 2=July 2012; 3=February 2013; 4=January 2014; 5=August 2014; 5=January 2015

Table 2 – Key Researchers Associated with NY-BEST Funded Projects

Funding Recipient	Key Researcher(s)
Binghamton University	Stan Whittingham
Brookhaven National Lab	Feng Wang
Stony Brook University	Esther Takeuchi
Cerion Enterprises	Robert Curtis; Peter Cowdery-Corvan
City Univ of New York	Sanjoy Banerjee
City Univ of NY/Columbia Univ	Stephen O'Brien
SUNY Polytechnic (Albany)	Pradeep Haldar / Manisha Rane-Fondacaro
Cornell University	Emmanuel Giannelis
General Electric + Univ partners	Matthew Hall (Alfred Univ); Dipankar Roy (Clarkson Univ); Dan Goia (Clarkson Univ); Job Rijssenbeek (GE)
General Motors / Cornell Univ	None identified
Hollingsworth & Vose Co.	Milind Godsay; John Wertz
Impact Technologies	Mark Redding
Ioxus / City Univ of New York	Thor Eilertsen; Chad Hall
Rensselaer Polytechnic Univ	Nikhil Koratkar
Rochester Inst of Technology	Gabrielle Gaustad
Custom Electronics Inc	Thor Eilertsen
Graphene Devices Ltd	John C. Brewer, Richard Allen Castle, Kevin Tanzil
Paper Battery Co	Robert Miller; Shreefal Mehta
Primet Precision Materials	Robert Dobbs; Archi Lal; Larry Thomas
Urban Electric Power	Technology licensed from ID #6
BESS; SUNY Poly; RPI	Fernando Gómez-Baquero
Bettergy Corp	Lin-Feng Li; Zhong Tang; Hongmin Jiang
Eos Energy Storage	Steven Amendola
NOHMS Technologies	Surya Moganty; Jayaprakash Navaneedhakrishnan
UTS Engineering	Joseph Ambrosio
Watt Fuel Cell Corp	Caine Finnerty
Cornell University / Proton	Hector Abruna
Ambri / Consolidated Edison	Donald Sadoway (MIT) - papers not included
Columbia University	Scott Banta; Alan West
Widetronix	Michael Spencer; Chris Thomas
RPI / Finch Paper / JNC	Trevor Simmons; Nikhil Koratkar; Liping Huang
Graphenix Development	Robert Anstey; William McKenna
Combined Energies / UTS	John Vogel
Lionano	Yingchao Yu
Eonix	Don Derosa
Raymond Corp / Navitas	Steve Medwin
Bren-Tronics	Leo Brenna; Sai Fung
Applied Power Systems	Joe Pignatelli
Varta Microbattery	None identified
Enermat Technologies	Eklavya Singh; Rahul Mukherjee
American Fuel Cell	Daniel O'Connell; David Wetter; Edward Hines
PowerHub /Applied Power Syst	Glenn Skutt; Jack Lesko

Table 3 – Number of Patents and Papers Included in Tracing Analysis

	Submitted to NY-BEST		Including Added Searches	
Funding Recipient	**# Patent Applications (# Granted)**	**# Papers**	**# Patent Applications (# Granted)**	**# Papers**
Binghamton University	0	7	0	94
Brookhaven National Lab	0	3	0	31
Stony Brook University	0	1	0	55
Cerion Enterprises	5(0)	2	5(1)	2
City Univ of New York	0	0	3(0)	31
City Univ of NY/Columbia Univ	0	7	4(0)	22
SUNY Polytechnic (Albany)	0	3	0	73
Cornell University	0	2	1(0)	73
General Electric + Univ partners	0	4	21(9)	8
General Motors / Cornell Univ	1(0)	0	8(1)	0
Hollingsworth & Vose Co.	0	0	14(5)	0
Impact Technologies	0	0	0	0
Ioxus / City Univ of New York	0	0	6(2)	2
Rensselaer Polytechnic Univ	1(0)	2	1(0)	114
Rochester Inst of Technology	0	2	0	44
Custom Electronics Inc	3(0)	0	3(1)	0
Graphene Devices Ltd	0	0	0	0
Paper Battery Co	4(2)	1	7(2)	1
Primet Precision Materials	0	1	3(1)	1
Urban Electric Power	0	0	0	0
BESS; SUNY Poly; RPI	0	0	2(0)	0
Bettergy Corp	2(0)	0	3(1)	0
Eos Energy Storage	0	0	8(1)	0
NOHMS Technologies	0	0	8(0)	4
UTS Engineering	0	0	2(0)	0
Watt Fuel Cell Corp	0	0	14(2)	0
Cornell University / Proton	0	0	8(2)	1
Ambri / Consolidated Edison	0	1	11(6)	1
Columbia University	0	0	5(0)	10
Widetronix	0	0	8(8)	4
RPI / Finch Paper / JNC	0	0	1(0)	2
Graphenix Development	0	0	1(0)	0
Combined Energies / UTS	3(0)	0	3(0)	0
Lionano	0	0	0	12
Eonix	0	0	0	0
Raymond Corp / Navitas	0	0	2(2)	0
Bren-Tronics	0	0	2(2)	0
Applied Power Systems	0	0	0	0
Varta Microbattery	0	1	0	1
Enermat Technologies	0	1	1(0)	1
American Fuel Cell	0	0	0	0
PowerHub /Applied Power Syst	0	0	0	0
TOTAL	**19(2)**	**38**	**155(46)**	**587**

Locating Prior Art References from Patents to NY-BEST Patents and Papers

The process outlined above resulted in a list of published patent applications, granted patents, and scientific papers (including conference papers and journal articles) for each recipient of NY-BEST funding. The next step was to trace forward from these patents/papers to determine which of them have been cited as prior art by subsequent US patents. As discussed earlier, this is regarded as a proxy for the impact of NY-BEST funded projects on subsequent developments in energy storage technology. While the discussion earlier in the report outlines the theoretical background for using patent citation analysis to measure technological impact, this section of the report is concerned with the practical details of how these citation links are identified.

Prior art references listed on US patents are divided into different sections. The main division is between references to earlier patents (both US and foreign) and references to non-patent items. Different processes are required for matching each of these two types of prior art references to a starting set of documents – in this case, scholarly outputs from recipients of NY-BEST funding. These two processes are outlined below.

Prior Art References to Patents – prior art references to patents are listed in the form of patent numbers. For example, US Patent #9,012,542 references nine earlier granted US patents as prior art, and these patents are identified by their patent numbers (#2,388,169; #3,450,667 etc). This patent also references five published US patent applications, and three foreign patents, all of which are again listed by their patent numbers.

Patent numbers (for both granted patents and published patent applications) are unique identifiers, and are typically listed in a standard format. As a result, it is possible to construct databases containing all citation links between generations of patents, such as the database we maintain at 1790. The citation links consist of pairs of citing-cited patent numbers, with both of these numbers being unique identifiers. Given access to such a database, it is relatively straightforward to take a starting set of patent numbers and published patent application numbers (i.e. the cited half of the pair), and locate subsequent patents that reference these patents as prior art (i.e. the citing half of the pair). In this analysis, we carried out such a process, with the starting set consisting of patent application numbers and granted patent numbers associated with NY-BEST funding recipients.

Prior Art References to Non-Patent Literature - prior art references to items other than patents are typically referred to as Non-Patent References (NPRs). These NPRs can be to any published document, from comic strips and brochures, to scientific journal articles, conference papers and standards documents. They are much more difficult to work with than prior art references to patents, since they are in free text. Inventors are not required to use a standard form for listing references, in contrast to an author submitting a manuscript for publication in a scientific journal. There is also no equivalent to an editor or reviewer ensuring that the references are complete,

since this is typically not a major concern of the patent examiner. As a result, NPRs are free text that can be in any format, and may be incomplete. Author names may be present or absent, and journal names can be in many different formats (for example, there are more than 30 variant spellings of the journal title *Journal Of Thoracic And Cardiovascular Surgery* found in patents, including misspellings of thoracic and different ways of abbreviating cardiovascular).

We have built a number of tools specifically to address these issues with NPRs. We applied these tools here to locate prior art references from patents to journal articles and conference papers authored by NY-BEST funded researchers. This process involved matching one set of free text (i.e. NPRs listed on patents) against a second set of free text (i.e. papers written by NY-BEST funded researchers).

Our tools use what is known as a 'bag-of-words' approach to text analysis. In simple terms, this approach involves treating a text – in this case a bibliographic reference – as a set (or 'bag') of words, with no meaning, grammar or word order considered. It is then possible to match different texts based on the contents of their 'bags' of words, with texts having a high proportion of words in common being considered as particularly likely to be a match. In this analysis, the bags-of-words consist of NPRs on one side of the match, and bibliographic references for journal articles and conference papers authored by NY-BEST funding recipients on the other side of the match.

As noted above, many terms, such as journal names, can appear in multiple forms in NPRs. We thus process these NPRs using a thesaurus we have built. The thesaurus first maps different versions of commonly-used terms to a single base term. For example, Journal and Jrnl are mapped to J.; American and Amer are mapped to Am; Physics and Physical are mapped to Phys etc. Then, each word in the resulting text string is truncated at four characters, and these truncated terms are collected as the bag-of-words corresponding to the original NPR. Both the original NPR and the bag-of-words associated with the NPR are stored in our databases.

Prior to running the bag-of-words match, we also transformed each paper written by a NY-BEST funded researcher into the same standard form, following a similar process to the one described above for NPRs. An example of transforming the reference for a single paper is shown in Table 4. The original reference for this paper is:

Argyro Klini, Stavros Pissadakis, Rabindra N. Das, Emmanuel P. Giannelis, Spiros H. Anastasiadis, Demetrios Anglos. ZnO–PDMS Nanohybrids: A Novel Optical Sensing Platform for Ethanol Vapor Detection at Room Temperature. *The Journal of Physical Chemistry C*, 119(1), 2015, 623-631.

The first step in processing this reference was to parse the various elements of the reference into separate fields. The results of this step are shown in the left half of Table 4. Having parsed the

reference, we then applied the thesaurus that maps different versions of commonly-used terms to a single base term. Then, each word in the resulting text string was truncated at four characters. The result of this process is the formatted reference shown in the right-hand side of Table 4. In the final step, the various elements of the formatted reference were collected together into a bag-of-words, which is shown in the right-hand column of Table 4.

Table 4 – Example of a NY-BEST Reference Transformed into a Bag-of-Words

Original Reference					Formatted Reference					Final
Year	**Journal**	**First Page**	**First Author**	**Title**	**Year**	**Journal**	**Page**	**Name**	**Title**	**Bag of Words**
2015	The Journal of Physical Chemist -ry C 119(1)	623	Klini	ZnO–PDMS Nanohybrids: A Novel Optical Sensing Platform for Ethanol Vapor Detection at Room Temperature	2015	The J Phys Chem C 119 1	623	Klin	ZNO PDMS NANO A NOVE OPTI SENS PLAT FOR ETHA VAPO DETE AT ROOM TEMP	The J Phys Chem C 119 1 623 KLIN ZNO PDMS NANO A NOVE OPTI SENS PLAT FOR ETHA VAPO DETE AT ROOM TEMP

We then ran a match of the bag-of-words for each paper associated with NY-BEST funded researchers against the bag-of-words corresponding to each NPR listed on all US patents. Potential matches were identified based on the number of terms there are in common, and which bibliographic elements they represent (e.g. a match on author name is weighted higher than a match on a single title word; a page number match is weighted higher than a volume number match etc). High-scoring matches represent potential prior art references from a patent to a paper associated with NY-BEST funded researchers. In a final step, we checked each of the highest-scoring matches manually, and incorrect matches were removed.

Removing References to Outputs Not Related to NY-BEST Funding – the processes described above for matching prior art references to a starting document set involve extensive processing time. This is particularly true of identifying patent-paper citations via text matching. Hence, as discussed earlier in the report, we ran the matching process using a starting superset of all documents produced by recipients of NY-BEST funding since they received this funding, irrespective of the subject matter described in these documents.

Using a starting superset of documents enabled us to run the matching process a single time. However, it also resulted in the inclusion of prior art references from patents to documents produced by NY-BEST recipients covering subjects other than those for which they received funding from NY-BEST. We thus manually reviewed the list of citations returned by the matching process, and removed those cases where the cited document was written by a NY-BEST funded organization or researcher, but describes a subject very different to their NY-BEST funded project.

For example, Pradeep Haldar from SUNY Polytechnic was funded by NY-BEST to study electrolytes for ultracapacitors. However, Professor Haldar has also researched many other subjects. In this case, we located prior art references from patents to papers describing solar cell materials on which he is listed as a co-author. These papers appear to be unrelated to NY-BEST funding, so we removed the citations to them from the final list. Similarly, Emmanuel Giannelis from Cornell University was funded to study non-flammable battery electrolytes. We located prior art references from patents to papers from Professor Giannelis' lab describing superhydrophilic coatings for fabrics. Again, these papers do not appear to be relevant to the NY-BEST funded project, and so the citations to them were removed from the final list.

It should be noted that, in this process of removing references to outputs not related to NY-BEST funding, some cases were more clear-cut than others. For example, in the two cases detailed above, we are reasonably certain that the cited papers are not related to NY-BEST funding. However, there are other cases that are less certain, particularly since the list of confirmed NY-BEST funded outputs (i.e. those submitted by the recipients) is very short. Where the relationship to NY-BEST funding is uncertain, we erred on the side of including the citations in the final list, while also noting (in the detailed narrative profiles) the reasons for this uncertainty.

The outcome of the processes described in this section of the report is a list of prior art references from US patents to scholarly outputs produced by recipients of NY-BEST funding. A discussion of how these references reflect the technological impact of NY-BEST funded research is provided in the following section of the report.

Results

The analysis presented in this report is designed to evaluate the technological impact of NY-BEST funded research upon subsequent developments both within and beyond energy storage. This impact is measured via the proxy of tracing prior art references from US patents to scholarly outputs – primarily patents, scientific journal articles, and conference papers – produced by recipients of NY-BEST funding.

As discussed in the methodology section of the report, many of the recipients of NY-BEST funding have not designated any patents or papers as being associated with this funding. We therefore carried out additional searches to identify scholarly outputs that may be related to NY-BEST funding – based on matching researchers, submission dates, and subject matter – but that recipients have not designated as such. The number of patents and papers located via these additional searches for each funding recipient was listed earlier in Table 3.

Table 5 shows the total number of patents and papers included in the tracing analysis, categorized according to whether they were submitted to NY-BEST by funding recipients, or identified through our additional searches.

Table 5 – Number of Scholarly Outputs in Tracing Analysis by Source

Submitted to NY-BEST		Including Added Searches	
# Patent Applications (# Granted)	# Papers	# Patent Applications (# Granted)	# Papers
19(2)	38	155(46)	587

This table reveals that a high percentage of NY-BEST related patents and papers included in the tracing analysis were located via our additional searches. Specifically, 88% of the published patent applications (and 96% of the granted patents) included in the tracing were located through the additional searches, as were 94% of the papers. This reflects the important role of these additional searches in the analysis, given the lack of scholarly outputs submitted to NY-BEST by funding recipients.

Table 6 shows the number of prior art references from US patents to the scholarly outputs of each of the 42 recipients of NY-BEST funding. These recipients are listed in descending order according to how many citations their outputs have received from subsequent patents. This table reveals that 18 out of the 42 NY-BEST funded organizations have been cited by at least one subsequent US patent, with the highest number of citations received by CUNY/Columbia, Widetronix, Hollingsworth & Vose, Brookhaven, and Eos Energy Storage.

In general, the citation counts in Table 6 are relatively low. This is not particularly surprising, since NY-BEST is a relatively new program. Hence, there has not been much time for scholarly outputs resulting from projects funded by the program to be referenced by subsequent patents.

Table 6 – Number of Prior Art References from US Patents to NY-BEST Funding Recipients

Funding Round	Recipient	# References from US Patents
1	City Univ of NY/Columbia Univ	27
4	Widetronix	23
1	Hollingsworth & Vose Co.	19
1	Brookhaven National Lab	18
3	Eos Energy Storage	16
4	Ambri / Consolidated Edison	10
1	General Electric + Univ partners	8
3	Watt Fuel Cell Corp	5
1, 2	Ioxus / City Univ of New York	3
2	Paper Battery Co	2
3	BESS; SUNY Poly; RPI	2
1	Rensselaer Polytechnic Univ	1
2	Primet Precision Materials	1
2, 3, 4, 5	Custom Electronics Inc	1
3	NOHMS Technologies	1
5	Combined Energies / UTS	1
5	Raymond Corp / Navitas	1
6	Bren-Tronics	1
1	Binghamton University	0
1	Stony Brook University	0
1	Cerion Enterprises	0
1	City Univ of New York	0
1	Cornell University	0
1	General Motors / Cornell Univ	0
1	Impact Technologies	0
1	Rochester Inst of Technology	0
1, 2	SUNY Polytechnic (Albany)	0
2	Graphene Devices Ltd	0
2, 6	Urban Electric Power	0
3	UTS Engineering	0
3, 5	Bettergy Corp	0
4	Cornell University / Proton	0
4	Columbia University	0
4	RPI / Finch Paper / JNC	0
5	Graphenix Development	0
5	Lionano	0
5	Eonix	0
6	Applied Power Systems	0
6	Varta Microbattery	0
6	Enermat Technologies	0
6	American Fuel Cell	0
6	PowerHub /Applied Power Syst	0

Also, as noted earlier in the report, the period in which to generate citations is made even shorter by the time lags associated with the patenting process. The existence of these lags means that many patents filed in the most recent years have yet to be granted, so any prior art references from them to NY-BEST funded scholarly outputs are yet to appear.

This is especially true for NY-BEST projects funded in the most recent rounds. Table 7 shows the number of organizations that received an award from NY-BEST in each funding round, and how many references there have been from US patents to scholarly outputs associated with each funding round. As noted earlier, some organizations were funded in multiple rounds. In order to avoid double counting, in Table 7 these organizations are assigned to the first round in which they received an award (for example, Ioxus was funded in Round 1 and Round 2, and is assigned to the former in this table).

Table 7 – Number of References from US Patents by NY-BEST Funding Round

Funding Round	Date	# Recipients*	# References from US Patents
1	March 2010	15	76
2	July 2012	5	4
3	February 2013	6	24
4	January 2014	5	33
5	August 2014	5	2
6	January 2015	6	1
Total		**42**	**140**

* Based on the first round in which each recipient received funding from NY-BEST

Table 7 reveals that scholarly outputs associated with projects from the first round of NY-BEST funding have been referenced most frequently by US patents. Outputs associated with Round 3 and Round 4 have also been referenced relatively frequently, mainly due to two highly-cited projects in each round (Eos and Watt Fuel Cell in Round 3; Widetronix and Ambri in Round 4). Outputs related to projects from the two most recent funding rounds have yet to be referenced by many patents, which is not surprising given the lack of time available for such references to accrue. More notable is the lack of references to outputs associated with projects from Round 2 of NY-BEST funding, with an average of less than one reference to each of these projects.

Beyond the age of the referenced NY-BEST scholarly outputs, it is also interesting to examine the source of these outputs - i.e. whether they were submitted by NY-BEST recipients, or located via our additional searches. In this way, it is possible to observe the effect of these additional searches on the results of the tracing analysis. Table 8 thus divides the reference counts reported earlier in Table 6 according to the source of the referenced items.

The left-hand column of figures in Table 8 is the same as the total reference count shown earlier in Table 6. The two right-hand columns split this count into references to scholarly outputs submitted to NY-BEST, and references to outputs located via our additional searches. These columns reveal that 135 out of the 140 references from US patents to NY-BEST are to scholarly outputs located via our additional searches.

The figures in Table 8 highlight the strong impact the additional searches had on the results of the tracing analysis. Without these additional searches, there would be an almost complete absence of references from US patents to NY-BEST funded scholarly outputs. However, these

figures also raise a question as to whether the additional outputs are actually related to NY-BEST funding, since they were not explicitly designated as such by the recipients of this funding.

Table 8 – References to NY-BEST Outputs Divided Based on Source

Recipient	Total References from US Patents	References to Outputs Submitted to NY-BEST	References to Outputs Added via Searches
City Univ of NY/Columbia Univ	27	0	27
Widetronix	23	0	23
Hollingsworth & Vose Co.	19	0	19
Brookhaven National Lab	18	0	18
Eos Energy Storage	16	0	16
Ambri / Consolidated Edison	10	0	10
General Electric + Univ partners	8	0	8
Watt Fuel Cell Corp	5	0	5
Ioxus / City Univ of New York	3	0	3
Paper Battery Co	2	2	0
BESS; SUNY Poly; RPI	2	0	2
Rensselaer Polytechnic Univ	1	1	0
Primet Precision Materials	1	0	1
Custom Electronics Inc	1	1	0
NOHMS Technologies	1	0	1
Combined Energies / UTS	1	1	0
Raymond Corp / Navitas	1	0	1
Bren-Tronics	1	0	1
Total	**140**	**5**	**135**

Table 9 provides more detail regarding the relationship between NY-BEST funding and the scholarly outputs located via our additional searches. There are four categories listed in this table. The first contains outputs submitted to NY-BEST by funding recipients, and has the same five references listed in this category in Table 8. The other three categories contain references to NY-BEST scholarly outputs located via our additional searches.

Table 9 – Summary of References to NY-BEST Outputs Divided Based on Source

Source of NY-BEST Scholarly Outputs	# Recipients	# References from US Patents
Items submitted by recipient to NY-BEST	4	5
Located via searches; recipient did not submit any items to NY-BEST	10	57
Located via searches: items relate to, but pre-date, NY-BEST funding	3	60
Located via searches: question whether items relate to NY-BEST funded technology	1	18
Total	**18**	**140**

The first of these three categories contains cases where the recipient of NY-BEST funding did not identify of its scholarly outputs as being associated with this funding, but we were able to locate outputs that appear relevant based on matching researchers, time periods and subject matter. There were 10 such recipients, and their outputs have received 57 citations from US patents.

The second category contains three cases where we located scholarly outputs that appear relevant to NY-BEST funding based on the identity of the researchers and the subject matter, but these outputs pre-date this funding. The organizations in these cases are CUNY/Columbia, Widetronix and Ambri. These may be examples of ongoing research efforts that have been funded in part by NY-BEST or, in the case of Ambri, where NY-BEST helped to fund commercialization of a technology licensed from another organization. The outputs associated with these three recipients have been referenced as prior art by 60 US patents.

The third category contains a single case where the funded researchers and time period match NY-BEST funding, but the subject matter of the referenced paper is slightly different to that funded by NY-BEST. The recipient in this case is Brookhaven, whose paper concerns energy storage, but describes a different specific battery chemistry to that funded by NY-BEST.

The results in Table 9 suggest that there are questions regarding the nature of the relationship between NY-BEST funding and some of the scholarly outputs included in the tracing analysis. It is therefore beneficial to undertake a more detailed examination of these outputs, and the references to them from subsequent US patents. In addition, analyzing the individual citations to each NY-BEST funding recipient can reveal more detail regarding how these citations reflect the impact of NY-BEST funding on subsequent technological developments.

The remainder of this results section is thus dedicated to individual profiles of each of the 18 NY-BEST funding recipients that have been cited by at least one subsequent US patent. These profiles are presented below, in the same order that the funding recipients appear in Table 6. The profiles place particular emphasis on the patents that cite the scholarly outputs associated with these recipients as prior art, and what these citations suggest in terms of the impact of NY-BEST funding. The profiles also highlight, where applicable, any questions regarding whether the cited documents can be considered as being NY-BEST funded.

Funding Recipient Citation Profile: City University New York & Columbia University

NY-BEST Funding Date: March 2010

Project Description (from NY-BEST Annual Report)

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

CUNY/Columbia Patents and Papers

CUNY lists a total of seven papers that resulted from NY-BEST funding. The papers focus on thin films containing metal oxide nanocrystals. These films can be used in ultracapacitors, and in memory and power storage devices. In addition to these seven papers, we searched for other papers written by their authors since the inception of the NY-BEST program. We identified an additional 21 such papers (note: these additional papers did not necessarily result from NY-BEST funding, but were included in the tracing for completeness).

Alongside these papers, we also identified four patent applications that appear to be related to the NY-BEST funded project. These patent applications cover similar technology to the papers listed by CUNY as being NY-BEST funded – i.e. the preparation and application of thin films in energy storage and electronics. They are shown in the table below.

Patent Application #	Application Date	Current Status	Assignee	Title	# Cites Received
20100135937	9/24/2009	Abandoned	Columbia Univ	Metal oxide nanocrystals: preparation and usage	27
20130207231	1/18/2013	Abandoned	City Univ of NY	Dielectric film with nanoparticles	0
20130224473	2/25/2013	In Prosecution	City Univ of NY	Prevention of hydrophobic dewetting through nanoparticle surface treatment	0
20150094199	7/29/2014	Allowed	City Univ of NY	Multi-metal oxide ceramic nanomaterial	0

Out of these four applications, two were abandoned by the applicant in the face of a rejection by the patent examiner; one is still in prosecution (i.e. the examiner is still in the process of determining whether to grant the patent); and one has been allowed (i.e. the examiner has indicated acceptance of the application, and a granted patent will issue shortly).

From an impact perspective, the most interesting patent application is one of the two that was abandoned. This application (Publication #20100135937 – hereafter the '937 application) was filed in September 2009, just prior to the start of the NY-BEST program. It is assigned to Columbia University, which is where Stephen O'Brien (who appears to be the key researcher on

the research effort) was based before moving to CUNY in 2009. The '937 application thus appears to be part of an ongoing research effort, which was funded in part by NY-BEST.

The '937 application was rejected by the patent examiner, specifically for the invention being obvious given the prior art. However, despite this rejection, the '937 application has gone on to have a strong impact on subsequent technological developments, with 27 granted US patents citing is as prior art. Hence, although the application did not itself result in a granted patent, its teachings appear to have had an important influence on other researchers.

None of the other three patent applications in the table above have been cited as prior art by any subsequent US patents. Also, based on our research, none of the CUNY papers – either those listed by the university as NY-BEST funded, or those identified by our additional searches – have been cited as prior art by any subsequent US patents. Hence, the original Columbia patent application seems by far the most interesting in terms of its subsequent impact.

Patents Citing CUNY/Columbia Patents as Prior Art

The table below lists the organizations whose patents cite the CUNY/Columbia patent applications (specifically the '937 application) as prior art.

Organization	# Citing Patents	Example Citing Patent	Technology
Cerion Technology	3	8679344	Improved nanoparticle preparation
Epistar Corporation	3	8344409	Method of manufacturing optoelectronic devices
Pixelligent Technologies	3	8883903	Manufacture of improved nanocomposites
Western Digital	3	8821736	Improved disk drive with nanoparticle layer
IBM	2	8030687	Field effect transistor for integrated circuits
Samsung Electronics	2	8394668	Semiconductor thin film for electronics
Taiyo Yuden	2	9023311	Ceramic powder for capacitors in electronic devices
Univ of Central Florida	2	8309489	Nanoparticle powders and films as catalysts
Intermolecular Inc	1	9178011	Dielectric layer for capacitors for DRAM chips
Iowa State Univ	1	9051180	Nanocrystals for capacitors in electronic devices
King Abdulaziz City for Sci & Tech	1	7951976	Nanocrystalline catalysts
Pooya Nano Powders	1	8512654	Nanoparticles for use in fuel cells
Tel-Aviv Univ	1	9257238	Manufacturing electrodes for energy storage
Univ of Colorado	1	9090971	Method for thin film deposition
UT-Battelle LLC	1	8623941	Dielectric materials for power transmission

There are a total of 15 such organizations, and they make for an interesting group. They include very large multinational corporations such as IBM (whose citing patents describe field effect transistors for integrated circuits); Samsung (thin films for electronic devices); and Western Digital (disk drives with a nanoparticle layer). There are also a number of academic and non-

profit organizations whose patents cite the ‘937 application as prior art. These include US-based organizations such as the universities of Central Florida, Iowa State and Colorado, plus UT-Battelle; and overseas-based organizations such as Tel-Aviv University and the King Abdulaziz City for Science and Technology, which is responsible for the advancement of science and technology in Saudi Arabia.

Alongside these large organizations, there are a number of less well-known companies whose patents cite the ‘937 application. These companies include Cerion, whose three citing patents describe improved nanoparticle preparation, and which was another recipient of NY-BEST funding. This connection may thus be an example of one NY-BEST project being beneficial in the development of another NY-BEST project. Epistar is another company with three patents that cite the ‘937 application as prior art. These patents describe a method for manufacturing optoelectronic devices (specifically LEDs), which is the main business line for this Taiwanese company. Similarly, Pixelligent is another LED company with three patents that cite the ‘937 application as prior art.

The organizations in the table above cover a wide range, in terms of size, location and technological focus. This suggests that the ‘937 application has had a broad influence upon subsequent technological developments, even if it was not itself granted by the patent examiner.

Funding Recipient Citation Profile: Widetronix

NY-BEST Funding Date: January 2014

Project Description (from NY-BEST Annual Report)

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 electrons from an embedded isotope into electric power enabling decades of power. Target markets include those where the longevity, high power density, and robustness in harsh environmental conditions are important characteristics for critical monitoring needs.

Widetronix Patents/Papers

Based on our research, there are a total of eight granted US patents covering Widetronix's betavoltaic technology. In addition, Michael Spencer, the founder of Widetronix, published a paper on betavoltaic technology in Applied Physics Letters in 2016.

Widetronix has also been granted patents describing chemical vapor deposition for semiconductor manufacturing, but these patents are not included here, since NY-BEST does not appear to have funded development of that technology at Widetronix.

The eight Widetronix patents are listed in the table below.

Patent #	Application Date	Issue Date	# Cites Received*	Assignee	Title
8134216	3/7/2011	3/13/2012	7	Widetronix Inc	Nuclear Batteries
7939986	12/14/2009	5/10/2011	4	Cornell Univ	Betavoltaic cell
8866245	1/16/2012	10/21/2014	3	Widetronix Inc	Nuclear batteries
8017412	9/23/2010	9/13/2011	2	Widetronix Inc	Betavoltaic battery with a shallow junction and a method for making same
8153453	8/1/2011	4/10/2012	2	Widetronix Inc	Betavoltaic battery with a shallow junction and a method for making same
8487392	8/6/2010	7/16/2013	2	Widetronix Inc	High power density betavoltaic battery
9099212	6/10/2012	8/4/2015	2	Widetronix Inc	Low Volumetric Density Betavoltaic Power Device
8802456	2/14/2012	8/12/2014	1	Widetronix Inc	Betavoltaic battery with a shallow junction and a method for making same

* Includes citations to underlying published patent applications

These patents describe energy-dense betavoltaic cells for long-term, low-power applications. Betavoltaic cells differ from typical rechargeable batteries, in that they do not have a charge-

discharge cycle. Instead they provide power continually over a long period based on the decay of radioactive compounds. As such, they are ideal for applications requiring long-term power without replacement, for example in spacecraft or in implantable medical devices.

Seven of the eight patents are assigned to Widetronix, with the eighth (and earliest) patent assigned to Cornell University. Widetronix was founded by researchers from Cornell, specifically the inventors on the Cornell patent. This patent is included here, since it appears to describe the basic concepts of the Widetronix betavoltaic technology.

It is worth noting that the patents in this table were filed prior to Widetronix receiving funding from NY-BEST. This aligns with stated purpose of that funding, which was to enhance Widetronix's existing technology platform, rather than to develop an entirely new technology. As such, it is not surprising that the patents describing key elements of the Widetronix platform were filed prior to its receipt of NY-BEST funding.

Patents Citing Widetronix Patents as Prior Art

The patents that cite the Widetronix patents as prior art are shown in the table below.

Citing Patent #	Application Date	Issue Date	# Cites to Widetronix	Assignee	Title
8872408	4/15/2013	10/28/2014	6	Ultratech, Inc.	Betavoltaic power sources for mobile device applications
9266437	7/2/2013	2/23/2016	6	Ultratech, Inc.	Betavoltaic power sources for transportation applications
8866152	11/19/2010	10/21/2014	2	Cornell Univ	Betavoltaic apparatus and method
9006955	11/1/2011	4/14/2015	2	Medtronic Inc	High-energy beta-particle source for betavoltaic power converter
9183960	5/28/2010	11/10/2015	1	Medtronic Inc	Betavoltaic power converter die stacking
9064610	4/5/2012	6/23/2015	2	Raytheon Co.	Betavoltaic battery with diamond moderator and related system and method
8487507	12/14/2009	7/16/2013	2	Unassigned (City Labs?)	Tritium direct conversion semiconductor device
8802456	2/14/2012	8/12/2014	2	Widetronix Inc	Betavoltaic battery with a shallow junction and a method for making same

The two patents at the head of this table are both assigned to Ultratech Inc. (www.ultratech.com). Each of these Ultratech patents cites six different Widetronix patents, suggesting they build particularly extensively on the Widetronix betavoltaic technology. The Ultratech patents describe betavoltaic cells for use in mobile devices and transportation, specifically electric cars. It is interesting to note that this seems to be a new business line for Ultratech, which has traditionally been associated with semiconductor packaging.

There are a number of other interesting patents in this table. They include two patents from Medtronic, both of which describe the use of betavoltaic cells in implantable medical devices. This is an example of a specific practical application building on Widetronix's technology. Also, there is an unassigned patent (i.e. owned by its inventor) in this table. This patent appears to be owned by City Labs (www.citylabs.net), since the first named inventor is CEO of that company. City Labs is the developer of the NanoTritium battery, a betavoltaic cell, so again this appears to be an example of Widetronix's technology helping form the foundation for a practical application.

It is also interesting to note that there are betavoltaic patents from Cornell that cite Widetronix. These Cornell patents were invented by researchers from the SonicMEMS lab, not the lab from which Widetronix originated, suggesting that interest in betavoltaics at Cornell extends beyond just a single research group.

Funding Recipient Citation Profile: Hollingsworth & Vose

NY-BEST Funding Date: March 2010

Project Description (from NY-BEST Annual Report)

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

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

Hollingsworth & Vose Patents/Papers

Hollingsworth & Vose did not submit any papers or patents that resulted from NY-BEST funding. We did a search for patents and papers from the company that describe battery separators, and were from the period since the company received funding from NY-BEST.

We did not identify any papers from Hollingsworth & Vose after it received NY-BEST funding. However, we did locate a total of 14 published patent applications from the company that describe fiber webs designed for use as filters or as battery separators. To date, five of these applications have resulted in granted US patents.

It should be noted that the project description in the NY-BEST annual report states that the new separators developed under NY-BEST funding did not show sufficient performance improvements, and that the project was terminated. Hence, while the patent applications we identified appear to cover relevant technology (i.e. battery separators), it is unclear whether they are a legacy of the NY-BEST funded research project, or whether they result from a separate research effort at Hollingsworth & Vose into different battery separators.

Hollingsworth & Vose Patents/Papers cited by Subsequent US Patents

Four Hollingsworth & Vose's patents have been cited as prior art by subsequent US patents (see table below). These patents are all similar, and describe the company's fiber web technology.

Patent / Application #	Application Date	Issue Date	# Cites Received*	Assignee	Title
8753483	7/26/2012	6/17/2014	5	Hollingsworth & Vose	Systems and methods for making fiber webs
8758559	7/26/2012	6/24/2014	5	Hollingsworth & Vose	Systems and methods for making fiber webs
20120312487	5/11/2012	N/A	5	Hollingsworth & Vose	Systems and methods for making fiber webs
8877011	5/11/2012	11/4/2014	4	Hollingsworth & Vose	Systems and methods for making fiber webs

* Includes citations to associated patent applications

Patents Citing Hollingsworth & Vose Patents as Prior Art

As the table below shows, out of the 19 citations from US patents to Hollingsworth & Vose's patents, all but one come from the company's own patents. Further, these citing patents share the same title and much of the same content as the cited patents. This suggests that Hollingsworth & Vose is filing a series of patent applications covering different aspects of the same underlying technology (i.e. fiber webs for battery separators and filters), each of which references the earlier applications as prior art. This is typical of a company attempting to protect a key technology as extensively as possible. As noted above, from a NY-BEST perspective, the question is the extent to which this technology resulted from research that it funded.

The one patent from outside Hollingsworth & Vose that cites its patents is assigned to Oji Holdings of Japan. This patent describes a method for producing a fibrous sheet for use as a battery separator.

Patent / Application #	Application Date	Issue Date	# Cites to Holl. & Vose	Assignee	Title
8758559	7/26/2012	6/24/2014	4	Hollingsworth & Vose	Systems and methods for making fiber webs
8956504	5/8/2014	2/17/2015	4	Hollingsworth & Vose	Systems and methods for making fiber webs
9062415	5/7/2014	6/23/2015	4	Hollingsworth & Vose	Systems and methods for making fiber webs
8753483	7/26/2012	6/17/2014	3	Hollingsworth & Vose	Systems and methods for making fiber webs
8877011	5/11/2012	11/4/2014	3	Hollingsworth & Vose	Systems and methods for making fiber webs
8845862	12/16/2011	9/30/2014	1	Oji Holdings Corp	Device for producing fibrous sheet

Funding Recipient Citation Profile: Brookhaven National Laboratory

NY-BEST Funding Date: March 2010

Project Description (from NY-BEST Annual Report)

Dr. Feng Wang is examining lithium-titanate batteries for lower cost electric grid storage.

Brookhaven Patents/Papers

Brookhaven identified three papers that resulted from NY-BEST funding. These papers describe nanoscale materials based on lithium titanate for use in energy storage. In addition to these three papers, we searched for other papers published since 2010 on which Feng Wang is listed as an author. We identified 29 such papers.

We also searched for patents and patent applications from Brookhaven that either refer to lithium titanate, or that list Feng Wang as an inventor. We did not locate any such patents.

Brookhaven Patents/Papers Cited by US Patents

Only one of the Brookhaven papers we identified has been cited as prior art by subsequent US patents. Details of this paper are shown in the table below.

First Author	Journal	Year	Title	# Citing Patents
Zhou, X.	Journal of Materials Chemistry	2011	Graphene modified LiFePO4 cathode materials for high power lithium ion batteries	18

This paper (referred to hereafter as the Zhou paper) was co-authored by researchers from Brookhaven (including Feng Wang), along with researchers from Ningbo Institute of Material Technology & Engineering (NIMTE), which was set up by the Chinese Academy of Sciences. Indeed, the first author and corresponding author are both from NIMTE. The paper describes a lithium iron phosphate (LiFePO4) battery, which is different to the lithium titanate battery chemistry for which Brookhaven received funding from NY-BEST. As such, it is questionable whether this paper can be considered to be related to NY-BEST funding.

Patents Citing Brookhaven Patents/Papers

Out of the 18 US patents that cite the Zhou paper as prior art, 17 are assigned to Semiconductor Energy Lab (SEL), as shown in the table below.

Organization	# Citing Patents	Example Citing Patent	Technology
Semiconductor Energy Lab	17	8993156	High conductivity graphene for lithium ion batteries
Nanotek Instruments	1	8765302	Graphene enhanced cathode for lithium ion batteries

These SEL patents describe various aspects of the use of graphene in lithium ion batteries, including details of the material itself, and methods for incorporating the material into batteries. As a company, SEL is focused on research and development, rather than producing products itself. It generates revenue by licensing its patented technologies to operating companies, or enforcing these patents if a license cannot be negotiated. In the patent world, this type of business is typically known as a non-practicing entity (NPE).

The other patent that cites the Zhou paper is assigned to Nanotek Instruments. Nanotek is a developer of nanotechnology-based energy storage devices. Its patent that cites the Zhou paper describes a graphene-based cathode for lithium ion batteries, similar to the SEL patents that also cite the Zhou paper.

Funding Recipient Citation Profile: Eos Energy Storage

NY-BEST Funding Date: February 2013

Project Description (from NY-BEST Annual Report)

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

Eos Patents and Papers

There were no patents or papers reported by Eos as resulting from NY-BEST funding. We did a search for patents and papers from Eos describing zinc batteries. This search produced a total of 18 US patent applications published from 2012 onwards. To date, one of these applications has resulted in a granted patent (US #8,802,304). We did not identify any papers written by Eos describing zinc batteries.

Eos Patents and Papers Cited as Prior Art by Subsequent US Patents

Out of the 18 Eos US patent applications, three have been cited as prior art by subsequent US patents, receiving a total of 16 references (see table below). All but one of these references are to two Eos patent documents. The first is the granted US patent, which describes an air electrode for metal-air (e.g. zinc-air) batteries. The second is a published patent application (#20120021303) that describes a metal-air battery system for electric grid energy storage.

Patent / Application #	Application Date	Issue Date	# Cites Received*	Assignee	Title
8802304	8/10/2010	8/12/2014	8	Eos Energy Storage LLC	Bifunctional (rechargeable) air electrodes comprising a corrosion-resistant outer layer and conductive inner layer
20120021303	7/21/2010	N/A	7	Eos Energy Storage LLC	Electrically rechargeable, metal-air battery systems and methods
20130115531	7/20/2011	N/A	1	Eos Energy Storage LLC	Electrically rechargeable, metal-air battery systems and methods

* Including citations to underlying patent applications

These two Eos patent documents thus appear to have had a substantial impact on technological developments. It should be noted that both were filed in 2010, before Eos was funded by NY-BEST. This aligns with the stated purpose of NY-BEST's funding of Eos, which was to scale its existing battery technology, rather than to undertake research into brand new technology. As such, it is not surprising that the patents describing the fundamental features of Eos's battery technology were filed prior to its receipt of NY-BEST funding.

Patents Citing Eos Patents as Prior Art

Out of the 16 prior art references to Eos patents, half are from patents assigned to EnerVault Corporation (www.enervault.com), as shown in the table below.

Organization	# Citing Patents	Example Citing Patent	Technology
EnerVault Corp	8	8906529	Redox flow battery system for electric grid energy storage
Eos Energy Storage	2	8802304	Air electrode for metal-air (e.g. zinc-air) batteries
Dynantis Corp	1	9054394	Metal-air battery for grid storage and electric vehicles
Ford Motor Co.	1	9166218	Electrolyte replenishment for metal-air batteries
Hyundai Motor Co.	1	9184450	Lithium-air battery for electric vehicles
NGK Insulators Ltd.	1	8846256	Substrate for use as metal-air battery electrode
Samsung Electronics Co.	1	9263779	Lithium air battery with improved lifespan
ZAF Energy Systems	1	8728671	Electrodes for metal-air batteries

EnerVault designs and manufactures large scale energy storage systems using redox flow battery technology, and its systems have been successfully demonstrated in the field at the megawatt-hour scale. The company is currently looking for new owners to fund its next stage of development. EnerVault's patents that reference Eos's patents as prior art describe a redox flow battery system for grid storage, and thus cover key elements of its technology. It thus appears that Eos's technology has helped form the foundation for an implemented energy storage solution, albeit one developed by a company that is currently facing funding difficulties.

Beyond EnerVault, there are a number of other large companies whose metal-air battery patents reference Eos's patents as prior art. These include Ford (whose citing patent describes electrolyte replenishment for metal-air batteries); Hyundai (lithium-air batteries for electric vehicles); NGK (metal-air battery electrodes); and Samsung (lithium-air battery with improved lifespan). Eos's technology thus appears to play an important role in the development of metal-air battery technology.

Funding Recipient Citation Profile: Ambri Inc.

NY-BEST Funding Date: January 2014

Project Description (from NY-BEST Annual Report)

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 which helped form the underlying technology licensed by MIT to Ambri in 2010.

Ambri Patents and Papers (licensed from MIT)

There is a single paper identified by Ambri as being funded by NY-BEST, a 2015 report entitled 'An Economic Analysis of the Impacts of Ambri Storage and Varying Levels of Renewables in Hawaii'. There are no NY-BEST funded patents identified by Ambri.

In searching for additional Ambri patents and papers that could be related to NY-BEST funding, the situation was somewhat different than that for other funded organizations, since Ambri licensed its technology – specifically from MIT. We focused our search on MIT patents rather than papers, since licensable technology is particularly likely to be codified in patents.

We searched for MIT patents that describe liquid metal batteries, and that list as inventors either Donald Sadoway or David Bradwell. These are the two main inventors of the technology licensed by Ambri, and they are both listed as co-founders of the company. We identified a total of 11 US patent applications, six of which have resulted in granted patents to date. Two of the recent applications are assigned to Ambri, rather than MIT, suggesting that the company itself is continuing to innovate, rather than relying solely on pre-existing technology.

Ambri Patents Cited as Prior Art by Subsequent US Patents

Out of the eleven Ambri patent applications, two have been cited as prior art by subsequent US patents. These two applications, both of which have resulted in granted patents, are shown in the table below. They both describe alkaline earth metal ion batteries for energy storage applications, and each has been cited as prior art by five subsequent US patents.

Patent #	Application Date	Issue Date	# Cites Received*	Assignee	Title
8323816	7/20/2009	12/4/2012	5	MIT	Alkaline earth metal ion battery
9076996	7/19/2010	7/7/2015	5	MIT	Liquid electrode battery

* Includes citations to underlying patent applications

Patents Citing Ambri Patents as Prior Art

The organizations whose patents cite the Ambri patents as prior art are shown in the table below.

Organization	# Citing Patents	Example Citing Patent	Technology
Invention Science Fund 1 LLC	4	8968903	Battery with fluid-surfaced electrode for renewable energy storage applications
MIT	3	9000713	Self-citation describing similar technology to cited patents
General Electric	1	8324719	Packaging for electronic devices
Toyota Motor Corp	1	8685564	Magnesium ion battery for consumer devices, hybrid vehicles etc
Univ of Kentucky	1	8841014	Liquid metal electrode for lithium ion battery

The assignee at the head of this table is the Invention Science Fund. This is an assignee name used frequently by Intellectual Ventures (IV) - www.intellectualventures.com. IV is known as perhaps the most prominent non-practicing entity (NPE), whose primary business model is to purchase patents in order to license them to, or enforce them against, operating companies. However, IV also has another strand based upon developing innovations in-house, focusing on technologies that the company believes will be particularly influential in the future. The patents in the table above result from this effort. Specifically, these IV patents describe batteries for renewable energy storage applications. It is interesting that Ambri's technology forms part of the foundation for these IV patents, which were specifically developed to cover innovations with particular future promise.

The other patents that cite Ambri's technology as prior art (other than subsequent MIT/Ambri patents) include a General Electric patent describing packaging for electronic devices; a Toyota patent describing a magnesium ion battery for consumer devices and hybrid electric vehicles; and a University of Kentucky patent describing a liquid metal electrode for lithium ion batteries. Ambri's technology thus appears to have influenced developments across a range of organizations and technologies.

Funding Recipient Citation Profile: General Electric (plus university partners)

NY-BEST Funding Date: March 2010

Project Description (from NY-BEST Annual Report)

General Electric Co. (Schenectady), under the largest NY-BEST R&D award made under this first funding round, is partnering 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.

General Electric Patents and Papers

General Electric (GE), helped in part by funding from NY-BEST, carried out extensive research into sodium-metal halide batteries. This research led to the launch of GE's Durathon batteries, although the company announced it was scaling back production of these batteries in 2015.

We located a total of 21 published patent applications assigned to GE describing its sodium metal halide battery technology. Out of these 21 applications, nine have resulted in granted patents. These granted patents are shown in the table below, along with the one published application that has been cited as prior art by a subsequent patent. The remaining published applications are not shown here due to space considerations.

Patent / Application #	Application Date	Issue Date	Current Status	# Cites Received	Assignee	Title
8471406	12/22/2009	6/25/2013	Granted	5	General Electric	Controllable energy utilization system and associated method
8647767	3/23/2010	2/11/2014	Granted	1	General Electric	Sodium-metal-halide energy storage device with sodium level control mechanism
8757471	8/27/2012	6/24/2014	Granted	0	General Electric	Active braze techniques on beta-alumina
8988047	8/30/2012	3/24/2015	Granted	0	General Electric	Method of charging an electrochemical cell
9067818	1/19/2012	6/30/2015	Granted	0	General Electric	Sealing glass composition and article
9148025	7/25/2012	9/29/2015	Granted	1	General Electric	System and method for a

						rechargeable battery
9153844	1/31/2011	10/6/2015	Granted	0	General Electric	System and methods of using a sodium metal halide cell
9159980	12/27/2012	10/13/2015	Granted	0	General Electric	Electrochemical cell
9257698	11/13/2012	2/9/2016	Granted	0	General Electric	Composition, energy storage device, and related process
20110206984	2/25/2010	N/A	Abandoned	1	General Electric	Presealed anode tube

The patent at the head of this table (#8471406) has been cited as prior art by five subsequent patents. This GE patent describes a method for back-up electric power, with sodium metal halide batteries being a specifically claimed option. This patent was filed before GE received funding from NY-BEST, and appears to represent an early application of GE's sodium metal halide battery technology.

While GE did not designate any of its patents as being specifically funded by NY-BEST, it did submit one of its papers as being NY-BEST funded, plus two theses. The paper was published in the Journal of the Electrochemical Society in 2015, and describes a mixed iron-nickel cathode for an electrochemical cell. Neither the paper nor the theses have been cited as prior art by any patents.

Patents Citing General Electric Patents as Prior Art

The table below shows the companies whose patents cite GE's sodium-metal halide patents as prior art. These include GE itself, whose recent patents describing molten salt batteries build upon its own earlier patents.

Organization	# Citing Patents	Example Citing Patent	Technology
Younicos Inc	4	9209640	Controlling renewable energy storage devices via charging/discharging
General Electric	3	9005793	Molten salt batteries
SolarCity Corp	1	9270118	Controlling solar energy storage device via charging/discharging

Beyond GE, the company at the head of this table is Younicos Inc, with four patents that all cite the GE patent at the top of the previous table. Younicos (www.younicos.com) is a German-American company that develops and sells energy storage solutions for power networks, all based on renewable energy sources. Its four patents that cite GE describe a method for controlling the charging and discharging of renewable energy storage devices, in order to provide reliable power supply.

The other citing patent in the table above is assigned to SolarCity Corp (www.solarcity.com). SolarCity designs and installs solar panels, for example on commercial and residential buildings. Its patent that cites GE is similar to the Younicos patents, in that it describes a method for controlling the charging and discharging of energy storage devices, in this case specifically devices working with solar energy.

As companies, both Younicos and SolarCity are well beyond simply the research stage, and are both actively installing renewable energy solutions – battery plants in the case of Younicos and solar panels in the case of SolarCity. The fact that their patents build upon GE's may thus be an example of a practical outcome from GE's research into sodium metal halide batteries, even if GE itself is scaling back production of these batteries.

Funding Recipient Citation Profile: WATT Fuel Cell Corp.

NY-BEST Funding Date: February 2013

Project Description (from NY-BEST Annual Report)

Watt Fuel Cell Corp. (Port Washington) is 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.

WATT Fuel Cell Patents and Papers

The table below lists WATT's granted patents and published patent applications since it was founded in 2010. WATT did not designate any of its patents specifically as being NY-BEST funded, but these patents are all connected in some way to fuel cell technology, and as such may be related to NY-BEST funding. We also searched for papers from the company describing fuel cell technology, but we did not locate any.

Patent / Application #	Application Date	Issue Date	Current Status	# Cites Received*	Assignee	Title
8652707	9/1/2011	2/18/2014	Granted	2	WATT Fuel Cell Corp	Process for producing tubular ceramic structures of non-circular cross section
9017893	6/24/2011	4/28/2015	Granted	1	WATT Fuel Cell Corp	Fuel cell system with centrifugal blower system for providing a flow of gaseous medium thereto
20120251922	3/28/2011	N/A	In Prosecution	1	WATT Fuel Cell Corp	Electrode for a solid oxide fuel cell and method for its manufacture
20130056911	9/1/2011	N/A	In Prosecution	1	WATT Fuel Cell Corp	Process for producing tubular ceramic structures
20130230787	3/1/2012	N/A	In Prosecution	0	WATT Fuel Cell Corp	Tubular solid oxide fuel cell assembly and fuel cell device incorporating same
20150024297	7/18/2014	N/A	In Prosecution	0	WATT Fuel Cell Corp	Apparatus and Methods for Mixing Reformable Fuels and an Oxygen Containing Gas and/or Steam
20150125771	11/6/2014	N/A	In Prosecution	0	WATT Fuel Cell Corp	Integrated gaseous fuel CPOX reformer and fuel cell systems,

						and methods of producing electricity
20150137044	11/5/2014	N/A	In Prosecution	0	WATT Fuel Cell Corp	Liquid fuel CPOX reformers and methods of CPOX reforming
20150144841	11/6/2014	N/A	In Prosecution	0	WATT Fuel Cell Corp	Gaseous fuel CPOX reformers and methods of CPOX reforming
20150192134	03/24/2015	N/A	In Prosecution	0	WATT Fuel Cell Corp	Centrifugal blower system and fuel cell incorporating same
20150192138	3/24/2015	N/A	In Prosecution	0	WATT Fuel Cell Corp	Centrifugal blower system and fuel cell incorporating same
20150194683	3/24/2015	N/A	In Prosecution	0	WATT Fuel Cell Corp	Centrifugal blower system and fuel cell incorporating same
20150264871	3/20/2014	N/A	In Prosecution	0	WATT Fuel Cell Corp	Plant cultivation system and method
20160006063	2/18/2014	N/A	In Prosecution	0	WATT Fuel Cell Corp	Modular fuel cell systems and methods

* Including citations to underlying published patent applications

To date, two of WATT's published patent applications have resulted in granted patents. The remaining applications are still in prosecution, meaning that a final determination as whether they should be granted is yet to be made by the examiner. The WATT patents describe various technologies relating to fuel cells, including components of such cells, notably electrodes; fuel reformers for providing fuel inputs to these cells; and methods for supplying these fuel inputs to the cells using centrifugal blowers. It is thus an interesting question as to whether NY-BEST funding helped in the development of these various technologies.

Patents Citing WATT Patents as Prior Art

The table below lists the patents that have cited the WATT patents as prior art. The first patent in this table is assigned to WATT itself. This patent cites two of the other WATT published applications, showing that the company is building on its own technology as it works to extend its patent portfolio.

Perhaps of more interest are the other three citing patents shown in this table. These patents are all assigned to large companies, and describe different technologies related to fuel cells. Specifically, the Samsung SDI patent describes a fuel cell with improved connectors in order to reduce leakages from the cell, while the Toshiba patent describes a fuel cell with reduced anode-electrolyte reactivity to improve performance. The Eaton patent is slightly different, in that it is

mainly directed to air supply systems for engine superchargers. However, it also makes reference to the use of these air supply systems for inputs to fuel cells, and has specific claims covering this application.

Patent #	Application Date	Issue Date	# Cites to WATT	Assignee	Title
8652707	9/1/2011	2/18/2014	2	WATT Fuel Cell Corp	Process for producing tubular ceramic structures of non-circular cross section
9184462	10/4/2012	11/10/2015	1	Samsung SDI Co Ltd	Fuel cell module and method manufacturing the same
8999600	2/14/2013	4/7/2015	1	Toshiba Corp	Solid oxide electrochemical cell
9074524	12/9/2011	7/7/2015	1	Eaton Corp.	Air supply system with two-stage roots blower

These citations from the patents of large companies are an encouraging sign in terms of the potential future impact of WATT's technology. They suggest that, not only is the company itself building on its own technology, but so are other large companies interested in fuel cell technology.

Funding Recipient Citation Profile: Ioxus

NY-BEST Funding Date: March 2010 (with CUNY); July 2012 (solo)

Project Description (from NY-BEST Annual Report)

2010: Ioxus (Oneonta) in conjunction with CUNY is exploring enhancements to its ultracapacitors by developing a novel electrode-electrolyte interface.

2012: Ioxus (Oneonta) is developing thermally optimized ultracapacitors for hybrid vehicle applications.

Ioxus Patents and Papers

Ioxus received two different sets of funding from NY-BEST, the first in 2010 (with CUNY) and the second in 2012 (on its own). The company did not identify any patents or papers that resulted from NY-BEST funding in either case.

We searched for patents and papers from the key researchers at Ioxus describing ultracapacitor technology. We identified a total of six relevant patent applications published since 2011, as shown in the table below. Two of the patent applications have resulted in granted US patents, two were abandoned by the applicant, and two are still in prosecution (i.e. the examiner has yet to determine whether to grant them).

Patent / Application #	Application Date	Issue Date	Current Status	# Cites Received*	Assignee	Title
8760850	9/9/2010	6/24/2014	Granted	0	Ioxus Inc	Methods and apparatus related to a purge valve for a capacitor
9245693	5/13/2011	1/26/2016	Granted	1	Ioxus Inc	High voltage EDLC cell and method for the manufacture thereof
20120033347	2/11/2011	N/A	Abandoned	1	Ioxus Inc	Electrochemical Capacitors
20140002958	4/1/2013	N/A	Abandoned	1	Ioxus Inc	High voltage EDLC cell and method for the manufacture thereof
20140242436	2/26/2014	N/A	In Prosecution	0	Ioxus Inc	Energy storage device assembly
20140377592	2/26/2014	N/A	In Prosecution	0	Ioxus Inc	Energy storage device assembly

* Including citations to underlying patent applications

We also identified two conference papers that list authors from Ioxus and Binghamton University, and are concerned with ultracapacitor technology. These papers, which were

presented at American Society of Mechanical Engineers (ASME) conferences in 2011, are shown in the table below.

First Author	Conference	Year	Title	# Citing Patents
X. Xu	ASME 2011 Pacific Rim Technical Conference	2011	Multiphysics Approach to Modeling Supercapacitors for Improving Performance	0
X. Xu	ASME 2011 International Mechanical Engineering Congress and Exposition	2011	Thermal Modeling and Heat Management of Supercapacitor Modules by High Velocity Impinging Fan Flow	0

Patents Citing Ioxus Patents and Papers as Prior Art

As shown above, the Ioxus patents have received a total of three citations from subsequent patents. Two of these citations come from Ioxus's own recently granted patent, while the third comes from Corning (see table below).

Patent #	Application Date	Issue Date	# Cites to Ioxus	Assignee	Title
9245693	5/13/2011	1/26/2016	2	Ioxus Inc	High voltage EDLC cell and method for the manufacture thereof
9136064	1/28/2014	9/15/2015	1	Corning Inc	Carbon for high voltage EDLCs

The Ioxus citations show that the company is building upon its own related applications, which is a common exercise in this type of specialized technology area. The Corning patent that cites Ioxus describes a method for forming activated carbon for ultracapacitor electrodes. It represents the first evidence from a citation perspective of Ioxus's influence beyond the company itself.

Funding Recipient Citation Profile: The Paper Battery Company

NY-BEST Funding Date: July 2012

Project Description (from NY-BEST Annual Report)

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

Paper Battery Patents and Papers

Paper Battery identified two of its patents as being funded by NY-BEST, and these patents are listed at the head of the table below. This table also contains one additional granted patent, plus four published patent applications. We identified these additional patent documents by searching for Paper Battery patents related to energy storage sheets and their use in ultracapacitors. We also searched for papers from the company related to this technology, but did not locate any.

Patent / Application #	Application Date	Issue Date	Current Status	# Cites Received*	Assignee	Title
8514548	7/27/2010	8/20/2013	Granted	2	The Paper Battery Co	Compliant energy storing structural sheet
8964358	3/18/2013	2/24/2015	Granted	0	The Paper Battery Co	Compliant energy storing structural sheet
9293264	2/23/2015	3/22/2016	Granted	0	The Paper Battery Co	Compliant energy storing structural sheet
20140014403	3/9/2012	N/A	Abandoned	0	The Paper Battery Co	Energy storage and dispensing flexible sheeting device
20140268617	9/30/2013	N/A	In Prosecution	0	The Paper Battery Co	Supercapacitor Structures
20140287277	3/17/2014	N/A	In Prosecution	0	The Paper Battery Co	Energy storage structures and fabrication methods thereof
20150092343	9/15/2014	N/A	In Prosecution	0	The Paper Battery Co	Ultra-capacitor structures and electronic systems with ultra-capacitor structures

* Including citations to underlying published patent applications

The three granted patents in the table above are very similar, and describe the fundamental energy storage sheets developed by Paper Battery. Meanwhile, the more recent published patent

applications describe the use of these sheets in ultracapacitors. Three of these applications are still in prosecution (i.e. they are still in the process where the examiner either accepts or rejects them), while the fourth was abandoned after the company failed to respond in a timely manner to the patent examiner.

Patents Citing Paper Battery Patents as Prior Art

To date, only the earliest Paper Battery patent has been cited as prior art by any subsequent patents as prior art. The two patents that cite this Paper Battery patent are shown in the table below.

Patent #	Application Date	Issue Date	Assignee	Title
8964358	3/18/2013	2/24/2015	The Paper Battery Co	Compliant energy storing structural sheet
9293264	2/23/2015	3/22/2016	The Paper Battery Co	Compliant energy storing structural sheet

These citing patents are actually the two more recent granted Paper Battery patents shown in the earlier table. Hence, these are self-citations from the company to its own earlier patent. This suggests that the company is protecting its technology carefully with a series of patents surrounding the same underlying invention (i.e. energy storage sheets). However, there is not yet any evidence of this invention influencing researchers outside the company.

Funding Recipient Citation Profile: Battery Energy Storage Systems Technologies

NY-BEST Funding Date: February 2013

Project Description (from NY-BEST Annual Report)

Battery Energy Storage Systems (BESS) Technologies (Albany), a startup company from SUNY Polytechnic, collaborated with the 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.

BESS Technologies Patents and Papers

BESS did not identify any of its patents and papers as resulting from NY-BEST funding. We did additional searches for BESS patents and papers describing electrodes for lithium-ion batteries. We did not locate any papers, but we did identify two patent applications that appear relevant. These patent applications are shown in the table below.

The first of these applications is assigned to SUNY. It is included here because it covers similar technology to the BESS patent application listed second – i.e. branched nanostructures such as nanowires for lithium ion battery electrodes. Also, both patent applications have an inventor in common (Isaac Lund), who is listed as scientific adviser to BESS on its website. Plus, BESS was spun out by SUNY as a start-up company.

Patent Application #	Application Date	Current Status	# Cites Received	Assignee	Title
20130143124	8/23/2011	Allowed	2	State Univ of New York	Branched nanostructures for battery electrodes
20150118572	10/29/2013	In Prosecution	0	BESS Technologies	Solid state battery and methods of fabrication

Neither of the two patent applications has resulted in a granted patent yet. However, the first application has been allowed, which means the patent examiner has accepted it, and a granted patent will be issued shortly; indeed the issue fee has just been paid by the applicant. The second application is in prosecution, meaning that the examiner has not accepted it in its current form.

Patents Citing BESS Patents as Prior Art

As shown in the table above, the earlier SUNY patent application has been cited as prior art by two subsequent patents. These two citing patents are listed in the table below.

Patent #	Application Date	Issue Date	Assignee	Title
8652683	11/6/2012	2/18/2014	Catalyst Power Technologies Inc	High capacity electrodes
8658310	11/6/2012	2/25/2014	Catalyst Power Technologies Inc	High capacity electrodes

Both of these patents describe battery electrodes coated with support filaments, such as nanotubes or nanowires. They are both assigned to a company named Catalyst Power Technologies (CPT) - www.catalystpowertech.com. We could not find much information on CPT, although it claims on its website to be a nanomaterials-based research group whose technology dramatically improves the performance of lithium ion batteries. This type of profile – i.e. a company with recent patents in a hi-tech space but with little other presence – is often seen with non-practicing entities (NPEs). These are companies set up with the purpose of licensing or enforcing patents. Hence, it may be that CPT is an NPE, although we cannot confirm this.

Funding Recipient Citation Profile: Rensselaer Polytechnic Institute

NY-BEST Funding Date: March 2010

Project Description (from NY-BEST Annual Report)

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.

Rensselaer Polytechnic Institute (RPI) Patents and Papers

RPI identified two of its papers as being funded by NY-BEST. These two papers are shown in the table below.

First Author	Journal	Year	Title	# Citing Patents
Krishnan, R.	Nano Letters	2010	Functionally strain-graded nanoscoops for high power Li-ion battery anodes	1
Mukherjee, R.	Nano Energy	2012	Nanostructured electrodes for high-power lithium ion batteries	0

We also did an additional search for other papers co-authored by Nikhil Koratkar since he received NY-BEST funding. We identified 114 such papers. These papers are not necessarily related to NY-BEST funding; indeed they cover many different technologies. We included them at the initial stage of the analysis in case any were cited as prior art by patents, in which case we could review them further to determine their relevance to NY-BEST. We found that none of the papers have been cited by any patents, so this additional review was not necessary.

RPI also identified one provisional patent application that was NY-BEST funded. This provisional application has yet to result in a regular published patent application, having only been filed recently. Provisional applications expire after one year, and applicants must file a regular patent application within this period to be able to claim coverage back to the filing date of the provisional application.

It is also worth that Nikhil Koratkar is listed as an inventor on a published patent application (US #20140050910) describing graphene-based electrodes for lithium-ion batteries (rather than the silicon electrodes in this NY-BEST award). This graphene-based technology led RPI researchers to form EnerMat, a start-up company also funded more recently by NY-BEST. The patent application has yet to be cited as prior art by any subsequent patents.

Patents Citing RPI Patents and Papers as Prior Art

The first RPI paper listed in the table above has been cited as prior art by one subsequent patent, while the second RPI paper has yet to be cited. The patent that cites the first RPI paper is shown in the table below.

Patent #	Application Date	Issue Date	Assignee	Title
8734674	4/26/2012	5/27/2014	Northwestern University	Method of enhanced lithiation of doped silicon carbide via high temperature annealing in an inert atmosphere

This patent is assigned to Northwestern University, and describes an improved silicon carbide anode for lithium ion batteries. It is thus an example of a patented technology that builds upon the earlier research into nano-engineered silicon based electrodes published by RPI in the initial stages of its funding by NY-BEST.

Funding Recipient Citation Profile: Primet Precision Materials

NY-BEST Funding Date: July 2012

Project Description (from NY-BEST Annual Report)

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

Primet Patents and Papers

Primet identified one of its papers as resulting from NY-BEST funding. We searched for additional papers, and identified another paper co-authored by researchers at Primet, Cabot Corp and the University of Muenster. It is not clear whether this paper is related to NY-BEST funding. In the table below, the Primet-identified paper is listed first, followed by the co-authored paper.

First Author	Journal	Year	Title	# Citing Patents
Karker, J.	Proceedings of Materials Research Society	2012	Energy and Power Through Synchronized Process and Crystal Engineering	0
Qi, X.	Journal of the Electrochemical Society	2015	Influence of Thermal Treated Carbon Black Conductive Additive on the Performance of High Voltage Spinel Cr-Doped LiNi0.5Mn1.5O4 Composite Cathode Electrode	0

Primet did not identify any of its patents or patent applications as being NY-BEST funded. We carried out a search to identify any of the company's patent filings describing raw materials for energy storage devices, since these could possibly be related to NY-BEST funding.

Patent / Application #	Application Date	Issue Date	Current Status	# Cites Received	Assignee	Title
8377509	2/28/2007	2/19/2013	Granted	0	Primet Precision Materials	Lithium-based compound nanoparticle compositions and methods of forming the same
20110049421	8/26/2010	N/A	In Prosecution	1	Primet Precision Materials	Compositions and processes for making the same
20130122300	12/18/2012	N/A	Abandoned	0	Primet Precision Materials	Lithium-based compound nanoparticle compositions and methods of forming the same
20150152303	11/24/2014	N/A	In Prosecution	0	Primet Precision Materials	Small particle compositions and associated methods

We located three published US patent applications, plus an earlier granted patent describing similar technology to these published applications. They all describe nanoparticle compositions for lithium ion batteries, and are shown in the table above.

Patents Citing Primet Patents and Papers as Prior Art

The tables above reveal that neither of the Primet papers has been referenced as prior art by any US patents. The same is true for three out of the four Primet patents, with the fourth having been cited by a single patent. This citing patent is shown in the table below.

Patent #	Application Date	Issue Date	Assignee	Title
8377509	2/28/2007	2/19/2013	Primet Precision Materials	Lithium-based compound nanoparticle compositions and methods of forming the same

This citing patent is actually the granted Primet patent listed in the previous table. Hence, the citation is simply one Primet patent application referencing the other while they are both pending. As such, this finding does not appear particularly meaningful from the perspective of Primet's technological impact.

Funding Recipient Citation Profile: Custom Electronics Inc.

NY-BEST Funding Dates: Several (see below)

Project Description (from NY-BEST Annual Report)

July 2012: 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.

February 2013: Custom Electronics (Oneonta) is 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.

January 2014: Custom Electronics, Inc. (Oneonta, NY) is 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.

August 2014: Custom Electronics (Oneonta, NY) is partnering with Unique Technical Services (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.

Custom Electronics Patents and Papers

Custom Electronics was awarded funds by NY-BEST under a series of funding rounds. Based on the project descriptions in the annual report, these funding rounds appear have helped Custom Electronics from early exploratory research into graphene-based ultracapacitors, through to developing commercialization plans for these ultracapacitors.

Custom Electronics identified two provisional patent applications that resulted from NY-BEST funding. We located the regular published patent applications associated with these provisional applications (which expire after one year, and must be replaced with a regular application). We also searched for other patents and papers from Custom Electronics related to ultracapacitors. In total, from these two approaches we identified three patent applications filed since Custom Electronics first receiving NY-BEST funding. One of these applications has resulted in a granted patent, while the other two are still in prosecution (i.e. the examiner is still determining whether to grant them). We did not locate any papers from Custom Electronics related to ultracapacitors.

The three Custom Electronics patent applications are shown in the table below. These patents describe improved graphene-based electrodes for ultracapacitors. The ultracapacitors can be used to provide more dependable output when faced with interruptions in the power supply.

Patent / Application #	Application Date	Issue Date	Current Status	# Cites Received*	Assignee	Title
9105406	10/24/2012	8/11/2015	Granted	1	Custom Electronics Inc	Graphene electrolytic capacitor
20140114592	10/22/2013	N/A	In Prosecution	0	Custom Electronics Inc	Operational monitoring of electrochemical capacitors
20140293513	3/24/2014	N/A	In Prosecution	0	Custom Electronics Inc	Graphene-based high voltage electrodes and materials

* Includes references to associated published patent applications

Patents Citing Custom Electronics Patents as Prior Art

As shown in the table above, two out of the three Custom Electronics patents have yet to be cited as prior art by any subsequent patents, while the third has been cited by a single patent. This citing patent is shown in the table below.

Patent #	Application Date	Issue Date	Assignee	Title
8940145	3/1/2013	1/27/2015	NASA	Graphene-based electrode for a supercapacitor

The Custom Electronics patents are still relatively recent, so the lack of prior art references to them is not surprising. Having said this, one promising sign in terms of the potential importance of these patents, and the underlying technology developed by Custom Electronics, is the identity of the assignee (owner) of the one citing patent. It is a NASA patent describing a method for manufacturing a graphene-based electrode for an ultracapacitor. The fact that Custom Electronics' patents help form part of the foundation for NASA technology may be regarded as a positive sign in terms of the potential future impact of these patents.

Funding Recipient Citation Profile: NOHMs Technologies Inc.

NY-BEST Funding Date: February 2013

Project Description (from NY-BEST Annual Report)

NOHMs Technologies (Ithaca and Rochester) is developing and testing a new prototype for longer-lasting mobile phones.

NOHMs Patents and Papers

NOHMs Technologies was founded in 2010 by researchers from Cornell University seeking to commercialize lithium sulfur batteries they had developed at the university. NY-BEST funded NOHMs in its efforts to design such batteries for use in mobile phones.

NOHMs did not identify any of its patents or papers as being funded by NY-BEST. We searched for NOHMs patents related to lithium sulfur batteries, since they could potentially be related to NY-BEST funding. We identified a total of eight published patent applications, which are shown in the table below. None of these eight patents has resulted in a granted patent yet, although one of them has been allowed, which means that the examiner has expressed acceptance of the application, and a granted patent will issue shortly.

Patent Application #	Application Date	Current Status	# Cites Received	Assignee	Title
20130330619	11/8/2011	In Prosecution	1	Cornell Univ	Sulfur containing nanoporous materials, nanoparticles, methods and applications
20140154588	7/10/2012	Allowed	0	Cornell Univ	Ionic-liquid nanoscale ionic material (IL-NIM) compositions, methods and applications
20140186695	11/19/2013	In Prosecution	0	NOHMs	Sulfur-infused carbon for secondary battery materials
20150155549	10/17/2014	In Prosecution	0	NOHMs	Functionalized carbons for lithium-sulfur batteries
20150207176	1/22/2015	In Prosecution	0	NOHMs	Functionalized ionic liquid combinations
20150234014	2/18/2015	In Prosecution	0	NOHMs	Charge control and termination of lithium sulfur cells and fuel gauging systems and methods
20150333374	5/15/2015	In Prosecution	0	NOHMs	Ionic liquids for solvating cyclic carbonates
20150340738	5/15/2015	In Prosecution	0	NOHMs	Ionic liquids for solvating lithium polysulfides

The first two patent applications in this table are assigned to Cornell. They are included here because they describe lithium sulfur batteries, and were invented by the researchers who founded NOHMs. As such, they appear to be closely related to NOHMs' technology.

We also searched for papers authored by the key researchers at NOHMs. We identified four such papers, as shown in the table below. These papers again focus on lithium sulfur batteries.

First Author	Journal / Conference	Year	Title	# Citing Patents
Yingying Lu	224th Electrochemical Society Meeting	2013	Ionic Liquid-Nanoparticle Hybrid Electrolytes and Their Applications in Rechargeable Lithium Metal Batteries	0
Surya Moganty	224th Electrochemical Society Meeting	2013	Ionic Liquids As Electrolyte Additives for Li-S Battery Applications	0
Lin Ma	Advanced Energy Materials	2014	Tethered Molecular Sorbents: Enabling Metal-Sulfur Battery Cathodes	0
Surya Moganty	Chemical Engineering Journal, 264	2015	Corrigendum to ‘‘Structure–property relationships in transport and thermodynamic properties of imidazolium bistriflamide ionic liquids for CO2 capture	0

Patents Citing NOHMs Patents and Papers as Prior Art

With the exception of the original Cornell patent applications, most of the NOHMs patents and papers are relatively recent. Not surprisingly, therefore, they have yet to be referenced as prior art by any subsequent patents.

The earliest Cornell patent application has been cited as prior art by one patent, which is shown in the table below. This citing patent is assigned to Toyota, and describes a cathode for lithium sulfur batteries, specifically for use in hybrid electric vehicles. As such, this is an example of a practical application of lithium sulfur batteries developed by a large automotive company, for which NOHMs' technology has helped form part of the foundation.

Patent #	Application Date	Issue Date	Assignee	Title
8980471	2/21/2013	3/17/2015	Toyota Motor Corp	Carbon-sulfur composites encapsulated with polyelectrolyte multilayer membranes

Funding Recipient Citation Profile: Combined Energies/Unique Technical Services

NY-BEST Funding Date: August 2014

Project Description (from NY-BEST Annual Report)

Combined Energies (Latham, NY) is partnering with Unique Technical Services (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.

Combined Energies/UTS Patents and Papers

Combined Energies submitted two patent documents that resulted from NY-BEST funding – a provisional patent application and a published patent application. Provisional patent applications are a way for applicants to establish a priority date for their invention, but they do not themselves result in a granted patent. Rather, after filing a provisional patent application, the applicant has one year to file a regular patent application (or applications), and still claim protection back to the date of the original provisional filing.

In this case, we identified a total of three published patent applications assigned to Combined Energies that have resulted from the patent documents identified by the company as being funded by NY-BEST. We also searched for other published patent applications and papers associated with Combined Energies and UTS, but did not locate any.

The three patent applications are shown in the table below. All three of these applications are currently in prosecution, which means that the examiner has yet to make a determination whether to grant a patent based on any of them.

Patent Application #	Application Date	Current Status	# Cites Received*	Assignee	Title
20140268931	3/2/2014	In Prosecution	1	Combined Energies LLC	Power conversion system with a DC to DC boost converter
20140272656	12/29/2013	In Prosecution	0	Combined Energies LLC	Dynamically Responsive High Efficiency CCHP System
20140278709	11/19/2013	In Prosecution	0	Combined Energies LLC	Intelligent CCHP System

The first application in the table above describes a voltage booster for low voltage sources such as fuel cells. Meanwhile, the second and third applications describe a fuel-cell based cooling, heating and power system. To date, the first application has been cited as prior art by one US patent, while the second and third applications have yet to be cited. These low citation counts are

not particularly surprising, given the time lags associated with the patenting process, and the relatively recent application dates of the Combined Energies applications.

Patents Citing Combined Energies/UTS Patents

The single patent that has cited the Combined Energies patent applications is shown in the table below. This patent is assigned to Sharp Corporation, and describes electric power generation with a DC-DC converter, especially for use with solar energy. Hence, while the Sharp patent describes a different power source to the Combined Energies patent (i.e. solar cells vs. fuel cells), it builds on the latter's teachings related to boosting voltage from a given power source.

Patent #	Application Date	Issue Date	Assignee	Title
9088170	9/5/2013	7/21/2015	Sharp Corp	Electric power conversion apparatus, power storage system and power storage method

Funding Recipient Citation Profile: Raymond Corporation

NY-BEST Funding Date: August 2014

Project Description (from NY-BEST Annual Report)

Raymond Corporation (Greene, NY) is 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.

Raymond Corp. Patents and Papers

Raymond did not identify any patents or papers that resulted from NY-BEST funding. Through additional searches, we identified two patents granted to Raymond describing energy storage systems for lift trucks, and these patents are shown in the table below. We did not identify any relevant papers from the company.

Patent #	Application Date	Issue Date	# Cites Received	Assignee	Title
8689943	3/10/2010	4/8/2014	0	The Raymond Corporation	Energy storage on an elevated platform and transfer method
8869944	6/15/2011	10/28/2014	1	The Raymond Corporation	Energy storage on an elevated platform and transfer method

These two patents both describe similar technology. Specifically, they outline the use of a dedicated rechargeable battery for the platform element of a lift truck, removing the need for power to be transferred via wires from the engine of the truck. Lithium-ion batteries are suggested as one possible solution, along with nickel metal hydride batteries. It should be noted that these patents were both filed prior to Raymond receiving NY-BEST funding, so may represent earlier research carried out by the company into applications for rechargeable battery technology.

Patents Citing Raymond Patents as Prior Art

To date, the Raymond patents have only been cited as prior art by a single subsequent patent, which is shown in the table below.

Patent #	Application Date	Issue Date	Assignee	Title
9041340	2/21/2013	5/26/2015	Unassigned	Systems and methods for in-vehicle charging of pallet jack batteries

This patent describes a method for in-vehicle charging of batteries for pallet trucks. It thus describes similar technology to the Raymond patents, albeit for a different type of vehicle. The citing patent is unassigned. This means that it is owned by its inventor, Wayne Spani, who appears to be the owner of a company named Tekassist in San Diego. We could not find much information on this inventor or his company.