# NEW YORK STATE ENERGY STORAGE TESTING: CAPABILITIES AND NEEDS

Final Report of the New York Academy of Sciences to the
New York Battery and Energy Storage Technology Consortium
Testing Inventory and Needs Working Group

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## I. Executive Summary

The New York Battery and Energy Storage Technology (NY-BEST$^{TM}$) Consortium[1] was established to accelerate the commercialization of energy storage technologies developed in New York State and to establish the State as an industry leader in this sector. The New York State Energy Research and Development Authority (NYSERDA), which provided seed funding and organized the Consortium at the Governor's request, asked the New York Academy of Sciences to compile and analyze information on the energy storage testing needs and capabilities of stakeholders in New York's research and business community. The expectation was that the data would identify one or more energy storage capabilities that NY-BEST could acquire in the near term for use by a broad cross-section of the battery and advanced energy storage community.

The data collected, however, did not point toward the immediate acquisition of new capabilities. Instead, they indicated a complex and varied set of needs, some of which could be matched with existing in-state capabilities. Those that could not be matched directly were often specific and project dependent, requiring capabilities designed for the particular product being tested or to meet unique standards. These findings pointed to the key recommendation from this report: a database that NY-BEST members can use to locate available capabilities, along with a "testing facilitator" to assist companies in matching needs with capabilities and to identify common unmet needs that become apparent in the future.

*Methodology*

The Academy utilized three sources of information during this process:

a. sixty-nine research concept papers solicited by NYSERDA,
b. twenty-four responses to a survey of energy storage needs and capabilities designed by a subset of NY-BEST stakeholders and distributed by NYSERDA, and
c. forty-three interviews conducted by the Academy.

NYSERDA and the Academy structured the four-month information-gathering process to keep it open and inclusive at every stage. A major tool was the NY-BEST e-mail distribution list, in which NYSERDA invested significant effort to include the full range of the State's energy storage stakeholders. Stakeholders or interested parties not on the list can sign up on the NY-BEST website. Anyone, regardless of affiliation with NY-BEST, could participate in each stage of the process.

*Key findings*

Each method of collecting information offered a unique but complementary view of NY-BEST's energy storage testing landscape.

> Those who submitted **research concept papers** proposed the largest number of projects in the area of lithium-ion battery development. Other commonly proposed technologies were ultracapacitors and systems-level equipment as well as several other battery chemistries. Application areas for the technologies submitted were largely in

[1] At the time of this project, the New York Battery and Energy Storage Technology Consortium had not yet become a legally incorporated entity. All citations of the Consortium in this paper refer to the initial efforts managed by NYSERDA.

medium/heavy-duty transportation, electric grid storage, and specialized electronic applications. Testing needs and capabilities reflected these foci.

**Survey** respondents expressed strong capabilities in materials testing and mechanical/environmental testing. These are sited largely in universities and commercial testing companies, respectively.

In **interviews**, stakeholders augmented the information provided by other means and provided qualitative information about the Consortium's direction, location, and administration. Stakeholders indicated a desire to know the types of technologies the Consortium will support and emphasized the importance of having testing capabilities strategically sited to maximize ease of use.

*Main conclusions*

Taken together, the information led to the following main conclusions:

1. **A database of energy storage testing capabilities would be of immediate value.** Where needs and capabilities align, there is currently no structure for connecting them. Storing information on capabilities in a centralized database would aid significantly in forging those connections. The information compiled by the Academy could serve as the basis for the database. **The value of the database could be optimized by a facilitator.** A facilitator with knowledge of NY-BEST members' capabilities, needs, and overall research aims would add considerable value to the electronic database. A facilitator could update the database with new capabilities, suggest helpful collaborations even in the absence of specific needs, and identify new capabilities needed by the Consortium.

2. **There is no clear-cut pressing need that calls for the immediate expenditure of resources on testing capabilities.** Needs are sufficiently varied that no single need emerged as requiring urgent fulfillment for a large number of stakeholders. This finding is likely to change with research developments and growth of the energy storage community.

3. **Several energy storage testing needs can be fulfilled with existing capabilities.** This is true especially in the area of materials testing and is less true later in the value chain.

4. **Capabilities should be sited for maximum ease of use.** Consideration should be given to the distance most members would need to travel to reach the capabilities and the number of locations they would need to visit to take full advantage of the Consortium's resources. Consideration should also be given to which types of testing capabilities should be located together due to practical concerns with transporting the product being tested.

5. **The acquisition of testing capabilities should be tied to the overall strategic goals of the Consortium**. As common needs emerge over time, a set of criteria will need to be determined to direct the prioritization of needs and investment decisions. These criteria should be congruent with the overall Consortium strategy.

## II. Introduction

In his 2009 State of the State Address, Governor David A. Paterson announced the creation of an advanced battery consortium to accelerate the commercialization of energy storage technologies developed in New York State and to establish the State as an industry leader in this sector. In addition to improving the State's economy, technologies supported by the New York Battery and Energy Storage Technology Consortium and utilized by the transportation and renewable power sectors will reduce nitrogen oxide emissions.

NYSERDA has provided seed funding of $25 million for the Consortium, raised from the Clean Air Interstate Rule's nitrogen oxide cap-and-trade program. Once the initial funding is expended, the Consortium will derive its revenue from membership dues and fees for licensing, equipment usage, or other services. Among its mandates, the Consortium has been charged with acquiring energy storage testing capabilities that will be accessible to its membership.

One of the goals of the Consortium is to fund research and, as stated above, acquire testing capabilities for its membership. In August 2009, NYSERDA initiated a collaboration with the New York Academy of Sciences on a project to identify energy storage testing capabilities that NY-BEST should consider acquiring in the near term. The aim was to provide guidance as NYSERDA established the Consortium. The work was carried out in close consultation with the Consortium's Testing Inventory & Needs working group, one of three working groups in the preliminary NY-BEST structure (the other two were Governance and Research).

The Academy was selected based upon its experience conducting this type of analysis, as well as its capabilities. Founded in 1817 and fully independent, it has an internationally recognized ability to serve as a neutral moderator on cutting-edge scientific issues. Moreover, the Academy facilitated the initial NY-BEST Stakeholder Workshop in Albany in April 2009. It offers an understanding of science and innovation issues generally, and of NY-BEST in particular.

The goal of the Academy's work was to conduct analysis that helps NY-BEST determine which energy storage testing capabilities would offer greatest value to its members. Initially, the Academy hoped to conclude the analysis with specific recommendations of testing capabilities for NY-BEST to acquire. The data collected, however, indicated a complex and varied inventory of needs in the State's energy storage community and did not point conclusively toward the immediate acquisition of particular new capabilities. Instead, they pointed toward the initial need for a database that NY-BEST members can use to locate available capabilities around the State. A NY-BEST database facilitator (a role that NYSERDA will serve initially) would further ease the process of matching needs and capabilities, as well as track common unmet needs that become apparent in the future.

## III. Methodology and Results

In conducting its analysis, the Academy utilized three sources of information: electronic surveys, research concept papers, and interviews. NYSERDA and the Academy carefully structured the information-gathering process to keep it open and inclusive at every stage. A major tool was the NY-BEST e-mail distribution list, in which NYSERDA invested significant effort to include the full range of the State's energy storage stakeholders. Stakeholders or interested parties not on the list can sign up on the NY-BEST website.

*Research Concept Papers*

In June 2009, NY-BEST solicited preliminary research concept papers to identify areas of synergy among State energy storage professionals prior to developing a strategic research direction and initial research and development funding solicitation. Research concept papers were solicited via the NYSERDA website and the NY-BEST email distribution list; anyone, regardless of affiliation with NY-BEST, could submit one. Sixty-nine proposals were received. Some were submitted collaboratively by multiple sites[2], and many sites submitted—or collaborated on—more than one concept paper. Ultimately, 47 sites were represented in the concept papers.

| Type of Energy Storage Research | Number of Sites Submitting Proposals |
|---|---|
| **Materials Level Work** | |
| Lithium-Ion Batteries | 15 |
| Ultracapacitors | 8 |
| Metal-Air Batteries | 3 |
| Sodium Metal Halide Batteries | 2 |
| Nickel-Zinc Batteries | 1 |
| **Systems Level Work** | 11 |
| **Computer Analysis & Monitoring** | 5 |
| **Other** | 5 |

**Chart 1. Number of research proposals, by type of technology.**

Chart 1 depicts the number of sites that submitted proposals for each research area. The area with the most proposals was lithium-ion batteries, followed by systems-level work, ultracapacitors, and other battery chemistries. The total number of sites in the chart is 50 because some sites submitted research proposals in more than one area. It is worth noting that this analysis was limited in scope by the concept papers submitted and is not intended to reflect the entire breadth of electrochemical energy storage activities occurring in New York, or the extent of technologies that NY-BEST will support. This study serves as a starting point to add value to NY-BEST members through testing capabilities and begin to identify gaps that NY-BEST can help to fill.

*Surveys*

The NY-BEST Testing Inventory and Needs working group collaborated to design a survey to assess the Consortium's energy storage testing capabilities and needs. In July 2009, surveys were distributed to all members of the email distribution list and, as with the concept papers, were accepted from any interested party. Respondents were asked to list capabilities and needs on separate copies of the survey to keep the distinction clear. Twenty-four completed surveys were returned directly to NYSERDA, which passed them on to the Academy. Figure 1 (page 6) depicts a sample survey.

In the surveys, as well as the interviews discussed below, institutions were asked to list only those capabilities that could be made available to the Consortium membership. The information contained in this report should therefore not be considered an exhaustive list of the capabilities or activities of the State's energy storage researchers. The survey contained another portion (not

[2] "Site," as used in this paper, usually refers to one university, company, national laboratory, or nonprofit organization. For large universities with two relevant research centers or institutes presenting distinct needs or capabilities, however, each of those centers or institutes may be counted as a separate site in this study. No institution is counted as having more than two sites.

shown) asking respondents to enumerate the capabilities represented by “X’s” in the table. Thus, NY-BEST could compile a more precise assessment of the needs and capabilities in the State. Most respondents, however, did not provide complete information in that section.

Ten sites returned surveys depicting their needs, and 14 returned surveys depicting their capabilities. Of those, two sites returned both kinds of survey, meaning that a total of 22 sites participated. The Academy began its analysis by tallying the number of positive responses for each type of need or capability. The results are depicted in Figures 2a and 2b (page 7).

**Testing Equipment Matrix**

| | | Materials Characterization | | | Device Testing | | | | | | | | Combinations | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Materials structure/composition/ synthesis | Electrochemical cell construction for the purpose of characterizing materials | Other materials characterization | Electrical (performance, capacity, cycle, pulse test, cycle life, etc.) | Environmental (temperature, humidity, salt, corrosion, etc.) | Mechanical (Vibration, shock etc.) | Qualification and/or safety testing (charge/discharge cycle, abuse, shock/vibration, etc) | System Testing, including ESD, EMI, EMC testing | Reliability/Durability (mean time between failure , accelerated testing ,etc.) | Transportability (bounce, hammer shock, altitude, etc.) | Other (specify) | Environmental and electrical | Environmental, electrical, and mechanical |
| | | A | B | C | D | E | F | G | H | I | J | K | L | M |
| Materials | 1 | | | | | | | | | | | | | |
| Cells | 2 | | | | X | | | | | | | | | |
| Modules | 3 | | | | | | | | | | | | | |
| Full energy storage pack or systems | 4 | | | | | | | | | | | | | |
| Integrated systems | 5 | | | | | | | | | | | | | |

**Figure 1. Sample survey.** This survey could be used to indicate either needs or capabilities in energy storage testing. In this example, the “X” in space D-2 indicates a need or capability in electrical testing at the cell level.

*Interviews*

The third source of information utilized by the Academy was interviews. The Academy contacted the following stakeholders for interviews:

a. at least one representative from each site that submitted a research concept paper;
b. at least one representative from each site that submitted a survey (16 of these sites overlapped with those in item (a));
c. representatives from other sites recommended by staff at NYSERDA or the New York State Foundation for Science, Technology, and Innovation (NYSTAR) on the basis of known expertise and research programs in energy storage.

Additionally, any interested party could contact the Academy to arrange an interview.

The Academy was successful in interviewing a sizable majority of those contacted, conducting a total of 43 interviews representing 39 sites. Four of the interviews were follow-ups requested by NYSERDA (explained below).

## NY-BEST CONSORTIUM TESTING CAPABILITIES SURVEY

| Testing Equipment Matrix | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Materials Characterization | | | Device Testing | | | | | | | | Combinations | |
| | | Materials structure/composition/ synthesis | Electrochemical cell construction for the purpose of characterizing materials | Other materials characterization | Electrical (performance, capacity, cycle, pulse test, cycle life, etc.) | Environmental (temperature, humidity, salt, corrosion, etc.) | Mechanical (Vibration, shock etc.) | Qualification and/or safety testing (charge/discharge cycle, abuse, shock/vibration, etc) | System Testing, including ESD, EMI, EMC testing | Reliability/Durability (mean time between failure , accelerated testing ,etc.) | Transportability (bounce, hammer shock, altitude, etc.) | Other (specify) | Environmental and electrical | Environmental, electrical, and mechanical |
| | | A | B | C | D | E | F | G | H | I | J | K | L | M |
| Materials | 1 | 7 | 6 | 7 | 6 | 6 | 2 | 3 | 0 | 2 | 2 | 2 | 3 | 2 |
| Cells | 2 | 6 | 6 | 5 | 10 | 7 | 4 | 5 | 1 | 3 | 2 | 2 | 4 | 3 |
| Modules | 3 | 1 | 1 | 1 | 7 | 5 | 4 | 3 | 3 | 3 | 2 | 1 | 3 | 3 |
| Full energy storage pack or systems | 4 | 1 | 1 | 1 | 7 | 5 | 5 | 5 | 4 | 3 | 3 | 3 | 4 | 4 |
| Integrated systems | 5 | 1 | 1 | 1 | 6 | 4 | 4 | 2 | 3 | 3 | 3 | 3 | 4 | 4 |

**Figure 2a: Compiled needs surveys.** This chart shows the number of respondents who marked an "X" in each space.

## NY-BEST CONSORTIUM TESTING NEEDS SURVEY

| Testing Equipment Matrix | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Materials Characterization | | | Device Testing | | | | | | | | Combinations | |
| | | Materials structure/composition/ synthesis | Electrochemical cell construction for the purpose of characterizing materials | Other materials characterization | Electrical (performance, capacity, cycle, pulse test, cycle life, etc.) | Environmental (temperature, humidity, salt, corrosion, etc.) | Mechanical (Vibration, shock etc.) | Qualification and/or safety testing (charge/discharge cycle, abuse, shock/vibration, etc) | System Testing, including ESD, EMI, EMC testing | Reliability/Durability (mean time between failure , accelerated testing ,etc.) | Transportability (bounce, hammer shock, altitude, etc.) | Other (specify) | Environmental and electrical | Environmental, electrical, and mechanical |
| | | A | B | C | D | E | F | G | H | I | J | K | L | M |
| Materials | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cells | 2 | 1 | 3 | 1 | 8 | 5 | 6 | 5 | 3 | 5 | 4 | 1 | 5 | 5 |
| Modules | 3 | 2 | 3 | 1 | 9 | 5 | 6 | 6 | 4 | 7 | 5 | 2 | 5 | 6 |
| Full energy storage pack or systems | 4 | 3 | 3 | 2 | 7 | 5 | 6 | 7 | 5 | 5 | 4 | 2 | 5 | 7 |
| Integrated systems | 5 | 3 | 2 | 1 | 5 | 4 | 4 | 5 | 4 | 5 | 3 | 3 | 4 | 4 |

**Figure 2b: Compiled capabilities surveys.**

Results from interviews were qualitative and did not always fit neatly into the survey format. Thus, the Academy modified the original format, creating a new chart to accommodate the results of both the surveys and the interviews, grouping needs and capabilities by four broad categories: materials, electrical (which included needs and capabilities for testing cells, modules, and packs), environmental/mechanical (also for cells, modules, and packs), and systems integration. The decision followed from an observation that many of the needs and capabilities listed for testing cells, modules, and packs overlapped.

The Academy completed a row in the chart for each site that provided data. Each site was then asked to approve its row. Appendix A contains a sample row to portray the type of information included. The Academy also provided NYSERDA with a summary of each interview in paragraph form.

## IV. Analysis

In analyzing the information collected, the Academy examined the landscape of energy storage testing needs and capabilities both as a whole and with sites sorted according to the following types: industry, academia, government (national laboratories), and nonprofit. Sorting the sites allowed for a more precise portrayal of where needs and capabilities lie. In particular, isolating industry needs aided in recognizing major barriers to technology commercialization, described below.

*Capabilities Assessment*
The Academy received ample information from respondents on both needs and capabilities. As expected, academic institutions, commercial testing capabilities and national labs were much more likely to have capabilities they would offer to outside entities, while industrial groups were less likely to offer their capabilities to others.

Interviews revealed that stakeholders from industry are often more constrained by the confidentiality challenges of allowing others to access their facilities. Conversely, although universities are also focused on generating proprietary information, there exists significant work that is considered precompetitive research. Therefore, most universities provide some access to external clients.

Some companies also expressed concern over the safety of potential external clients, noting that insurance arrangements would need to be made before providing outsiders access to their capabilities.

Graphically depicting energy storage testing capabilities proved difficult, due in part to variability in responses to the testing survey. Certain sites inventoried each piece of testing equipment offered, while other, similarly endowed sites conveyed capabilities more broadly. Because of the heterogeneity of the data, the Academy determined that a graphic representation would not portray the capabilities accurately. Instead, it was recognized that the information would be most valuable as the basis for a database.

By supplementing surveys with interviews, the Academy was able to draw the following broad conclusions:

- New York's energy storage stakeholders have extensive capabilities to share in materials testing. This reflects thorough feedback from universities, which tend to focus more than industry on fundamental research.
- Stakeholders include testing companies that offer a wide range of services, with particular strength in mechanical/environmental testing.

*Needs Assessment*

In addition to determining testing capabilities, the Academy gathered information on stakeholders' testing needs, which are depicted in Figure 5 (page 10). To portray the large number of materials needs with greater precision, the Academy broke down the materials column of the graph into subcategories. In both the general and the materials-specific graph, the columns are broken down by the type of institution that provided the information: nonprofit, government, academia, or industry.

The needs of academic researchers are weighted toward the early end of the battery and energy storage product development value chain, in materials and electrical testing. Requests from industry, on the other hand, were nearly as common for systems integration as for materials. Many industry researchers expressed their desire to deliver a product to market quickly, which is one reason that they had a greater focus, as compared to the academics, on scale-up and systems integration.

Three sites listed 18-650 lithium-ion cell manufacturing as a need. In consultation with NYSERDA, the Academy conducted follow-up interviews with representatives from those sites, as well as another researcher in the State with particular expertise in the area. In the final analysis, however, this need was indicated as urgent and industry-driven for only one respondent. It was also found to require a large investment in equipment and labor. Thus, the Academy does not recommend expending resources on it at this time.

The surveys and interviews suggested the following broad conclusions on testing needs:

- Significant needs were expressed in the general areas of materials and electrical testing, e.g., microscopy and battery cycling.
- Common needs in the environmental/mechanical category included temperature, humidity, vibration, and impact testing.
- Testing needs for systems are often unique.

*Capabilities/Needs Overlap*

Stakeholders can offer many capabilities that overlap with common needs in materials testing. This is true particularly, though not exclusively, in the subcategory of microscopy. The Academy believes that the materials area is one that will benefit greatly from the forthcoming NY-BEST database in that researchers will more easily find capabilities that match their needs. The database will become continually more useful as sites add or update information on their capabilities.

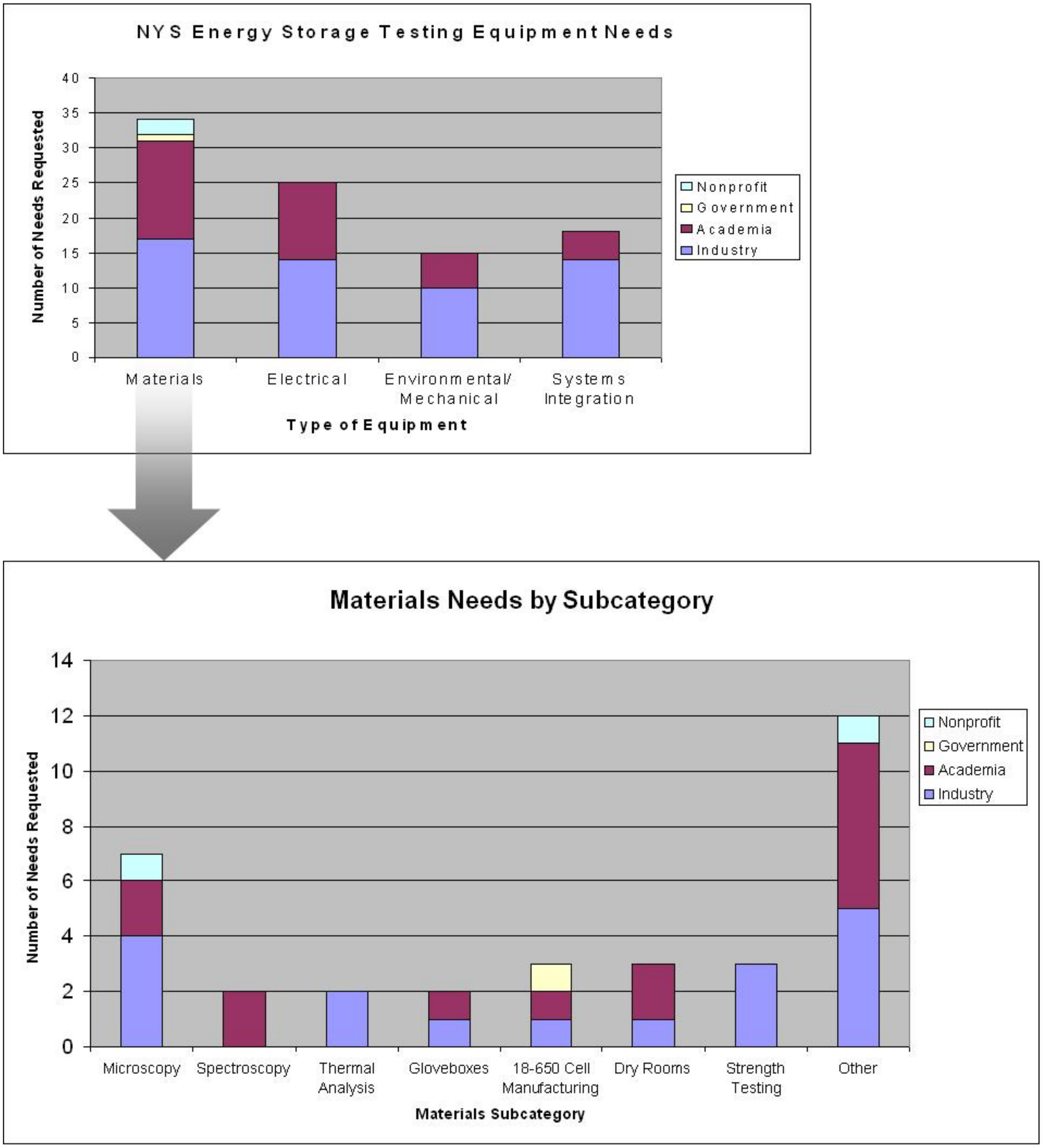


**Figure 5: Needs by type of institution.** The graph at bottom breaks down the needs represented in the materials bar of the graph at top.

Overlap between needs and capabilities also exists at the level of electrical testing, especially among battery cyclers. Despite this overlap, the Academy found that the availability of cyclers to energy storage researchers may be insufficient. Even researchers with an abundance of cyclers spoke of sometimes needing more, a problem that arises from the length of time that each one must be occupied to test a device over thousands of cycles. The database may be helpful for identifying cyclers available to Consortium members, or future experience may point to locations where additional cyclers would be useful.

Many of the needs in environmental and mechanical testing may be fulfilled by commercial testing companies. The database could be of great utility in matching needs and capabilities in this area.

Systems integration, at the end of the value chain, exhibited the least overlap between needs and capabilities. In interviews, the Academy heard that testing integrated systems is often a specialized task requiring capabilities acquired specifically for the product being tested or to meet specific standards. New batteries for hybrid-electric vehicles or plug-in hybrid-electric vehicles, for instance, often cannot be tested using capabilities designed for a conventional battery or even, in most cases, a different unconventional battery. NY-BEST may consider strengthening this area in the long term. At present, however, most stakeholders interviewed by the Academy did not have products far enough along the value chain for this to be an urgent need.

Needs at any point in the value chain can be very specific, and the database will not answer every question that a researcher could have about a capability. Therefore, the Academy recommends that the database include contact information of the party offering the capability so that pertinent details can be obtained. In addition, the Academy recommends that the database be overseen by a facilitator with broad knowledge of the State's energy storage testing landscape. He/She would update the database as changes or additional information becomes available and, as needed, assist in determining whether specific needs can be fulfilled by existing capabilities. The facilitator would also be invaluable for identifying new needs that emerge as research advances, membership grows, and the amount of information in the database increases.

*General Comments*
In addition to providing information about testing needs and capabilities, stakeholders offered many helpful comments about the Consortium. What follows are some of the more commonly expressed viewpoints:

**Location:** Stakeholders expressed an understandable preference for capabilities located at or near their own organizations. Recognizing the geographic diversity of New York's energy storage community, however, many stressed instead that capabilities should be strategically sited for maximum ease of use. Factors to consider include the distance most members would need to travel to use the capabilities and the number of locations they would need to visit to take full advantage of the Consortium's resources.

**Overall direction:** In interviews, several stakeholders expressed their hope that the Consortium will choose a focus soon, noting that they remained uncertain whether their own research is a type that NY-BEST will support. As noted previously, more research concept papers dealt with lithium-ion batteries than any other type of energy storage device. Several stakeholders expressed the opinion, however, that New York State – and the U.S. generally – is unlikely to catch up with lithium-ion R&D in Asia, and that investments might be more productive in areas where a clear technology leader does not yet exist. Identifying one or more general research directions for the Consortium will assist the Testing Inventory and Needs Working Group in targeting capabilities to acquire.

**Revenue streams:** Several stakeholders pointed out that each new capability acquired by NY-BEST is a potential revenue stream. Revenue-generating capabilities could include pieces of equipment, together with personnel and software to operate them, and services, such as certifying the performance characteristics of new batteries or other energy storage devices.

**Diverse capabilities:** While the Academy focused on research aimed at developing batteries or energy storage devices, it also spoke to stakeholders whose interests lie elsewhere on the value chain. Some stakeholders, for example, are eager to purchase technologies that may result from NY-BEST research. Others, in both industry and academia, offer expertise in designing manufacturing systems for advanced machinery, including electrochemical energy storage devices.

## V. Recommendations and Conclusions

Based on its research and analysis, the Academy offers the following findings regarding NY-BEST testing needs and capabilities:

1. **A database of energy storage testing capabilities would be of immediate value.** Where needs and capabilities align, there is currently no structure for connecting them. Storing information on capabilities in a centralized database would aid significantly in forging those connections. The information compiled by the Academy could serve as the basis for the database. **The value of the database could be optimized by a facilitator.** A facilitator with knowledge of NY-BEST members' capabilities, needs, and overall research aims would add considerable value to the electronic database. A facilitator could update the database with new capabilities, suggest helpful collaborations even in the absence of specific needs, and identify new capabilities needed by the Consortium.

2. **There is no clear-cut pressing need that calls for the immediate expenditure of resources on testing capabilities.** Needs are sufficiently varied that no single need emerged as requiring urgent fulfillment for a large number of stakeholders. This finding is likely to change with research developments and growth of the energy storage community.

3. **Several energy storage testing needs can be fulfilled with existing capabilities.** This is true especially in the area of materials testing and is less true later in the value chain.

4. **Capabilities should be sited for maximum ease of use.** Consideration should be given to the distance most members would need to travel to reach the capabilities and the number of locations they would need to visit to take full advantage of the Consortium's resources. Consideration should also be given to which types of testing capabilities should be located together due to practical concerns with transporting the product being tested.

5. **The acquisition of testing capabilities should be tied to the overall strategic goals of the Consortium**. As common needs emerge over time, a set of criteria will need to be determined to direct the prioritization of needs and investment decisions. These criteria should be congruent with the overall Consortium strategy.

## Appendix A: Example row from the Academy's chart depicting sites' energy storage testing needs and capabilities.

| | | |
|---|---|---|
| **Web Address (if appl)** | **Institution** | **Program or Initiative Name** |
| [EXAMPLE ONLY] | **[EXAMPLE ONLY]** | Center for Energy Storage Research |

| | Cells, Modules, Packs | | |
|---|---|---|---|
| **Materials Testing Capabilities** | **Electrical Testing Capabilities** | **Environmental/Mechanical Testing Capabilities** | **Systems Integration Testing Capabilities** |
| Scintag X-ray Diffractometer (XRD); Photon Meter | Arbin MSTAT Charge/Discharge station (8-Channel charge/discharge; Current: 10 mA to 5A; Voltage: -2 to 10V); MUDDER-Programmable DC load bank, 200 kW charge / discharge, > 600 V DC | Micro-hardness Testing; TestEquity model 195A Half Cube Environment Chamber for temperature-controlled testing of coin & cylindrical cells (-40 to +125 deg C range) | Battery and grid-tie inverter with PV (Pb-Acid, 48V-510Ah, 26A) |

| | Cells, Modules, Packs | | |
|---|---|---|---|
| **Materials Testing Needs** | **Electrical Testing Needs** | **Environmental/Mechanical Testing Needs** | **Systems Integration Testing Needs** |
| Furnace capable of making 1 kg material samples at 400C | Digatron UBT 100-10/45-3ME battery charge/discharge system (10-45V, 100A, 10-30 channels); Button cell making/testing equipment | Environmentally controlled chamber that spans -40°C to +80°C (for cell, module, and pack testing); High concentration (98% phosphoric acid) corrosion measuring system with corrosion cell, reference and working electrodes | Model grid with energy storage capacity; Environmental chamber that could accommodate large equipment (vehicle size), with temperatures ranging from -40 to elevated ambient temps |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **General Comments** | **Industry/Academic/ Government/ Nonprofit** | **Information Source** | **Contact Name** | **Contact Title** | **Contact Phone** | Contact Email | **New York State Region** |
| Electrical testing needs are urgent; would travel up to 150 miles to use equipment | Academic | Needs Survey and Interview | [EXAMPLE ONLY] | Chair, Center for Energy Storage Research | [EXAMPLE ONLY | [EXAMPLE ONLY] | Capital Region |

In the actual chart, this would appear as one contiguous row.