Charting Unmapped Waters: Adapting Our Research Methods for the Fast-Evolving Energy Storage Market

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ABSTRACT

The energy storage market has evolved quickly as demand for, and investments in, behind-the-meter and front-of-the-meter grid storage and electric vehicle technologies have accelerated. In the United States alone, multiple states have instituted policies supporting clean energy and energy storage that have fueled this growth. Despite recent decisions by the federal government to deemphasize the importance of a clean energy economy, existing state-level support for renewables and industry support for new energy storage applications will likely persist. As our industry begins conducting more research and evaluation on integrated-grid programs, we must adapt our methods to address broader-reaching questions and more complex markets than typically addressed in traditional DSM programs. Considering the fast-changing market dynamics, how can evaluators best provide meaningful, timely research to support energy storage programs and consortia? This paper describes three insights gained from the evaluation of the New York State Energy Research and Development Authority (NYSERDA)-funded New York Battery and Energy Storage Technology (NY-BEST) Consortium that is helping chart the course of the New York State energy storage market. The authors describe: (1) key differences in evaluating consortia versus traditional programs, (2) market characterizations based on disparate data sources, and (3) obsolete baselines and real-time evaluation. The authors conclude with advice on adapting research approaches for fast-evolving emerging markets like energy storage.

Background on Energy Storage, NYSERDA, and NY-BEST

In this section, we provide context for our discussion of key insights gained through the evaluation of the New York State Energy Research and Development Authority (NYSERDA) Energy Storage Program's investment in the New York Battery and Energy Storage Technology (NY-BEST) consortium.

The Quickly-Evolving Energy Storage Market

The energy storage market has evolved quickly in the seven years since NY-BEST was established. Demand for, and investments in, behind-the-meter and front-of-the-meter grid storage and electric vehicle technologies has accelerated across the globe. In the United States, multiple states have instituted policies and provided funding in support of clean energy and energy storage technology development and commercialization. Despite the current federal government's 180-degree turn away from supporting a clean energy economy, existing state-level support for renewables and industry support for new energy storage applications will likely persist.

With terms like "Tesla's Power Wall battery" and "grid storage" becoming more common in conversation, many in the energy industry recognize that energy storage has moved beyond consumer products like wireless keyboards and lead-acid batteries in conventional cars. While those traditional markets are still important and still innovating, new markets have quickly emerged over the past seven years, yielding new technologies and new business partners willing to invest in the transition to these technologies. Examples of new products, or new versions of existing products, include:

- Grid storage projects providing load-shifting services like those with Southern California Edison and Consolidated Edison in New York
- Residential battery storage units by companies like Sonnen and Mercedes-Benz
- Electric vehicles like the Tesla Model S
- New ultracapacitors and flow batteries emerging as competitors to traditional battery technologies

To put this surge of innovation in context, it is helpful to understand how demand is evolving. As reported in the NY-BEST impact evaluation report, the grid storage market grew globally "from roughly 125 GW in 2010 to roughly 185 GW (including planned projects, based on the DOE's Energy Storage Database) in 2015 (International Energy Agency 2014)." Within the United States, the "grid storage market grew from a valuation of $134M in 2014 to $432M in 2015. This corresponded to the addition of roughly 221 MW of utility-side grid storage in 2015 (Manghani 2016)." Likewise, the energy storage market just in New York State grew from $598M in revenues to $908M in 2015 (estimated) and from 2,992 jobs in 2012 to 3,931 jobs in 2015 (estimated). This accelerated investment is storage is likely to continue, regardless of federal policies.

Recent Changes in New York State Policies, NYSERDA, and NY-BEST

In 2014, New York State began instituting policies to accelerate the development of a clean energy economy, and NYSERDA began shifting its priorities to align with the REV and CEF.[1] NYSERDA channeled its resources to support emerging technology and market transformation programs, and the New York State utilities assumed more responsibility for demand-side management (DSM) programs. Energy Storage is one of many emerging technologies NYSERDA has invested in.

Like other NYSERDA programs, the Energy Storage Program supports the energy storage market by offering competitive solicitations for energy storage research, development, and commercialization projects. However, the program's main vehicle for affecting market transformation took an uncommon form. Rather than only offering project-specific funding, NYSERDA sought to catalyze the energy storage market in New York State by also investing in a consortium: the New York Battery and Energy Storage Technology (NY-BEST) Consortium.

By backing NY-BEST, NYSERDA's Energy Storage Program sought to connect disparate market actors throughout the newly-developing value chain, to use investment in NY-BEST to increase the pace of technological development and commercialization, and to influence the pace and direction of policies that would make market adoption of energy storage technologies possible. NY-BEST, like the energy storage market, evolved quickly between 2010 and 2016. NY-BEST grew significantly in membership, revenue, and the type of support it provided to the energy storage market. Membership expanded from 59 member organizations in 2010 to 151 in 2015.

With such a fast-changing emerging market, NYSERDA and NY-BEST were eager to assess how the market was changing, what influence NY-BEST was having on the market conditions, and more generally, whether the consortium model was an effective way to chart change in emerging markets. The evaluation, conducted between early 2015 and early 2017 used a relatively mainstream evaluation approach:

- Program logic model development
- Rapid-feedback process evaluation
- Market characterization
- Economic assessment

[1] In 2014, New York State instituted the Reforming the Energy Vision (REV) strategy which established new clean energy economy goals for New York State. These system-oriented goals covered not only energy generation and reduction in energy consumption goals, but also broader environmental and economic goals such as reduction in greenhouse gas emissions, affordability of energy services, and support for clean energy jobs. In January 2016, the New York State Public Service Commission (PSC) approved the 10-year, $5 billion Clean Energy Fund (CEF) to attract third-party funding to support the governor's Clean Energy Standard. See New York State REV goals: https://rev.ny.gov

- Impact evaluation that included patent analysis[2]

However, the evaluators found that they needed to pay attention to some key differences between the approaches typically taken with DSM programs and what was needed to assess this consortium situated in an emerging market. More so than a typical program bound by agency goals and policies, and implemented by a known set of market actors, this set of evaluation activities needed to capture a strong understanding of the fast-changing dynamics among an emerging cast of market actors and the influence they yielded on the storage market.

In this paper, we consider the fast-changing energy storage market dynamics as we address the following considerations in researching an emerging market:

1. Key differences in evaluating consortia vs. traditional programs
2. Market characterizations based on disparate data sources
3. Obsolete baselines and real-time evaluation

We conclude with advice on how to adapt the research methods commonly used in evaluating traditional energy efficiency programs for the fast-evolving energy storage market.

Key Differences in Evaluating Consortia vs. Traditional Programs – It's the Relationships That Matter

Whereas a traditional energy efficiency DSM program would focus on accumulating cost-effective, verifiable energy savings from a set of approved measures on a per-project basis, a consortium is typically focused on market transformation at a broader level. A consortium is "an agreement, combination, or group (as of companies) formed to undertake an enterprise beyond the resources of any one member."[3] Consortia and collaborative business networks are formed with the intention to work across a variety of stakeholder groups to resolve technological or market-based problems.

When technological or market-based problems arise in an industry, members of a R&D consortium can pool talent and financial resources to resolve the issue, benefiting from the solution to the problem as they take the technology back into their respective product designs. When an industry faces a set of outdated policies that prevent the market from adopting a technological or behavioral approach, a consortium can lobby on behalf of its members and pool resources to assist regulators in crafting policies that help, not hinder, market adoption of more efficient practices. For emerging markets with few connections among potential market actors, a consortium serves as a network facilitator, connecting key market actors, helping build trust and credibility among those actors, and disseminating information to update the broader community and bridge language barriers among industries.

In this section, we describe two key aspects of our evaluation approach for the NY-BEST consortium that differ from how a traditional DSM program might have been evaluated: the types of metrics included in the logic model and the assessment of network effects. In both aspects, the unit of analysis is an important consideration.

Logic Model Metrics That Matter: Selecting the Right Markers to Guide the Evaluation

The logic model, our beloved tool for mapping program activities to measurable outcomes and longer-term goals, serves as an evaluator's map for tracking the extent to which the program is accomplishing what it set out to do. DSM programs often reflect how individual activities and projects will purportedly add up to a positive effect on the market and possibly trigger spillover effects among non-participants. Programs often measure and sum up the progress of individually-funded projects to analyze the program's effect. Consortium metrics of success, however, are more likely to include market-level and policy-level metrics that are rooted in network connections and monitor the influence of the consortium on the market. The unit of analysis for evaluating a DSM

[2] Patent analysis conducted by 1790 Analytics http://1790analytics.com

[3] Definition of consortium taken from Meriam-Webster on April 18, 2017: https://www.merriam-webster.com/dictionary/consortium

program may be the individual project, whereas for a consortium, the unit of analysis may be the consortium activity.

For the NYSERDA NY-BEST energy storage evaluation, we tracked the progress of individual projects funded through the Energy Storage Program, noting the progression of funded technologies along the Technology Readiness Level (TRL) scale towards commercialization, and the amount of follow-on funding each project received. However, most of NY-BEST's medium- and long-term goals emphasized broader goals: [4]

- NY-BEST is self-sustaining
- Energy storage technologies are commercialized
- Regulatory barriers to energy storage fall
- Energy storage industry brings jobs and economic benefits to New York

While programs may also seek market transformation goals, consortia interim activities and short-term outcomes typically differ from those of a traditional program. Whereas a program typically focuses on supporting the development and completion of individual projects that infuse the market with new technologies or new types of work, a consortium focuses its support on the development of networks of researchers or companies, revision of policies, and formation of markets financed by multiple stakeholders. NY-BEST emphasized becoming a self-sustaining organization that could use networking and information sharing among its members as a driver for technological innovation and the development of a new value chain. The consortium prioritized the creation of much-needed prototyping and testing centers and helped extend its members' influence on New York State energy storage-related policy. As a result, NY-BEST is not only accountable to NYSERDA, but also to its membership. If the NYSERDA Energy Storage program had only invested in supporting individual projects, the program would be accountable to NYSERDA to demonstrate cost-effective use of rate-payer dollars, but not to the broader market. Further, the consortium (once financially detached from NYSERDA) will be able to participate more freely in policy making activities than NYSERDA, which is restricted in its policy advocacy activities.

[4] Logic model can be found on p. 23 of the NY-BEST Impact Evaluation Report.

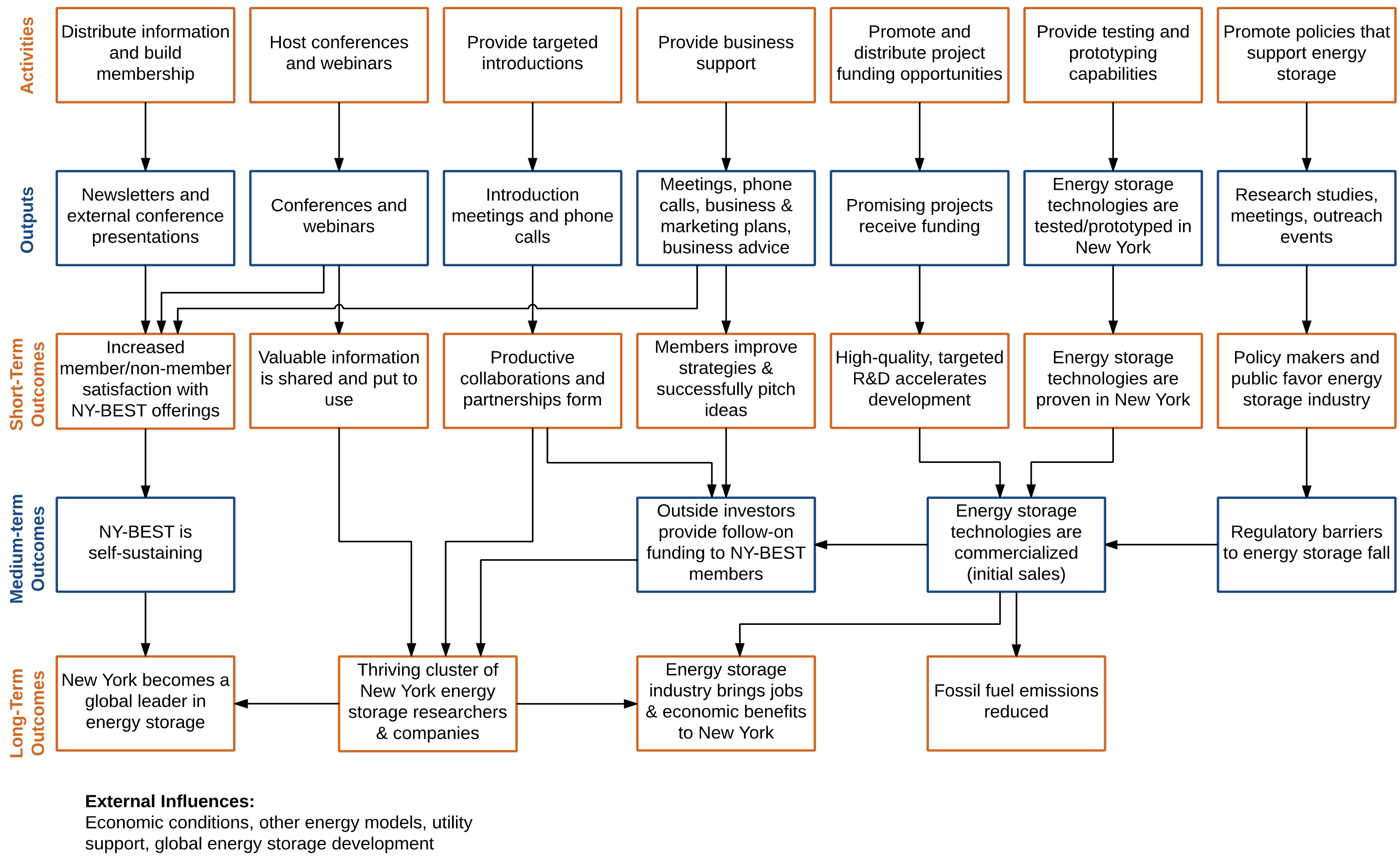

Figure 1. Logic Model

Assessing Network Effects: Who is Charting the Course? Who Else Is Out There?

Before a consortium can realize success at the market and policy levels, it must foster a strong network. For NY-BEST, its success was anchored in becoming a well-respected network weaver that could bring together—and foster collaborations among—a diverse array of market actors across the new energy storage value chain.

Through our process and impact evaluations, we documented the consortium's growth and cohesion and mapped the network against the broader market context and its potential for growth, as described in the reports, "NYSERDA Energy Storage and NY-BEST Program: Market Characterization and Assessment," and "The Energy Storage Industry in New York State: Recent Growth and Projections" (EMI Consulting, 2017; IEc, 2016). Whereas a DSM program would typically focus more on individual market actor satisfaction and interaction with the program, we considered how the network had grown, how effective it was at making new connections within and outside the membership, and how the network of members interacted with other energy storage groups. Among many factors, the evaluations assessed the membership's:

- Growth, stability, and satisfaction
  - Membership increased from 49 in 2010 to 151 in 2015, and satisfaction has ranged from 88%-94%
- Attendance at NY-BEST's information-sharing and networking events
  - Conferences and webinars increased from one conference in 2010 to four conferences, with over 1500 total attendees, as well as four webinars in 2015, with over 1000 total attendees
- Use of NY-BEST events and services to connect with other members and investors
  - In 2015, over 80% of members reported benefiting from NY-BEST facilitating connections
- Use of NY-BEST prototyping and testing center resources
  - In 2015, 35 members used the Battery Test and Commercialization Center (BTCC) that opened in 2014, and 45 members inquired about using the Battery Prototyping Center (BPC) that opened in 2015
- Participation in other energy storage consortia
  - In 2015, 35 members participate in ESA, CESA, or both

The overlap in membership among energy storage consortia highlights key market actors that were working on national-level issues, and generally from a large company or single-technology perspective. NY-BEST's membership was comprised mostly of small and start-up companies and research institutions across a variety of technologies with a vested interest in working in New York State, e.g., Paper Battery and Cornell University). A smaller number of members included large companies with facilities in NY State (e.g., General Electric and Johnson Controls). By contrast, the other two major energy storage consortia, Energy Storage Association (ESA) and California Energy Storage Association CESA memberships were comprised largely of established firms and focused more on a national agenda for energy storage.

Within the scope of our research we determined that NY-BEST had clearly navigated many members towards successful ventures. However, we identified three additional ways to further understand *how* the consortium network functions, *which types* of partnerships were most successful, and *the level* of collaborations that occurred. These additional tools may prove helpful in assessing the strength of consortia and collaborative business networks: The Collaboration Assessment Tool (CAT), Social Network Analysis (SNA), and SAFAR rubric.

The CAT is used to assess the effectiveness of collaborative organizations (Marek, L., Brock, D., and Savla, J., 2015). It is based on a 7-factor model, described as a "theoretical model that contains seven factors identified as critical for effective collaboration: Context, Members, Process and Organization, Communication, Function, Resources, and Leadership," (p. 69). The items in the assessment tool point to many items we considered when looking at the self-sufficiency and likelihood of success of NY-BEST based on member shared interests, etc.

SNA is used to assess the reach and interconnectedness of a network of people (Wasserman, S., and Faust, K., 1994). SNA can be used to track, over time, who is and is not in the network, and changes in the number and quality of connections among members of the value chain. Once the network is better understood, it is helpful to learn what types of information are shared within the network versus those outside the network, and which types of network members form collaborations or enter contracts. A consortium or program can use a map of their social network to identify connections the consortium can help facilitate and also identify the best communication paths to disseminate information throughout its network.

The SAFAR rubric is used to assess the strength and effectiveness of a collaborative effort as it progresses over time (Gajda, R., 2004). The rubric, based on five principles of collaboration theory, has five levels of integration: networking, cooperating, partnering, merging, and unifying. The rubric is a tool that can be embedded in an evaluation to capture baseline assessments of members' collaboration levels and perspectives and periodically updated as an assessment of progress towards the desired level of collaboration and communication for the group.

Regardless of the approach taken, the assessment of collaborative networks is a critical first step in understanding how a consortium or collaborative network will influence the market and which market actors will be most influential in setting the course for the journey.

Market Characterizations Based on Disparate Data Sources

Market characterization involves piecing together small bits of information from many sources to describe the market structure as a whole. In well-established markets like lighting and HVAC, there are often ample data sources from which to draw the necessary information. But in newer, less developed markets, these islands of data sources may be more difficult to find—and even after they are found, there is often additional effort that must be put into contextualizing and synthesizing the information. In the section below, we discuss several specific challenges we faced in characterizing the market for energy storage and how they were addressed.

Piecing Together the Data

Market characterizations related to traditional markets often rely on well-defined data sources—for example, a lighting market characterization may include data available on the number of units incentivized through a utility program. Similarly, HVAC market characterizations may include an analysis of ENERGY STAR sales data. But neither of these data sources are typically available when evaluating an emerging area such as energy storage. Instead, it is critical to find a small number of key secondary sources that will serve to *anchor* the market analyses, and to leverage data from these sources to the fullest extent possible. For example, as our anchor our work relied heavily on the U.S. Department of Energy's *Energy Storage Database*, which is a publicly-available internet resource containing data on energy storage projects around the world, and augmented that information with data from an array of less comprehensive sources—including news articles, press releases, company websites, and industry publications—to get a full view of the market. This was necessary because, although the Department of Energy database had a fair amount of quantitative data, it had very little additional contextual data that might be used to help understand the "story behind the numbers."

Value of the Data

Data taken from disparate sources give us the ability to view the market from different angles. This is an advantage, as it allows for a more comprehensive understanding of the market structure. However, these data sources, when integrated, often behave like cross currents creating choppy water and impeding navigation, because the classifications used by these different sources may not "line up." Technologies defined as "utility-scale storage" by one source may or may not be equivalent to another source defining technologies as "grid storage." Thus, the blending of data from different sources needs to be carefully conducted and appropriately qualified.

In a highly technical emerging market such as the energy storage market, defining a single market classification structure at the outset of the project may be a challenge. For our market characterization work, we used the structure shown in Figure 2 (which had been used for previous research in the State). This structure, while useful for answering the NYSERDA research questions, presented the expected difficulties related to compiling different sources, since the categories used by these sources rarely matched the categories in the market structure. In these situations, the research team used the "least generalized" definition that would still capture all applicable members of a category.

Market		Market Segment/Technology
Emerging Markets	Grid (Electricity) Storage	Residential Energy Storage (behind the meter)
		Commercial Energy Storage (behind the meter)
		Energy Storage on the Grid (front-of-the-meter)
		Community Energy Storage (front-of-the-meter)
		Energy Storage Management Systems
	Transportation Storage	Light-Duty Electric Vehicle Batteries
		Medium and Heavy-Duty Electric Truck Batteries
		Electric Vehicle Charging Equipment
Traditional Markets		Automotive Energy Storage (Lead-Acid Batteries)
		Industrial Fork Lift Trucks
		Medical *Technologies: Batteries & Ultracapacitors*
		Military *Technologies: Portable Batteries*
		Fuel Cells
		Materials
		R&D Supporting New Technologies
		Others

Figure 1. The Market Classification Used for the Study

Qualifying the Interpretation

Projections based on limited historical data are fraught with uncertainty. When making projections, it is therefore important to be clear about the level of uncertainty. This becomes increasingly difficult when a projection is based on *multiple* data sources, each with their own corresponding level of uncertainty. In these cases, it is important to account for all sources of uncertainty and make this uncertainty clear when presenting results. While the precise degree of uncertainty may be unknown, it may be possible to construct credible bounds around the projection. In Figure 2, we provide an example graphic showing the uncertainty surrounding the projected sales of electric vehicles in the coming decades.

Working at the Speed of the Market

A notable challenge in performing a comprehensive characterization for a quickly-changing market is that information becomes outdated in the time it takes to collect, synthesize, and present that information. Whereas monitoring traditional DSM program measures mostly involves tracking incremental changes among established manufacturers and vendors, new energy storage market actors enter the market, and existing market actors leave the market or form new entities by combining with other market actors. Between the time that our research team presented a draft market characterization report and finalized that report, several major market developments had occurred. Most notably, Tesla had merged with SolarCity, thereby consolidating two major players in the market and at the same time sending an important signal for where the market was heading in the future.

> "Premature optimization is the root of all evil."
>
> - *Sir Tony Hoare*

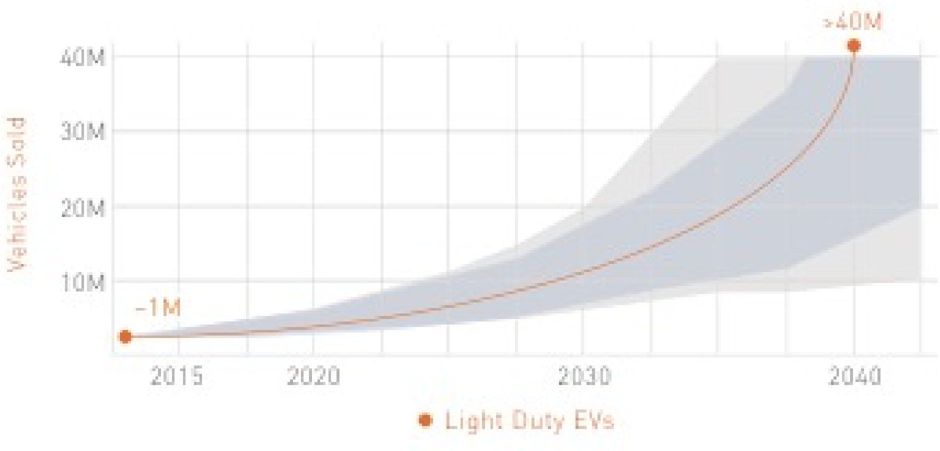

Figure 2. Example Graphic Showing Credible Bounds Around Projection for EV Sales

An additional consideration for evaluating a consortium model is the longitudinal tracking of individual member firms over time. For established blue-chip firms, the tracking of firms over time is relatively straightforward. For start-ups, however, this task requires more effort, as start-ups may exit the market during the evaluation period, or else be acquired by larger firms. In at least one case, we came across a firm that had changed its name during the evaluation period.

When navigating through quickly-changing conditions, it is useful to focus significant effort on first identifying *major trends* that will eventually affect all players in the market. Micro-level changes at the firm level will make more sense (and be more useful) if they are interpreted in the context of overall market trends. An understanding of these trends will also help to identify *bellwether events* (e.g., the merger of two major firms) that either confirm the current tack of the market, or else suggest a new one.

Obsolete Baselines and Real-Time Evaluation – Using Economic Assessments to Aid Evaluators

Traditional DSM program evaluation typically relies on empirical data to measure the effectiveness of specific policies and programs. While program designs build on theories of change, market potential, and other market characteristics that anticipate certain shifts in the market, evaluation methods—particularly for impact evaluations—typically focus on historical data that document performance, and do not generally emphasize charting the forward-looking estimates of potential future program benefits that reflect evolving markets.

In the case of energy storage, the high degree of uncertainty inherent in rapidly-evolving markets requires that evaluators: (1) consider—and measure—the possibility that markets may shift violently and in unexpected ways, and (2) have a reduced-form approach to considering the potential impacts of these shifts, as opposed to attempting to generate a retrospective point estimate of gross impact; the intention is to optimize policy as part of “real-time” evaluation that couples strategy with evaluation.

In emerging markets, baselines are quickly obsolete and trend data are limited (and suspect). As noted above, emerging technology markets are characterized by rapidly-shifting technology costs, regulatory structures, and intersecting technologies that can render even a well-researched “point-in-time” baseline obsolete even as it is measured. In addition to factors that have direct impacts on technology adoption (changes in funding or policy), more complex interactions are common as distributed generation changes the consumer/provider relationship. In this context, emerging energy storage technology can encourage adoption of linked technologies (e.g., energy storage management systems (ESMSs), hardware, and distribution technologies).

To ensure that programs are oriented around meaningful advances in effective technologies, program directors must be ready to integrate strategy into evaluation. This means being able to quickly assess changes in market conditions from the baseline **and** to identify impacts, if any, on program design and effectiveness.

Economic forecasting and scenario analysis can provide insights into the pace of broader market changes and their impact on specific markets and programs. Economic forecasts around the development and penetration of new technologies and markets are common tools for market assessment and initial program design and targeting. When applied carefully, economic forecasting for a limited number of key market indicators can also be a cost-effective tool for monitoring program implementation and identifying "course correction" opportunities. Economic forecasting models—even very simple, market-level (and not technology-specific) models, can provide:

- Forward-looking analyses and out-year projections of key metrics that are sector-specific or even broader (e.g., sector-level revenue, total employment)
    - These provide a context in which to consider program advances
- Simplified models allow analysts to explore the impacts of uncertainty with sensitivity analyses
    - Use of "what if" scenarios can illustrate how key growth assumptions and market conditions might affect trends and outcomes
- Information on key variables or indicators that can affect program metrics
    - Sensitivity analyses can be used to identify key variables that might affect program performance or design

At a minimum, economic projections can provide a set of out-year benchmarks that allow policymakers and stakeholders to compare actual market progress to projected estimates. After a baseline has been established, similar analyses can be performed in later years, creating new datasets that enhance comparison.

In support of the NY-BEST consortium, NYSERDA (with IEc) has developed and used reduced-form economic forecasting to provide contextual information about broader market shifts in energy storage, and to assess New York's changing position in global markets for the development and production of storage technologies. NYSERDA's New York State energy storage economic analysis examines two endpoints across a range of energy storage subsectors and a 20-year time horizon: total sector revenues, and total sector employment, in New York State.[5] The economic forecasts have documented recent changes in New York markets and the future trends these changes suggest, and have identified the sensitivity of market estimates to changes in key variables (e.g., public investment).

[5] Appropriately defining the endpoints of interest for a specific program is critical. The New York State energy storage economic analysis focused on revenues and employment, because these broadly link to the goals of the NY-BEST Consortium, and also provide accessible context. Other potential endpoints may include economic activity, as measured by GDP or an equivalent, net income, or the number of operating firms or establishments; selection of economic metrics to examine should be dependent on both the evaluation's purpose and the extent of available data supporting the use of a given metric.

Table 1. New York State Economic Forecasts

	New York State Revenues and Employment	Units	2015	2020	2025	2030	CAGR 2015-2020	CAGR 2015-2030
Revenues	Electricity Storage Market *(Emerging)*	$M	$150	$1,260	$3,450	$5,370	53.2%	27.0%
	Transportation Storage Market *(Emerging)*	$M	$167	$749	$1,500	$1,810	35.0%	17.2%
	Traditional Markets	$M	$589	$871	$1,180	$1,520	8.13%	6.53%
	Total Revenues	$M	**$906**	**$2,880**	**$6,130**	**$8,710**	**26.0%**	**16.3%**
Employment	Electricity Storage Market *(Emerging)*	Jobs	650	4,520	11,130	16,500	47.4%	24.1%
	Transportation Storage Market *(Emerging)*	Jobs	724	2,680	4,840	5,580	29.9%	14.6%
	Traditional Markets	Jobs	2,560	3,120	3,820	4,680	4.07%	4.11%
	Total Employment	Jobs	**3,930**	**10,300**	**19,800**	**26,800**	**21.3%**	**13.6%**

Figures in table rounded to three significant digits. Figures may not sum due to rounding.
$M = Millions of dollars
CAGR = Cumulative Annual Growth Rate over the target period, defined as: $(Sales_y/Sales_x)^{(1/(y-x))}$-1, where x is the first year of the target range, and y is the last year of the target range.

The research builds on a combination of subscription data series, primary data collected from NY-BEST consortium members, and public data on New York industries. The projections consider two different growth trajectories based on assumptions about the pace of New York's Reforming the Energy Vision (REV) proceedings and other policy initiatives in 2016. The research also considers two fundamentally different subsectors for energy storage – "traditional markets" reflecting existing technologies and applications (e.g., vehicle batteries), and "emerging markets" reflecting new technologies and applications (e.g., grid-connected energy storage).

It hasn't happened yet. Forecasting is inexact (by definition). Importantly, NYSERDA's economic analysis does ***not*** project the impacts of consortium-specific activities; instead, it provides a non-specific insight into the anticipated pace of change, against which consortium-related activities can be examined over time.

Forward-looking economic assessments can offer evaluators useful information across a temporal horizon, but their appropriate use must address (and leverage) key limitations; the economic analysis provides some insights into key limitations and best practices.

Data Sources and Challenges

Economic assessments and forecasts require data; nascent markets are inherently more difficult to assess due to the lack of historical data. While some program evaluations may focus on small, circumscribed markets with only a handful of market factors, which makes primary data collection feasible, many program evaluations—like evaluations of consortia—will focus on extensive markets with complex supply chains and market actor interrelationships. Third-party data series are a widely-used and cost-effective option for building economic forecasts of emerging, complex markets, but analysts must use caution in applying them. Proprietary data series typically reflect a "black box" combination of current public and internal market information about existing activity, planned projects, and emerging policies; literature-driven theories about technology adoption and market penetration patterns are then used to develop likely (but theoretical) future trajectories. While these data series can be well-sourced and high-quality:

- It is difficult to "unpack" the individual assumptions that contribute to projections, and generally impossible to determine a priori how a specific market shift or shock would change them;
- It is perilous to simply extrapolate aggregated (e.g., North American) estimates to smaller regions such as New York State, particularly for specific technologies and products; and
- It is critical to validate where possible with "local" data.

NYSERDA's New York State energy storage economic analysis is built partly upon third-party data series for emerging energy storage technologies; these data series are supplemented with primary data, external validation and a number of adjustments and caveats to ensure their appropriate use in the New York State context.

Differentiate market segments to isolate uncertainty. The New York State energy storage market reflects activity in both "traditional" technologies and applications (e.g., vehicle batteries) with well-established market actors and supply chains, and "emerging" technologies and applications, such as grid-scale storage. The growth in traditional markets is expected to be incremental, because products are relatively mature; the "emerging" energy storage market, meanwhile, consists of nascent technologies, still in development, that have limited presence currently, and are positioned for high potential growth but also feature significant uncertainty.

The New York State energy storage economic analysis crafted separate methodologies for documenting and forecasting the emerging and traditional market segments. The employment and revenue baselines for "traditional" market segments were directly documented using direct data from NY-BEST members, supplemented with public information about New York State market participants; these subsectors represent 65 percent of the 2015 New York energy storage employment and revenues but are projected to grow modestly, approximating the economy-wide economic growth rate. The emerging energy storage market, meanwhile, relied on third-party data forecasts of its growth path, which featured exponential increases in economic activity in the immediate future. By developing separate baselines and projections for sub-segments, the assessment: 1) isolates the uncertainty associated with nascent markets, and 2) allows program staff to quickly examine shifts or disruptive impacts in individual market segments.[6]

Validate and Scale Data when Extrapolating. And Repeat. The New York State energy storage economic analysis market used national revenue figures and forecasts from multiple Navigant Research reports when assessing emerging energy storage markets.[7] In the absence of state-level revenue estimates, the study scaled national estimates to reflect the proportion of economic activity that may accrue to entities within New York State, using New York State's contribution to U.S. GDP for manufacturing output or vehicle sales, as appropriate. Using revenue-per-employee parameters, segment-wide revenue levels were converted to segment-specific employment totals.

This assessment was designed to be able to compare current third-party data with earlier forecasts with a prior study in 2012; this provided validation for both the current methodology and the earlier time series data (ECG Consulting Group, 2012).[8] For best utility, an evaluation leveraging economic forecasts should include a plan

[6] The New York State energy storage economic analysis examined individual technologies and sub-sectors, such as energy storage on grid technologies and transportation batteries, and parsed these, where possible, into product types (e.g., light duty electric vehicle batteries versus medium/heavy duty truck batteries). This segmentation, where possible, further allows for a targeted assessment of market impacts or policy developments that may be limited to individual technologies or products.

[7] Navigant Research reports used include: *Advanced Energy Storage for Automotive Applications (AESA-15)*, published 3Q 2015; *Community, Residential, and Commercial Energy Storage (CRES-14)*, published 4Q 2014; *Electric Vehicle Charging Services (EVCE-15)*, published 1Q 2015; *Energy Storage for the Grid and Ancillary Services (ESGAS-16, ESGAS-14)*, published 2Q 2016 and 3Q 2014; *Market Data: Commercial & Industrial Energy Storage (MD-CI-16)*, published 1Q 2016; and, *Residential Energy Storage (MF-RES-16)*, published 2Q 2016.

[8] The most recent economic analysis of the New York State energy storage market reflects an update of an analysis with a similar methodology first developed in 2012. Notably, a comparison of the forecasted 2015 market with the actual 2015 market based on 2016 data suggests that earlier data and forecasts were reasonably successful at accurately forecasting market growth through 2015. However, given that the market was not projected to achieve substantial growth until the post-2015 period, there remains the possibility that it will develop in ways contrary to the projections. Additional verification will need to be conducted over time to determine whether earlier projections were reasonably accurate.

to update its economic analyses periodically in order to enable program staff to evaluate the impact of significant policy decisions or market shocks in "real time" and adjust program priorities as needed.

It may be illuminating to update the 2016 New York State energy storage market analysis with 2017 data, when available, to consider the impacts of changing federal priorities as these solidify.

Employ scenarios and sensitivity analyses to provide strategic insights. Nascent markets are highly sensitive to external market shocks (including changes in policy or general market conditions) that may substantially alter the development, implementation, or end-use of a given technology or product. Development and comparison of various hypothetical pre-shock and post-shock forecasts can provide an assessment not only of the immediate changes expected to ensue after a substantial market change, but also longer-term assessments of the potential impacts to the market's "growth path," allowing for a more comprehensive understanding of cumulative market changes beyond simple point-in-time analyses.

For NYSERDA, the examination of economic trends considered different options for the pace of market reform under the REV proceedings, to examine the short- and long-term impacts of near-term uncertainty related to policies that would affect energy storage on the grid and other innovations. This analysis indicated that near-term impacts or delays in market growth are less critical than longer-term factors that may consistently diminish the exponential growth forecasted to occur.

Overall, exploring a well-designed suite of sensitivity analyses can give policy-makers added confidence about what types of market shocks and changes will—and won't—affect program design or performance.[9]

Above all, keep it simple, and use it wisely. At its core, regardless of data quality, economic forecasting is guesswork, data are limited, uncertainties are manifest, and real-time responses to rapid changes are necessary as programs evolve. Therefore, the most useful economic tools are simple, flexible models whose data sources are limited in number,[10] whose methodologies are transparent, and whose assumptions are clear and easily modified (because forecasts, almost inevitably and unapologetically, will be incorrect).[11] Defining a small array of well-sourced assumptions that directly interact with input data will assist future evaluators, researchers, and stakeholders in updating models as the market evolves.

Another advantage of flexible, adaptive models is that simple structures align particularly well with consortia program models that enable simple data collection; the New York State energy storage analysis employed a two-question web-based survey to collect and validate employment and revenue data.

Ultimately, however, economic analysis and forecasting in the context of program evaluation is most effective not when "the numbers are right," but when the overall patterns of growth, and likely market responses to shocks, are able to guide program staff in ensuring robust (and resilient) implementation of well-targeted programs.

[9] For sophisticated analyses with a fixed number of critical variables and clear market thresholds that affect program design, Monte Carlo analyses and other analytic tools can quantify the potential for disruptive events to have a particular impact on markets.

[10] Limited data sources may also lead to circular logic or anchor bias challenges. For example, the 2012 economic analysis of the New York State energy storage market used a central estimate of $200,000 in revenues per employee. This estimate was not tied to any particular source, and reflects a general, central estimate of the ratio of revenues to employees in high-tech market sources. Because of its use in this study, other sources began citing and representing this number, sometimes outside the context of the New York State energy storage market economic analysis, or outside the context of energy storage altogether. Due to this cross-referencing, searches for updated revenue-to-employee parameters in the energy storage market yielded many sources using the $200,000 figure; in many cases, due to a lack of citations, it was unclear whether this parameter represented an independently-confirmed estimate, or simply a restatement of the parameter from the 2012 economic analysis.

[11] Given the uncertainty that surrounds economic forecasts and market projections, especially for rapidly-evolving markets that may be subject to substantial disruption over a short time period, detailed models with extensive, interrelated sets of assumptions may become obsolete as aspects of the market or the program under evaluation evolve.

Conclusions

When researching emerging markets, social, market, and economic forces play significant roles in how technologies are developed, proven, and commercialized. As our industry begins conducting more research and evaluation on integrated grid programs, we must adapt our methods to address broader-reaching questions and more complex markets than typically addressed in traditional DSM programs. In conducting the evaluation of the NY-BEST consortium for NYSERDA's Energy Storage program, three helpful pieces of guidance emerged for future emerging technology evaluations:

- **When evaluating a consortium, pay attention to who—not just what—is charting the course.**
    - A consortium's metrics of success should to be rooted in an understanding who is responsible for the market's direction, and how they must work together to affect change. Mapping the network helps identify those key companies or individuals situated in specific areas of the value chain who can significantly alter the direction of the market.
    - Identifying which market actors in each part of the value chain are connected and where gaps exist among market actors can help explain why certain technologies are moving faster than others, and help expose opportunities to bridge disassociated market actors. This is a helpful first step towards understanding the market and the consortium's role in the market.

- **Amidst a choppy sea of disparate data sources, use market characterization studies to help anchor the data analyses and consolidate the emerging market's language.**
    - Anchor the market data analysis in a safe "data harbor"—like the DOE Energy Storage database was for the NY-BEST market characterization—and attach other tributary data sources to the anchor source. The anchor source serves as the central point of comparison for all other sources that may measure the same concept in different ways.
    - When describing technology, trends, and market segments, provide clear examples of how the market needs to consolidate its language – identify how market actors are using different terminology to describe the same concept and how they are using the same terminology to describe different concepts.
- **Use a simple, easily-updated economic forecast to help chart, and correct, your course.**
    - Choose a reduced form economic model with a few readily-updated variables. It is worth more than an overly complex assessment that takes too long to generate and provides late, out-of-date feedback on market trends. Specific values are less important than the pattern of growth that, when updated frequently, lends a good understanding of what lies ahead on the journey.
    - Help stakeholders prepare for the kinds of market shocks that may substantially alter the course of the market by clearly differentiating where growth is occurring in traditional and emerging markets and using sensitivity analyses to identify which near- and long-term uncertainties may have the most impact on the market.

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