The New York Battery and Energy Storage Technology Consortium (NY-BEST) is pleased to present this Energy Storage Roadmap for New York’s Electric Grid. Energy storage is a key enabling technology to achieve New York’s goals of a cleaner, more efficient, cost-effective, reliable and resilient electric grid. The global energy storage industry is growing rapidly and is projected to grow exponentially over the next 10-15 years. This Roadmap recommends specific actions for the energy storage industry, policy-makers and stakeholders to take to ensure that New York’s electric grid and economy realize the enormous benefits of energy storage.

The Roadmap was developed with support from the following workshop participants and a diverse set of stakeholders in the New York energy storage community:

Tony Abate • NYSERDA
Doug Alderton • Vionix Energy
Mike Alt • Eastman Business Park
John Andreasakis • Oak-Mitsui Technologies
Mark Austin • Chandler Reed
Rob Belle-Isle • Toshiba
Mike Bennis • Bren-Tronics
Mike Berlinski • Customized Energy Solutions
Philippe Bourchard • EOS Energy Storage
Aubrey Braz • Con Edison
Paul Bundschuh • Ideal Power
Clay Burns • National Grid
Marty Byrne • Rensselaer Polytechnic Institute
Victor Cardona • Helsin Rothenberg Farley and Mesitli
H.G. Chissell • Virdity Energy
Joshua Clyburn • NYSERDA
Mike Cooper • Landis & Gyr
Rick Cutright • General Electric
Valerio D’Angelis • Urban Electric Power
Gary Davidsone • NYSO
Amair De La Cruz • Con Edison
Henrietta de Veer • Adaptive Energy Solutions
John DeBoever • UniEnergy Technologies
Jim DeJager • DNV GL
Jason Doling • NYSERDA
Richard Drake • NYSERDA
Michael Field • The Raymond Corporation
Rick Fioravanti • ECF International
Alex Fraenkel • Next Era Energy
Jim Frawley • NEC Energy Solutions
Matt Frank • Matt Frank & Associates
Larry Goldberg • ZBB Energy Corporation
Fernando Gomez-Baquero • Bess-Tech
Allen Goodman • ECG Consulting Group Inc.
Alexandra Goodson • Saft
Darren Hammell • Princeton Power
Jennifer Harvey • NYSERDA
Davion Hill • DNV GL
Sharon Hillman • AES Energy Storage
Jin Jin Huang • Con Edison
Ben Kearns • Stem
Ted Ko • Stem
Li Kuo • NYPa
Kiran Kumaswamy • AES Energy Storage
Tim LaBreche • Syracuse Center of Excellence
Phil Larochelle • Google, Inc.
Jeffrey Lawrence • Center for Economic Growth
Yuanfan Liu • ECG Consulting Group
Michael Lobinger • Center for Economic Growth
John Love • NYSERDA
David Lovelady • Siemens
Daryl Ludlow • Rensselaer Polytechnic Institute
William McKenna • Graphenix Development
Mark Mead • ECG Consulting Group
Glen Merfels • General Electric
Troy Miller • S&C Electric
Greg Moreland • SRA International
Paul Mutolo • Cornell University
Nenad Nenadic • Rochester Institute of Technology
Chris Orzel • Invenenergy
Arch Padmanabhan • Tesla
Brian Perusse • AES Energy Storage
Jennifer Phelps • NYSERDA
Paulo Piagi • Lockhead Martin
Clark Pierce • Landis + Gyr
Manisha Rane-Fondacaro • E2TAC at the SUNY Polytechnic Institute
Britt Reichborn-Kjenerud • Con Edison
Andrew Reid • Con Edison
Joel Rinebold • Northeast Electrochemical Energy Storage Cluster
Johannes Ritterhausen • Convergent Energy + Power
Robert Rudd • Solar City
Tal Shoklapp • Voltiaq
Doug Staker • Demand Energy
Ed Stein • EnerSys
Nils Swenson • Tyr Energy, Inc.
Alek Szeczy • Bond, Schoeneck & King
Bruce Toymans • Bess-Tech
Dan Vickery • Green Charge Networks
Ryan Wartenber • Geli
Betty Watson • Solar City
Neil Webb • O’Brien & Gere
Russ Weed • Green Charge Networks
Teresa Wells • Xcel Energy

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http://www.ny-best.org/page/ny-best-reports
EXECUTIVE SUMMARY

In 2012, the New York Battery and Energy Storage Technology Consortium (NY-BEST) published the first New York Roadmap for Energy Storage, which described the tremendous potential of the energy storage industry to improve the state’s electric grid, transportation system and economy. In the ensuing three years, the global energy storage industry has evolved and matured, and is growing rapidly. The price and performance of storage systems have improved considerably and deployments are expanding across a variety of applications. Energy storage applications on the electric grid, in particular, are increasingly recognized as effective ways to improve aging electric grid systems, enable the wide-scale deployment of renewable energy, and enhance electric grid efficiency and resilience. However, more needs to be done in order for New York’s electric grid to fully realize the benefits of energy storage. In this Energy Storage Roadmap for New York’s Electric Grid, we discuss the vital role that energy storage technology can play in helping New York State achieve its goals for a cleaner, more resilient and affordable electric grid, and we recommend specific actions by industry, government and electric system operators that should be taken to ensure that energy storage is able to fulfill its essential role in transforming New York’s electric grid.

New York’s electric grid faces a number of challenges. New York households pay well above the national average in annual energy costs and face some of the highest electricity rates in the country. The state’s grid infrastructure is aging and the transmission and distribution systems are increasingly being stressed by new demands placed on the system. Events such as major storms and heat waves further exacerbate the grid’s vulnerabilities. In addition, the imperative to reduce harmful pollutants and address the threat of climate change is driving the transition away from fossil fuel energy sources toward clean renewable energy.

New York State has taken a number of steps to address these challenges. The State Energy Plan sets aggressive goals for reducing the State’s greenhouse gas emissions — 40 percent by 2030 and 80 percent by 2050 — and generating 50 percent of the State’s electricity from renewable sources by 2030. In addition, the New York State Public Service Commission has launched an initiative entitled, “Reforming the Energy Vision” (REV), to modernize and transform the State’s electric grid by accelerating clean distributed energy resource deployment, adopting new business models that incorporate technological advances and engaging customers in their energy choices, while ensuring the quality, reliability, and affordability of the electricity system.

Energy storage has a major role to play in the transformation of New York’s electric grid and in achieving the goals of REV. Energy storage is already a cost-effective solution for many applications on the grid and it will be essential for meeting the State’s renewable energy goals. Distributed energy resources — including energy storage — are at the center of the REV initiative. In particular, energy storage provides key services and benefits that are essential to the REV initiative and the electric grid of the future, including the following:

- Improving the efficiency and capacity factor (utilization) of the electric grid;
- Integrating an increasing amount of renewable energy sources into the electric grid and enabling the flexibility of those resources; and
- Enhancing the overall reliability and resilience of the electric grid.
KEY GOALS AND RECOMMENDATIONS

In the 2012 New York Energy Storage Roadmap, NY-BEST set a ten-year goal of having 1 GW of storage on the grid. That goal for 2022 is still valid, but the dramatic changes in the energy system that are currently underway and accelerating justify even more ambitious goals going forward. To that end, this Roadmap establishes goals of having 2 GW of multi-hour storage capacity on New York’s electric grid by 2025 and 4 GW by 2030. By strategically deploying this much storage on New York’s grid, the system can substantially reduce its costliest peak electricity demand, provide flexibility for the substantial amounts of intermittent renewables that the State has committed to install over the next 15 years, and provide resilience and backup power throughout the grid.

In order for the energy storage industry to achieve its full potential to fundamentally change the nature of the State’s electricity system, it must overcome a number of obstacles and it must take specific actions. Stakeholders in New York’s energy storage industry must work together, as well as with government policy makers, to undertake initiatives that remove existing obstacles. Specific actions that must be taken include the following:

- Create new regulatory and market mechanisms to monetize the full value of energy storage;
- Create common financing vehicles that help provide access to capital, simplify project finances and reduce perceived project risks;
- Reduce soft costs of energy storage installations related to siting, permitting, interconnection and other transactional costs;
- Create standardized methodologies, codes, and regulations that are recognized by all jurisdictions to increase commercial confidence in energy storage solutions and reduce soft costs;
- Perform a study to evaluate options and assess requirements for storage and other assets needed to support the State’s renewable energy and greenhouse gas emissions goals;
- Increase the availability of information related to electric grid system needs and capabilities in order to enhance industry decision-making; and
- Implement a declining bridge incentive for storage that monetizes the value energy storage delivers to the electric system and provides long term revenue confidence to investors.

These actions will position New York State to realize the energy and economic benefits of the energy storage industry. The global market for storage is growing, and New York has significant industrial assets in the sector. In 2012, almost 3,000 were employed in New York State in this sector and New York companies sold nearly $600 million in global sales. In the next decade, Navigant Consulting projects the global market for storage to increase six-fold to $65-$75 billion, and by 2030 Citibank projects $400 billion in annual sales.
Energy storage is a key enabling technology to achieve New York’s goals of a cleaner, more efficient, cost-effective, reliable and resilient electric grid. The global energy storage industry is experiencing rapid growth and is projected to grow exponentially over the next 10-15 years. By addressing the barriers to energy storage’s wide-scale adoption and accepting the recommendations contained in this Roadmap, we will secure New York’s place as a leader in energy storage, realize the economic benefits of this growing industry and truly transform the state’s electric grid.
NY-BEST GOALS AND RECOMMENDATIONS

- Establish Standardized Safety Regulations: 2017
- Modify NYISO rules for Storage Participation in Wholesale Markets: 2018
- Provide Detailed Distribution Data with Locational Pricing: 2019
- Reduce Energy Storage Soft Costs by 33%: 2020
- Reach 1GW installed Storage capacity: 2022
- Reach 2GW installed Storage capacity: 2025
- Reach 4GW installed Storage capacity: 2030
- 50% power from renewables; 40% GHG emissions reduction
- 80% GHG emissions reduction: 2050

NEW YORK STATE GOALS

REV INITIATIVE
Energy storage technology is a critical and even essential element in the fundamental reshaping of two trillion-dollar industries: the electric system and transportation. Historically, these industries have evolved along very different paths, making use of disparate fuels and technologies. As society looks to reduce its dependence upon fossil fuels and mitigate the effects of global climate change, these two vast human enterprises are converging upon similar solutions to their most challenging problems. This Roadmap focuses solely on the role for energy storage on the electricity grid. We will discuss transportation in a future document.

The integration of energy storage into modern energy infrastructure is likely as necessary as it is inevitable.³

— New York State Department of Public Service
It has long been argued that the evolution of human civilization is dependent on the conversion of energy for human use. The evolution of energy use itself has basically defined the trajectory of civilization. The late eighteenth century marked the beginning of the fossil fuel age, and with it, the Industrial Revolution, and fossil fuels have been our primary energy source ever since that time. By the early twentieth century, electricity — powered primarily by fossil fuels — had become the dominant method for transmitting energy and its use transformed many aspects of how we live our lives.

Human endeavors have become increasingly electrified and our lives depend more and more upon electronic devices and technologies. In 1950, 20 percent of the U.S. gross domestic product was directly dependent on electricity. Since that time, that number has tripled to 60 percent. But even as our use of electricity has grown, so has the desire to move away from fossil fuel sources for generating it and to adopt cleaner renewable energy technologies. The need for secure and reliable energy and a growing imperative to reduce harmful air pollutants and greenhouse gas emissions from our energy sources have been driving dramatic changes in how we generate and use energy. There has been a transition towards onsite generation and towards more efficient resources. These factors will place new pressures on the state’s electricity industry. It needs to replace aging infrastructure, adapt business models to embrace technological advances, and ensure that the quality, reliability, and resilience of the electricity system meet the demands of an increasingly connected society while still managing energy costs.

While electricity has a unique and increasingly crucial role in society, it is also a commodity that is bought and sold. However, electricity differs from other commodities in that it cannot be directly stored. Electrical energy is ephemeral. To store it, it must be converted to other forms of energy, such as chemical energy, kinetic energy, thermal energy or potential energy. Electricity also must be delivered with very tightly controlled properties — especially its frequency and voltage. Managing these unique features has led to a highly developed electricity system that truly was the engineering marvel of the 20th century, with its ability to constantly maintain a fine balance between energy supply and ever-fluctuating customer demand. The end result, however, is also a system that relies on vast capital resources that are underutilized and expensive.

There are several factors that are driving the need to fundamentally change the electricity system. Demands on the system during peak times have grown at rates above that of the system’s base loads. As a result, the electricity system’s utilization factor has declined and the entire system — every single generator, pole, wire, substation and transformer — is sized to meet peak demand levels that may only occur a few

The energy storage industry can bring thousands and significant improvements in the quality of life
days or even hours a year. The resilience and reliability of the grid are constantly being tested. The electrical infrastructure is aging and transmission and distribution systems are becoming increasingly stressed. This is compounded by the rising occurrence of disruptive events such as heat waves and major storms. The rapid growth of intermittent renewable generation sources has created the need for increased flexibility on the grid and the increased customer adoption of distributed energy resources (DERs) is changing the relationship between utilities and end users. Last, but not least, is the need to significantly reduce carbon emissions to mitigate climate change.

All of these forces that are reshaping the grid are drivers for the adoption of energy storage technology. All functions of the grid — generation, transmission, distribution and end-use — can benefit from storage in multiple ways. The benefits from storage derive from the fact that energy storage changes the nature of electricity as a commodity in three ways:

+ Additional electrical energy can be available in the event of an unexpected and sudden need or can be set aside in anticipation of expected future need.
+ The quality of electricity being delivered can be restored in the event of short-duration problems with voltage, frequency, power factor or continuity.
+ The output of excess generation can be retained for later use.

Energy storage can “decouple” supply and demand on the electricity grid. Energy storage makes electricity much more like a standard commodity that can be warehoused and distributed with a degree of control that previously did not exist. Just as storage is a key factor in the supply chains of other commodities — making it cheaper and more efficient to store products than to produce them on site at the moment they are required by a customer — so too can storage create efficiencies for the electricity system. Storage fundamentally provides the ability to reduce the difference between base load and peak, while at the same time making both supply and demand more elastic and flexible in the presence of growing resource intermittency. To an extent, this has taken place with pumped hydro storage, but that technology is significantly limited with respect to where it can be located.

As a result of the profound effect that storage can have on the electrical system, there are multiple economic opportunities for storage technology and multiple value streams that can be derived from it, in many cases simultaneously. New York State is a prime market for energy storage that includes the largest metropolitan area in the country. The state has a large and aging electricity infrastructure whose transmission lines were mostly built more than 50 years ago and two-thirds of whose generating facilities are at least 30 years old. New York has substantial and growing clean energy storage industry can bring thousands of jobs, billions of dollars, and significant improvements in the quality of life in the state of New York.
generation resources in the northern and western “upstate” regions and growing demand in the southern “downstate” region, a situation that puts particular stress on aging transmission resources. Growing amounts of distributed generation resources are putting a strain on distribution systems. But New York is also a state whose government and regulatory agencies have recognized the need to modernize the electrical grid and embrace new technologies. The grid of the future is one in which energy storage must play a crucial role.

New York has arguably become the most progressive and proactive state in the U.S. with regard to laying out a comprehensive roadmap for establishing a clean, resilient and affordable energy system. The State’s Energy Plan embraces innovative technology and principles of regulatory reform, environmental justice, economic development, and greater engagement by all stakeholders in the state. It recognizes that a massive transition away from fossil fuels to an energy system dominated by renewables will require major changes in how that system operates. The State’s Reforming the Energy Vision (REV) initiative seeks nothing short of a complete remaking of the electricity industry in the state, embracing clean distributed energy resources, new business models and enhanced customer engagement. Energy storage has a major role to play in the evolution of New York’s energy system and in the state’s economy. The state already employs thousands of workers in the battery and fuel cell industry and is home to the New York Battery and Energy Storage Technology Consortium (NY-BEST), which is an industry-led, private-public coalition of over 150 entrepreneurial, academic, corporate, and government partners. New York State, with its leading universities, global companies, manufacturing assets, innovative entrepreneurs and world-class markets, has the potential to become the national leader in the advanced energy storage sector. The energy storage industry can bring thousands of jobs, billions of dollars, and significant improvements in the quality of life in the State of New York.
The existing electricity system is not well suited to addressing and overcoming New York’s economic and environmental challenges. The traditional one-way delivery of electricity to end user customers — with monthly bills for that specific service — is likely to be replaced by a much more dynamic set of options that provide customers with choices for when and how they consume and even produce electricity, how much that energy costs, how much carbon is emitted in producing it, and more. New York households pay well above the national average in annual energy costs and face some of the highest electricity rates in the country. Both residential and business customers are increasingly dependent upon high-quality electric supply. In the meantime, there are emerging cyber and physical threats to the centralized power system. The system has had to grapple with an increasing number of natural disasters — eleven presidentially-declared since

### RENEWABLES ON TODAY’S NEW YORK GRID

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Electricity Demand</td>
<td>33,956 MW</td>
</tr>
<tr>
<td>Average Electricity Demand</td>
<td>18,270 MW</td>
</tr>
<tr>
<td>Annual Electricity Usage</td>
<td>160,090 GWh</td>
</tr>
<tr>
<td>Total Renewable Capacity</td>
<td>6,264 MW</td>
</tr>
<tr>
<td>Percentage of Energy from Renewables</td>
<td>25%</td>
</tr>
<tr>
<td>Percentage of Energy from Hydropower</td>
<td>19%</td>
</tr>
<tr>
<td>Nameplate Wind Capacity</td>
<td>1,746 MW</td>
</tr>
<tr>
<td>Estimated Generation</td>
<td>5,300 GWh</td>
</tr>
<tr>
<td></td>
<td>(3.3% of total)</td>
</tr>
<tr>
<td>Nameplate Solar Capacity</td>
<td>519 MW</td>
</tr>
<tr>
<td>Estimated Generation</td>
<td>770 GWh</td>
</tr>
<tr>
<td></td>
<td>(0.5% of total)</td>
</tr>
</tbody>
</table>
2010 — including major storms Sandy, Irene and Lee. And in the face of the growing dangers of climate change, the State has set goals to reduce greenhouse emissions by 40 percent by 2030 and 80 percent by 2050, and to generate 50 percent of its electricity from renewable sources by 2030.4

Today’s U.S. grid is operated by more than 3,000 utilities that sell $250 billion worth of electricity a year, most of which is generated by burning fossil fuels in central power stations and is distributed over nearly 3 million miles of power lines. New York maintains a generation capability of 39 GW and has over 11,000 circuit miles of transmission that provide over $20 billion worth of electricity a year. The power industry continues to invest vast amounts of money to be able to meet the demand for electricity, including $336 billion in the distribution system since 2000, and roughly $20 billion a year in transmission infrastructure.5 New York has added over 11 GW of generation and 2,300 MW of transmission capability just since 2000. The current economic model for the electric grid and utilities is inefficient, providing a regulated return on these capital investments rather than on efficient operations. Regulators set rates for the utilities and utilities receive guaranteed returns. This functional and economic model is essentially unchanged since the days of Thomas Edison. Technology advancements, consumer trends, and global energy markets are challenging the current centralized utility model. There is a growing need for new reliability and resilience approaches for the grid. The electric grid infrastructure is aging and will require even more extraordinarily expensive upgrades if new regulatory and economic models are not adopted.

The state’s bulk power system is designed to meet retail peak demand, which is about 75% higher than the average load, and only occurs over a few hours per year. This situation has been likened to building a 16-lane highway to handle traffic that only occurs on three holidays a year. The consequence is an uneconomic oversizing of generation, transmission and distribution assets and results in significant underutilization of these assets. New York’s grid assets currently have a 55 percent utilization rate overall and many assets, such as gas-fired peaker plants, have only single-digit utilization rates, resulting in significant added costs. According to New York Public Service Commission (PSC) estimates6, the top 100 hours of demand cost New York’s ratepayers as much as $1.2-1.7 billion annually, making it some of the most expensive electricity in the world. In addition, approximately nine percent of generated power is lost because it has to travel long distances over transmission and distribution lines.

In the face of all these factors, distributed energy resources (DERs) including energy storage provide an enormous strategic and economic opportunity for New York. There are clean sources of energy that are now affordable...
that are not being utilized to their maximum potential as a result of regulatory and market barriers to their wide-scale use. Despite this, rapid declines in costs and increased capabilities of many forms of DER including solar, energy storage, and energy management technologies, are likely to drive increased DER penetration, even in the absence of additional enabling policies.

However, to more fully realize the potential of DER technologies — especially energy storage devices and systems — they must be allowed to fully participate in all markets in the electricity system. Energy storage is unique in that it encompasses a diverse range of functions and benefits whose value streams must all be appropriately and fairly captured. This requires the elimination of barriers to create an open, fair and level playing field in which there are a wide range of participants that includes private corporations, contracted third-party ownership, public/private partnerships, and utilities in which all alternatives are evaluated in a consistent manner.

In February 2015, the State’s Public Service Commission (PSC) publicly asserted that it will embrace the changes that are taking place in the electricity system and use them for New York’s economic and environmental advantage. The PSC stated that DERs should be “on a competitive par with centralized options,” and that utilities will have to take on a new role in developing and operating distributed energy markets. And thus, the Reforming the Energy Vision (REV) initiative was launched.

Glenwood, a luxury residential Manhattan real-estate group, realizes that their load contributes to the peak power usage which can contribute to system stability issues during the high demands of summer. They therefore elected to participate in load management to support the distribution grid.

In 2010, Glenwood began working with Demand Energy to develop the ability to reduce peak demand usage at times when grid stress occurs and to purchase energy at off-peak periods. In New York, open energy access allows Glenwood to buy energy on the day-ahead market based upon hourly locational based marginal pricing. Along with open choice for energy purchases, Con Ed offers some flexibility in their delivery charges. With time-based energy and power costs, the system can respond to market-driven pricing that aligns with the true marginal costs to deliver power through the grid. In August, 2012, Glenwood installed a 225 kW/2 MWh storage system in its Barclay Tower property in downtown Manhattan. The Barclay Tower system has demonstrated that battery-based storage can deliver the economic savings and operational robustness to meet grid challenges throughout the year. After the first year of operation of the Barclay Tower system, Glenwood saw about a 14% reduction in the cost of the energy and power (demand).

In March, 2014, Con Ed and NYSERDA launched new incentives for energy storage. Glenwood selected 10 buildings to deploy 100 kW/400 kWh systems for a total of 1MW/4MWh of storage for distributed grid support. The first of these new generation systems qualified for operation in August, 2015. The rest of the systems are scheduled to be installed in early Q1 2016.
The overall objective of the REV initiative is to transform New York’s electric industry — for both regulated utilities and non-regulated participants — with the creation of a new business model built around market-based, sustainable products and services that drive an increasingly efficient, clean, reliable, and customer-oriented industry. REV seeks to create a power grid that addresses the needs of 21st century society.

Accomplishing this remaking of the industry will require regulatory reforms that permit the use of a wide range of DERs that are coordinated to manage load, optimize system operations, and enable clean distributed power generation. It will require the creation of new markets and tariffs that allow customers to optimize their energy usage and reduce electric bills. New policies are needed to stimulate innovation and new products that will further enhance customer opportunities and provide improved incentives and remove disincentives that reside in the current paradigm.

From an economic standpoint, the new grid must monetize, in manageable transactions, a variety of system and social values that are currently accounted for separately or not at all. For example, benefits such as upgrade deferral and resilience are not monetized. Above all, the reimagined grid must provide reliable service at reasonable rates and maintain necessary consumer protections.

The basic topology of the electric grid, as envisioned by REV, is quite different from what it has been since its inception over a century ago. The hierarchical grid based on centralized power generation is to give way to a multiply-connected network of generators, storage, and loads with a strong emphasis on clean, local power.

The grid envisioned under the REV initiative is no longer based upon a centralized source of electrical power but is rather a bidirectional, transactive and situationally-aware system that more closely resembles the Internet in structure. Instead of a linear business model, the networked grid follows a platform business model. The role of a platform business is to acquire, connect, match up, and enable producers, consumers and even “prosumers” (producer-consumers) to make transactions. In the case of the reimagined grid, these transactions are the buying and selling of energy products and services.

REV seeks to create a power grid that addresses the needs of 21st century society. >>
YESTERDAY >> CENTRALIZED POWER

TOMORROW >> NETWORKED, CLEAN, LOCAL POWER
Enhanced customer knowledge and tools that will support effective management of their total energy bill

In the existing system, all that most customers know about their energy usage is how many kWh they use, the rate they pay, and a total price. In this way, the current system for electricity payments is analogous to someone who shops for groceries at their local store but only receives a bill once a month — after they’ve consumed the food. Under REV, customers would be given new energy management tools including timely information on how and when they used energy and how their use compares with other customers. This would allow them to make intelligent decisions about scheduling the use of electrical loads and about upgrading and replacing equipment.

Fuel and resource diversity

Under REV, utilities have a priority of seeking new energy sources and reducing dependence upon fossil fuels. Efficiency and carbon intensity will be valued as resources to be considered along with fuels, storage and other energy sources. Increasing fuel diversity will make customers less vulnerable to price fluctuations and supply fluctuations and will make for a more competitive market overall.

System reliability and resilience

The shortcomings of the existing system were apparent in New York City’s experience with Superstorm Sandy, when millions of electricity users had no power for more than a week. As a result, many customers are now interested in distributed power sources that are independent of the grid. With the increasing frequency and severity of storms and heatwaves, there is the need for enhanced reliability and resilience for our electricity system. Under REV, the new paradigm for the grid would in part be established to address emerging threats that are particularly a danger to centralized power systems.

Reduction of carbon emissions

New York’s Energy Plan calls for a 40 percent reduction in carbon emissions by 2030, and it is likely that there will be a number of federal carbon reduction rules imposed on the energy system over the next several years. And, most significantly, there is the overall need to reduce carbon emissions to mitigate the effects of climate change on the planet. Under REV, the proliferation of renewable DERs, the emphasis upon system-wide efficiency, and the increased awareness and use of energy management tools by customers will all contribute to the reduction of carbon emissions.

The overall goals for REV are to be accomplished by achieving six specific objectives specified in the initiative:

1. Enhanced customer knowledge and tools that will support effective management of their total energy bill
2. Market animation and leverage of ratepayer contributions
3. System-wide efficiency
4. Fuel and resource diversity
5. System reliability and resilience
6. Reduction of carbon emissions
REV has the goals of making energy more affordable, building a more resilient and reliable energy system, creating new jobs and business opportunities, promoting innovation, and protecting and improving the environment.

Under REV, customers and non-utility providers will be the drivers of the new grid and utilities will take on the new role of Distributed System Platform (DSP) providers. In this role, utilities are still responsible for the reliability of the grid and therefore must perform the functions needed to enable distributed markets to contribute to a stable grid. As platform providers, utilities are the primary interface among customers, aggregators, and the distribution system. Technology innovators and third-party aggregators (energy service companies, retail suppliers and demand-management companies) will develop products and services for the grid and utilities, acting in concert, will constitute a statewide platform that provides uniform market access to both customers and DER providers. The utilities will respond to new trends and capabilities by adding value, thereby retaining their customer base and their ability to raise capital on reasonable terms.

Utilities in the DSP model constitute “an intelligent network platform that will provide safe, reliable and efficient electric services by integrating diverse resources to meet customers’ and society’s evolving needs. The DSP fosters broad market activity that monetizes system and social values, by enabling active customer and third party engagement that is aligned with the wholesale market and bulk power system.”

DER service providers will participate in the new system in a transparent market-based environment. The idea is to have the DSP be interoperable among diverse technologies, products and services and to provide for the integration of variable renewable generation sources.

In one of the first group of REV demonstration projects sponsored by the New York Department of Public Service, Con Edison will partner with SunPower and Sunverge to integrate residential behind-the-meter storage resources into the grid. A hardware/software platform will provide aggregated control of individual residential resources thereby converting them into a virtual power plant (VPP). The VPP will have a total capacity of 1.8 MW and an energy output in aggregate of 4 MWh.

Over the next decade, Con Edison estimates that 700-800 MW of residential PV systems will be added to their networks. The majority of these systems are in networks that peak after 5 p.m. while, of course, peak generation occurs earlier in the day. This mismatch, along with the inherent intermittency of solar generation, makes it difficult for the utility to adapt its transmission and distribution infrastructure to ensure safe, reliable, and predictable transmission of electricity to its customers.

Energy storage at customer’s sites will provide them with resilience services during momentary or sustained power outages. In aggregate, the combined PV+storage systems can be used as a reliable, dispatchable resource that can be deployed to reduce load in congested areas, defer or avoid capital investments, and improve power quality. In the project, Con Edison will explore how aggregating hundreds of distributed energy resources can be used to provide firm capacity that can participate in and be monetized for competitive capacity markets and demand response programs. It will also provide a testing ground for various rate structures designed to incentivize certain customer behavior and will test a variety of mechanisms for monetizing the benefits provided by the system.
Distributed Energy Resources, both in front of and behind the meter, are at the center of the REV reimagining of the grid and depending upon the specific situation may be in the form of generation, storage, demand response, or energy efficiency. In many instances, energy storage may be the most essential DER in achieving REV’s goals. The primary motivating factors for using energy storage in the electrical system are all key elements of the grid of the future as described by the REV initiative and can be summarized as the following:

+ **Improving efficiency and capacity factor (asset utilization) on the grid**
  Energy storage can improve the efficiency and capacity factor of the grid both from behind the meter and as part of the distribution, generation and transmission systems by flattening peak loads and alleviating the need for underutilized assets.

+ **Integration of renewables into the grid via flexibility**
  Energy storage greatly enhances the integration of renewable energy sources on the grid at all levels by time-shifting the energy generated, by firming generator output, and by providing ancillary services such as frequency regulation and spinning and non-spinning reserves. Energy storage added to PV systems in constrained areas of the distribution system can enable the grid to accept amounts of PV that would otherwise require significant costly interconnection upgrades or curtailment of the resource.

+ **Enhancing reliability and resilience of the grid**
  Energy storage can provide reliability and resilience by adding backup power capability, assuring power quality and firming and stabilizing generation sources.

These benefits of storage are discussed in greater detail in Appendix I which is available online at [http://www.ny-best.org/page/ny-best-reports](http://www.ny-best.org/page/ny-best-reports)
**USE CASE:**

**MICROGRID STABILITY**

**NY Prize and NYSERDA Smart Grid Projects**

NYSERDA’s NY Prize program is a $40 million competition to help communities create microgrids that are capable of operating independently in the event of a power failure. The first stage of the program made 82 awards for feasibility studies to New York communities in July, 2015. Based upon the results of these studies, approximately 10 projects will be funded at levels up to $1 million to produce detailed designs for microgrid installations and the third stage of the program will provide approximately 7 awards of up to $5,000,000 for the build-out of the community microgrids.

The abstracts of nearly half of the feasibility study awards explicitly mention energy storage in the mix of technologies proposed for their microgrids. One example is the Long Island Community Microgrid Project, which aims to provide the East Hampton area with nearly 50% of its grid-area electric power requirements from local solar power, thereby avoiding substantial investments in utility infrastructure. The proposed microgrid would include 15 megawatts of solar power supported by a 25-megawatt-hour energy storage system.

NYSERDA’s Smart Grid Program supports a variety of projects that improve the resilience, reliability, efficiency, quality, and overall performance of the electric power delivery system in New York State. National Grid is involved with two important microgrid projects that are evaluating the role of energy storage. A project headed by Clarkson University is developing an engineering design for an underground microgrid that is capable of providing power restoration to a variety of entities in Potsdam, New York, including hospitals, water treatment facilities, college campuses, and retail establishments.

A second project, headed by EPRI, is centered around the extensive facilities of the Buffalo Niagara Medical Campus. The Roswell Park Cancer Institute alone represents an 8 MW load. In total, the proposed microgrid represents a 32 MW load. The overall goals of the project are to integrate command and control capabilities for their transmission and distribution grid infrastructure at the campus level; resilience; and to increase economic value through energy efficiency.

**USE CASE:**

**DISTRIBUTED PEAKER (AGGREGATED GRID SERVICES)**

**Stem**

Stem provides storage resources to the grid by aggregating multiple independently located and controlled, behind-the-meter systems and enabling them to respond as a single unit. As part of Pacific Gas & Electric’s Supply-Side Pilot, Stem aggregated a number of systems using its predictive software to automatically dispatch stored power into CAISO wholesale markets as demand response. Included in this aggregation are a number of hotel properties in San Francisco and San Mateo counties. Individual systems range from 18 kW to 36 kW in size. Accurately forecasting customer energy use is essential to ensure that the distributed systems can be used both for decreasing energy costs at the customer site (which is their primary purpose) as well as participating in energy markets.

Stem was also selected by Southern California Edison to provide 85 megawatts of distributed storage to serve as on-demand local capacity in West Los Angeles. For this procurement, Stem will deploy behind-the-meter storage systems at customer sites in specific locations within a constrained area of the grid and all 85 MW must be deployed by 2021. Stem is also deploying 1 MW of behind-the-meter energy storage in a demonstration project with Hawaiian Electric to support grid response services. This capability is particularly important in Hawaii where the penetration of solar technology is rapidly expanding. Extensive distributed solar capacity results in a drop off in demand in the sunny mid-afternoon when many people are at work. When people come home in the evening and the sun sets, there is a big spike in demand. Instead of having to rapidly ramp up conventional power plants, Stem’s energy storage and data analytics will draw upon stored power to respond to demand spikes.
The energy storage industry is in the early stages of an extended period of massive growth. Countries around the world and many states across the U.S. have been adopting policies to incorporate renewable energy and renewable generation costs are plummeting. As a result, 55 percent of newly installed generation capacity in the U.S. in 2014 was in the form of renewables. As more and more renewables enter the grid, there is an increasing need to find cost-effective means to store power and balance energy systems.

The preponderance of energy storage is still very large-scale pumped hydro storage, with more than 140 GW of capacity worldwide, much of which has been in place for decades. In New York, the Blenheim-Gilboa and Lewiston Pumped Storage facilities provide 1.4 GW of storage capacity. However, the specialized siting requirements for pumped hydro technology limit its expansion and broader applicability. As a result, the widespread growth in energy storage at present and going forward is in the form of other advanced technologies.

The use of thermal energy storage continues to expand. Ice energy storage is used in thousands of locations worldwide. For example, CALMAC has provided more than 500 MW of storage capacity to end user customers. Molten salt storage is increasingly being used for solar thermal generating plants, allowing them to continue to operate for many hours after the sun has set or during cloudy periods. Three large solar thermal plants in the U.S. and Spain utilize molten salt storage to extend the operating hours of over 500 MW of generating capacity.

Energy storage from electrochemical, electromechanical, and thermal storage projects grew from 70 MW to 900 MW between 2000 and 2015. According to GTM research, deployments during the second quarter of 2015 were the largest in three years and the largest ever for nonresidential storage. In total, global installations of grid-connected storage systems continue to grow significantly.

Major market research firms are all predicting explosive growth in the grid storage industry. For example, Bloomberg New Energy Finance predicts storage capacity will reach 11.3 GW by 2020. IHS predicts that grid-connected storage will exceed 40 GW by 2022. By 2030, Citibank estimates up to a 240 GW global market for grid storage. Global revenues from energy storage are growing as rapidly. Navigant predicts that revenues from storage will increase from $675 million in 2014 to nearly $16 billion in 2024. Citibank estimates the market for energy storage, excluding vehicles, could be worth over $400 billion by 2030.

Grid storage is growing rapidly in the U.S. The largest specific driver for storage in the U.S. is the California storage mandate under which the State’s Public Utilities Commission (CPUC) approved a target requiring the state’s three largest investor-owned utilities, aggregators, and other energy
**>> USE CASE: FREQUENCY REGULATION**

**Beacon Power**

Flywheel energy storage works by accelerating a rotor to a very high speed and then storing the energy in the system as rotational energy. When energy is extracted from the system, the flywheel’s rotational speed is reduced as a consequence of conservation of energy; adding energy to the system correspondingly results in an increase in the speed of the flywheel. Stephentown, New York, is the site of Beacon Power’s first 20 MW plant (40 MW overall range) and has been providing frequency regulation service to the NYISO since 2011.

The plant is one of the largest non-hydropower, non-thermal energy storage facilities currently operating in North America. It utilizes 200 high-speed Beacon flywheels to store energy and provide fast-response, short duration frequency regulation services to the New York grid with zero emission and no fuel consumption. The system has the ability to absorb or discharge power for as long as 15 minutes and to respond to the grid operator’s control signal in under 4 seconds. The Stephentown plant currently provides about 10% of New York’s overall frequency regulation needs and provides over 30% of the Area Control Error correction, doing so with over 95% accuracy. A June 2010 study by DNV KEMA determined that 30 to 50 MW of fast-response energy storage (i.e., flywheels) can be expected to provide the same or greater regulation effect as a 100 MW combustion turbine performing frequency regulation.

Beacon has additional operating plants in Tyngsboro, Massachusetts and in Hazle Township, Pennsylvania. The Hazle plant also includes 200 flywheels and provides 20 MW of frequency regulation to the PJM interconnection. In total, Beacon Power flywheel systems have accumulated over 7 million operating hours and a throughput of more than 265,000 MWh.

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**>> USE CASE: FREQUENCY REGULATION/PEAKER REPLACEMENT**

**AES Energy Storage**

In 2008, in a collaboration with AES Energy Storage, PJM added a 1 MW containerized lithium-ion battery system to its headquarters. PJM is the nation’s largest Regional Transmission Operator, managing the flow of wholesale electricity for over 61 million customers in 13 states and the District of Columbia. The AES system was able to both supply and withdraw up to 1 MW of power, thus allowing it to participate in the PJM market for regulation services.

AES added the 64 MW Laurel Mountain energy storage resource in 2011 and the 40 MW Tait resource in 2013. The Tait system project was completed in less than six months including all regulatory, interconnection, construction and commissioning activities. The Laurel Mountain installation is currently the largest battery energy storage system in the United States and one of the largest in the world, providing frequency regulation and firming to the PJM grid.

In total, with its three AES systems, PJM now has the ability to provide more than 100 MW of variation in less than one second, more than 100 times faster than traditional generation sources. These storage resources have been deployed at an installed cost lower than gas peakers and show a real-time response at least 100 times faster than conventional generators. In 2013 alone, these storage assets yielded more than $20 million in savings to PJM and its customers. By displacing regulation services provided by traditional peaker plants, AES’ energy storage systems are estimated to reduce greenhouse gas emissions by 62,000 tons of CO2 annually, the equivalent to removing 11,000 cars from the road.
service providers to procure 1.3 GW of energy storage by 2020. For instance, the utility Southern California Edison is moving forward with a total of 264 MW of storage systems. Among these projects is a 100 MW battery system being built in West Los Angeles by AES Energy Storage.

Energy storage coupled with PV also continues to gain momentum. A study by the Rocky Mountain Institute predicted that in 10 to 15 years, in many parts of the country, solar-plus-battery home systems will be the most economical choice for electric service. The U.S. solar market continues to boom. Installations of nearly 1.4 GW of PV were installed in the second quarter of 2015 alone, bringing the U.S. total installed capacity to 22.7 GW. This exponential takeoff of solar provides a template for the energy storage industry and is itself a major driver for the expansion of grid-connected storage. The expansion of the solar market has been driven by the plummeting price of solar panels and a clear revenue model, as well as the declining costs of solar installations. This lower cost has made solar far more competitive and has greatly expanded its markets. In turn, the larger market for solar power has continued to drive down prices through increased production and economies of scale; and the cycle continues. The same process has begun with energy storage.

For one example, look to lithium-ion batteries — the primary chemistry used in electric vehicles. Battery prices have been declining for two decades, but during the past ten years as demand has grown, lithium-ion prices have fallen more rapidly than even many optimistic projections. Since 2005, lithium-ion battery pack prices have fallen from $1,000-1,500/kWh to less than $500/kWh and are expected to fall below $300/kWh by 2020. This cost reduction has resulted in the availability of lower-cost lithium-ion batteries for grid storage use.

The evolution of prices for solar PV panels serves as a template for what might be expected to occur with batteries. Bloomberg Finance has presented this comparison. As the plot at the top right shows, with increasing volume, battery prices are dropping in very much the same manner as have solar panel prices.

The prices of both wind and solar power have fallen precipitously as installed volume has increased over time. The historical trajectories of both of these technologies are compared with lithium-ion battery pack prices on the following plot which shows how costs decrease with growing installed volume.

Lithium-ion technology has dominated electrochemical grid storage due to its versatility in handling both power and energy intensive tasks. However, there are other technologies for grid storage that may ultimately be lower-cost and longer lasting than lithium-ion. For example, many other battery chemistries including several types of flow batteries are beginning to take their place in grid-connected storage installations and additional non-chemical technologies such as flywheels, compressed air energy storage systems, and others may also capture a share of the market. Whatever the technology, a combination of the market pull of expanding renewables and the market push of lower prices will drive growth of grid-storage that is likely to mirror the experience of solar power.

With the REV initiative, New York is leading the charge in the transition to a more distributed electricity system in which storage will be an essential element.
New York is one of the fastest growing markets for energy storage due to a combination of its specific market needs and its progressive policies. The diverse membership of NY-BEST represents a substantial ecosystem for energy storage. Market drivers in New York City in particular include very high demand charges and the need for increased reliability and resilience in the face of events like Superstorm Sandy. According to Moody’s Investors Service, New York City represents the most promising economic market for peak-shaving because of its demand charges, followed by California, Hawaii and the remainder of the Northeast. With the REV initiative, New York is leading the charge in the transition to a more distributed electricity system in which storage will be an essential element. New York’s growing ecosystem in energy storage has the opportunity to deliver substantial statewide economic benefits that would be provided by a robust and diverse storage industry.
Energy storage has the potential to drastically change the electricity industry and, as is the case for every disruptive technology, one of energy storage's challenges in achieving widespread adoption is to prove itself to its skeptics. Potential investors and users of storage technology need to have confidence in its performance and in the revenue streams associated with it. This is why the growing number of use cases and demonstration programs are so important. Once stakeholders are convinced that storage can provide its benefits economically, reliably and at scale, there is little doubt that energy storage can become an enormous industry.

At present, the deployment of energy storage on the grid (apart from long-standing pumped hydro installations) is still on a relatively small scale. There are diverse technologies in use, with varying amounts of real-world penetration (see Appendix III: Storage Technology). To achieve widespread adoption, grid energy storage must be recognized by all stakeholders — including utilities, grid operators, policy makers, manufacturers, entrepreneurs, and customers in industrial, commercial and residential markets — as a viable, economically-attractive solution.

In order for the grid energy storage industry to achieve its potential as one that fundamentally changes the nature of the electricity system, a number of specific challenges must be overcome. However, there are still multiple DER benefits that are not recognized or monetized through these programs. These benefits may include services to the local distribution system (such as for upgrade deferment and voltage/VAR support) and in the revenue streams associated with it.

+ **The inability to participate in existing markets**

Regulatory and market rules frequently limit the ability of storage to receive compensation for the services and benefits it could provide. Most electricity markets are not structured to allow effective participation by energy storage and other small DERs. The result is that competitive power markets that encourage energy storage deployment are slow to emerge.

FERC Orders 752 relate to energy storage participating in regulated electricity markets. FERC Orders 1000 and 792 relate to storage projects receiving fair interconnection and transmission treatment as a grid resource. New York, some DERs are currently compensated in the ancillary services markets, and the electricity storage projects in regulated electricity markets are not structured to allow effective participation by energy storage. The result is that competitive power markets that encourage energy storage deployment are slow to emerge. When new regulatory mandates that address the valuation of specific energy storage services are introduced, markets develop. Several FERC Orders in recent years have led to effective compensation for energy storage and other small DERs.

However, there are still multiple DER benefits that are not recognized or monetized through these programs. These benefits may include services to the local distribution system (such as for upgrade deferment and voltage/VAR support) and in the revenue streams associated with it.
a number of environmental or other public policy benefits. Furthermore, regulations on participation by energy storage based on, for example, minimum capacity threshold can also present a serious obstacle to broader use of the technology.

+ **The inability to monetize the full value of storage**

Beyond challenges of individual market participation, perhaps the largest barrier to realizing the full value of storage is the inability to monetize multiple stacked services provided by a single storage installation. The same storage resource can be used to offset energy, capacity, transmission and distribution costs, but these services are planned on different timelines by different entities (e.g. utilities, ISO, and curtailment service providers, and consumers.) Their costs are recovered through different mechanisms (tariff, tags, contracts, market payments and incentives), FERC has previously disallowed combining these revenue streams for storage, and forcing storage to participate as four separate resources would burden developers even if it were possible.

+ **Customer confidence in performance and lifetime**

The wide array of different technologies and products, combined with many applications and use profiles, makes it difficult for customers and investors to assess and have confidence in product performance and lifetime.

+ **Lack of common financing vehicles**

The current ability of storage to engage capital and simplify project finances is low given the relatively low volume of existing projects. There is a lack of standardized and transparent processes, procedures and associated documentation that help investors reduce perceived risks and increase the likelihood of high rewards. The development of third-party financing, solar leasing, power purchase agreements, and other financial vehicles has played a huge role in the explosive growth of the PV industry. Loan guarantees, manufacturing incentives, investment tax credits, and tax exemptions have all helped to create an active financing market for solar power. Energy storage technology must develop a similarly robust financing market in order to achieve widespread commercial adoption.

+ **High soft costs**

Soft costs are those not associated with batteries, battery management systems, inverters and other hardware, but rather with a long list of items that include labor, real estate, acquisition, siting, legal, taxes and fees, management, accounting, permitting, inspection, transactional, interconnection, subsidy applications and system design costs. Solar energy has had to deal with the same problem over the past decade of escalating growth and has made great progress in labor and customer acquisition costs as well as in financing.

Potential investors and users of storage technology need to have confidence in its performance and in the revenue streams associated with it.
costs. Reducing as many of the soft costs as possible is essential for storage to achieve pricing that can drive a booming market.

+ **Insufficient information availability**
In order for storage to be widely deployed, there must be provider and end-use customer awareness of its capabilities and how those capabilities map on to their own system’s needs. Potential users of energy storage need to have information regarding system needs and capabilities by location. This information would facilitate the development of projects in areas where the need and presumably the payment for DER services such as storage would be the greatest. In addition, energy service companies and other third parties need customer account and usage information in order to better understand how storage can be deployed.

+ **Lack of standardized safety procedures and regulations**
As is the case for all equipment, installing and operating storage systems has safety considerations. Storage systems must obviously be engineered and validated to the highest level of safety possible. In addition, there must be established procedures and techniques for responding to emergency situations or system failures. Such procedures must include techniques to extinguish fires and respond to any non-fire incidents that may require fire department or other first responder interactions. This is complicated by the diversity of materials and technologies that may be present in energy storage systems. All of these practices and requirements must then find their way into codes, standards and regulations of all the entities responsible for permitting and regulation in the locations of systems. There has been some progress in establishing uniform standards for the industry. In 2014, for example, Underwriters Laboratories released UL 9540, which is a safety standard for energy storage systems. Ultimately, all of these safety regulations and procedures provide uniform guidance for the design, construction, testing and operation of energy storage systems. In New York City, for example, standardized permitting processes and codes for the Fire Department, City of New York (FDNY), are essential for the expanding deployment of energy storage in the City.

+ **Technology cost**
The high historical cost of batteries and energy storage devices sometimes creates the perception that the technology is not economically viable for commercial or industrial uses. However, battery prices have been declining rapidly. As shown in the previous section, lithium-ion battery prices have fallen by 50% since 2010, dropping an average 8-10% a year. There are significant ongoing development efforts on a broad range of battery technologies and many are making significant progress. NY-BEST members in particular are driving the development of a variety of technologies and new products to further reduce the cost of energy storage systems. Advancing technologies and growing market volume are continuing to lower battery prices, which will continue to improve the economic case for battery storage. Assessing the economic viability of energy storage is highly dependent upon the choice of value streams to analyze. In many cases, storage can perform multiple functions and, in principle, access multiple value streams and this is often not taken into account in analyses. Nevertheless, although the economic case for storage is already strong in many applications, further cost reductions will drive a dramatic expansion of storage markets.
There are well-known battery cost targets aimed at specific applications. For example, $125/kWh is nominally considered to be the target price for an electric vehicle’s battery pack in order for it to compete on a pure cost basis with an internal combustion engine. For grid storage applications, setting cost targets is more complicated due to the diversity of use cases for storage. From the utility perspective, the cost of storage technology might be compared to alternative investments of various types needed to meet certain power system requirements. For example, adding storage could be an alternative to increasing transmission capacity or adding a peaking generator, which are two very different investments. Unlike the case of electric vehicles, storage may not be replacing an existing system, but rather providing a new capability or a new way of improving system reliability. There are also externalities to consider in making cost comparisons such as environmental costs and benefits. Without an informed cost-benefits analysis, the notion that energy storage is too costly does not stand up to close scrutiny, but without increased customer awareness and education, the perception of the high cost of storage represents a continuing challenge for its adoption.

That being said, battery costs have been dropping precipitously over the past several years and there are multiple drivers that are lowering those costs further. For example, battery manufacturing is scaling up dramatically with facilities such as Tesla’s Gigafactory coming on line in the near term. With volume, manufacturers have a clear path to cost reductions. Further reductions in hardware and soft costs will only improve the value proposition for a broader range of storage applications.17

>> USE CASE:

ENERGY TIME SHIFTING/VOLTAGE SUPPORT/FREQUENCY REGULATION

General Electric

GE Power & Water has undertaken several utility-scale energy storage projects based upon lithium ion battery technology in systems incorporating GE controllers, transformers and inverters. The Con Edison Development project in Central Valley, California, is primarily aimed at solar energy time shifting and will supply 2 MW over a 4-hour period. This project represents GE’s first lithium-ion-based energy storage installation and includes the complete energy storage solution along with associated long-term service agreements. The Ontario ISO project is a partnership with Convergent Energy + Power, which is an energy storage asset development company that will be responsible for economic evaluation, contract and financial structuring, design, development and ongoing operations. The system will provide 7 MW for a 4-hour period and is designed to help the IESO to balance longer duration voltage and frequency irregularities in its service area. Although the system is primarily engineered to provide ancillary services, it will also offer energy related services such as peak shaving and load shifting.

The third and largest project will provide Coachella Energy Storage Partners (CESP) with a 30 MW, 20 MWh storage solution designed to aid grid flexibility and increased reliability on the Imperial Irrigation District grid, located 100 miles east of San Diego. It will be one of the largest battery storage plants in the western United States and will be operated by ZGlobal, a local engineering firm. The system will provide solar ramping, frequency regulation, power balancing and black start capability for an adjacent gas turbine.
As discussed earlier, there are three primary driving forces for using energy storage in the electrical system:

- Improving efficiency and capacity factor of the grid
- Integration of renewables into the grid via flexibility
- Enhancing reliability and resilience of the grid

These three topics describe the dominant needs of today’s grid. Energy storage provides ways to address all of them in every segment of the electricity system. It can deliver value in multiple ways and often can provide it in several ways at the same time.

The table shown lists the primary applications of storage across the three major segments of the grid — behind the meter, the distribution system, and the generation and transmission system — categorizing them according to which major driver they address. These applications are described in detail in Appendix II. The beneficiary of the storage does not necessarily dictate the physical location of the storage. While it is the case that the services specifically identified as behind-the-meter cannot be provided by centrally located storage, all of the benefits outlined here include those aimed at the distribution or transmission systems can, in principle, be derived from storage located behind the meter. For this reason, many have contended that behind-the-meter storage carries the greatest value.

<table>
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<tr>
<th>DRIVERS</th>
<th>CUSTOMER-SITED (BEHIND THE METER)</th>
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| Capacity and Peak Load Reduction | + Demand charge reduction (peak shaving)  
|                           | + Avoiding interconnection upgrades                     
|                           | + Permanent load shifting                                |
| Renewables Integration   | + Integrating distributed generation                     
|                           | + Microgrid stability                                    
|                           | + Optimizing energy cost (Time shifting)                 |
| Resilience and Reliability | + Uninterruptible Power Supply                            
|                           | + Maintaining power quality                              
|                           | + Microgrid stability                                    
|                           | + Building emergency power                               |
CALMAC Manufacturing utilizes thermal energy storage to reduce the electrical capacity needed for building cooling. Its IceBank® technology uses standard cooling equipment in a building plus an ice storage tank to shift all or a portion of a building’s electrical demand for cooling needs to off-peak, nighttime hours. During the day, the ice provides cooling alongside of or instead of the air conditioning compressor. CALMAC has installed over 4,000 systems worldwide, including more than a dozen buildings in New York City.

The installation at Jefferson Community College in Watertown, New York, provides a compelling example of the value of the technology. The McVean Center on campus had insufficient cooling capability, being short some 50 tons of cooling capacity and the building did not have the additional electrical capacity required on site to add it. A costly substation upgrade would have been necessary to provide the necessary power. Instead, the college installed a 90-ton Trane air-cooled chiller and four CALMAC IceBank modules. The chiller makes ice at night using off-peak power and then both the chiller and the IceBanks operate during the day. The net result is lower operating costs that avoid demand charges and effective cooling for the building without requiring additional electrical capacity. The system saves the college approximately $15,000 a year in operating costs.

Thermal storage provides congestion relief to the grid by targeting a major source of peak demand: afternoon air conditioning. Such an approach yields a higher load factor on the grid and thereby reduces the need for additional T&D infrastructure. Ice storage is a thermal technology but effectively, it is like a battery for a building’s air conditioning system.
This Roadmap focuses on the role of energy storage in the future of New York’s energy system. Overall, New York has already adopted an aggressive and comprehensive set of energy and environmental goals as part of the 2015 New York State Energy Plan, which provides a comprehensive roadmap for a clean, resilient and affordable energy system for the state. The plan has set clean energy goals for 2030 to achieve a 40 percent reduction in greenhouse gas emissions from 1990 levels, generate 50 percent of the state’s electricity from renewable energy sources, and decrease energy consumption in buildings by 23 percent from 2012 levels.

In addition, in 2009, New York’s Executive Order No. 24 established a goal to reduce greenhouse gas emissions by 80 percent compared with 1990 levels by the year 2050. This goal is also included in the State Energy Plan. The “80x50” goal can only be achieved by a dramatic transition away from fossil fuels for all major energy uses. As far as the grid is concerned, a nearly complete conversion to renewable sources will be required. New York has the advantage that 19 percent of its generation comes from clean hydroelectric power. However, it is clear that solar and wind power will have to comprise a major part of the future generation mix, necessitating the greater use of energy storage.

The REV process is at the center of this plan but in concert with REV, there are multiple initiatives underway or planned to help achieve the plan’s goals. Energy storage has important roles to play across many of these objectives, as described in more detail below:

The Clean Energy Fund, as proposed by NYSERDA, is a 10-year, $5 billion initiative to support clean energy market development and innovation. It includes specific programs such as NY-Sun and the NY Green Bank as well as a broad range of innovation, research and market development activities. The primary goals are to foster efforts to reduce greenhouse gases, make energy more affordable, and accelerate the growth of New York’s clean energy economy. This initiative can provide substantial support for the development of energy storage technology and deployment in New York.

The $1 billion NY-Sun initiative is significantly expanding the deployment of solar power across the state with the goal of adding more than 3 GW of renewable capacity and to create a self-sustaining solar industry in the state. As this distributed solar generation enters the grid, integrated energy storage will become increasingly important to manage the widening wedge between daytime energy consumption and evening peak consumption in many parts of the state and avoid either curtailment of generation or rapid ramping of alternative resources. Storage can increase the overall value delivered by solar power to the electricity system. The NY-Sun MW Block program offers an additional incentive for the installation of solar systems larger than 200 kW that integrate storage.
The NY Green Bank (NYGB) is a State-sponsored, specialized financial entity working in partnership with the private sector to increase investments into New York’s clean energy markets. Eventually, it will have a $1 billion pool of capital to lend. The Green Bank partners with private sector clients to address and alleviate specific gaps and barriers in current clean energy capital markets through a variety of approaches and transaction structures. As of June 2015, proposals requesting over $734 million of NYGB capital have been received, in connection with total proposed clean energy investments in New York State of an estimated $3 billion (including private sector capital).19

The $40 million NY Prize microgrid competition seeks to reduce energy costs and promote clean energy reliability and resilience in communities across the state. Stage 1 of the program has funded 83 feasibility studies across the state. The proposed projects involve the use of a variety of DERs ranging from natural gas generators to anaerobic digesters to solar installations. Some involve the use of combined heat and power, demand management, or fuel cell technology. The majority of the projects incorporate the use of energy storage, which can provide resilience and many other benefits. Approximately ten of the Stage 1 projects will be funded to complete detailed designs.

In 2014, the Public Service Commission approved Con Edison’s “Brooklyn Queens Demand Management” program designed to offset the need to build a $1 billion substation to serve the neighborhood. The strategy is to encourage the deployment of local energy resources that offer customers more choice and control over energy use in their communities. The ultimate solution is likely to involve more efficient lighting, air conditioning and appliances, battery-based energy storage, distributed generation like solar where feasible, and the introduction of microgrids into the system.

Each of the major utilities in the state were required by PSC to propose at least one REV demonstration project in 2015. All of the utilities complied and notably, Consolidated Edison proposed a Clean Virtual Power Plant as one of its demonstrations projects. This REV demonstration project is designed to demonstrate how aggregated fleets of solar plus storage assets in hundreds of homes can collectively provide network benefits to the grid, resilience services to customers, and monetization value to Consolidated Edison.

There are many other State initiatives working in concert with the REV initiative, all of which are embracing emerging energy technologies, which in many cases, may include energy storage.
New York has established aggressive goals for reducing greenhouse gas emissions and adopting renewable energy sources. With the REV initiative, the State has provided a path towards the restructuring of its energy system. The success of all these endeavors will be greatly enhanced and quite likely enabled by the widespread adoption of energy storage technologies on the grid.

In the 2012 New York Energy Storage Roadmap, we set a ten-year goal of having 1 GW of storage on the grid. That goal for 2022 is still valid, but the dramatic changes in the energy system that are currently underway and accelerating justify even more ambitious goals going forward.

**TO THAT END, NEW YORK SHOULD ESTABLISH THE GOAL OF HAVING**

| 2 GW of storage capacity on the grid by 2025 |
| **AND** |
| 4 GW of storage capacity on the grid by 2030* |

* Above and beyond the existing pumped hydro capacity and with multi-hour duration
Having multi-hour storage resources of this capacity in the state’s energy system will make significant contributions to the three overarching needs of the electricity system and reduce the net costs to the grid and to end-use customers:

1. Improving efficiency and capacity factor of the grid
2. Integration of renewables into the grid
3. Enhancing reliability and resilience of the grid via flexibility

New York’s goal of reducing total greenhouse gas emissions by 80% by 2050 implies that the electricity sector will have to eliminate essentially all of its emissions in that timeframe. A number of studies have looked at how large amounts of intermittent renewables can be incorporated into the grid and they conclude that substantial amounts of storage will be required. In its Renewable Electricity Futures Study, NREL in 2012 looked at a variety of scenarios for the adoption of 80% renewable electricity sources nationwide by the year 2050. Under these various scenarios, the study concluded that a total deployment of energy storage between 100 and 152 GW would be required. It also concluded that the bulk of these deployments would need to take place much sooner than 2050 in order to support the expansion of renewables. According to its analysis, New York would need to deploy about 2.5 GW by 2025 and 3.2 GW by 2030 for this purpose alone. The NREL study underweighted the contributions of battery technology because it did not anticipate the rapid pace of battery cost reductions that have occurred in the past few years. The economics of battery storage are substantially better than the assumptions of the study. The study also did not reflect the changing nature of New York’s energy mix, overemphasizing biomass energy over solar power. In addition, it did not address the impact of storage in dealing with constraints on the distribution system, such as the limited hosting capacity of distribution circuits.

The Union of Concerned Scientists study Achieving 50 Percent Renewable Electricity in California, released in August 2015, looked at the issue of preventing the curtailment of renewable generation by the use of non-generation strategies including energy storage. The study concluded that an additional 6-9 GW of non-generation flexibility in California was required to eliminate curtailment and avoid the use of fossil fuel generation sources to provide flexibility. The UCS study included natural gas plants as an important part of the approach for providing flexibility to renewables, but that strategy flies in the face of emission reduction goals.

It is also important to note that the goal of having 4 GW of storage capacity in the state in 2030 supports multiple needs of the energy system beyond the need for flexibility for renewable resources. The storage capacity goals we are setting for energy storage deployment in New York are commensurate with the State’s overall energy goals.
Approximately 14% of the state’s peak load is associated with just the top 100 peak load hours, corresponding to 4.8 GW of capacity and 195 GWh of energy. Meeting the needs of these 100 hours costs billions of dollars and results in a diminished system utilization factor.

This peak load could be completely flattened by a combination of energy storage, demand response and efficiency measures. The 2022 goal of 1 GW of storage with two-hour duration (2 GWh), for example, would be able to eliminate over thirty of the top hundred hours. Further, having 2 GW of storage capacity with 5 hours (10 GWh) would eliminate well over a third of the total energy (in GWh) required during the 100 peak hours, leaving about two thirds to be addressed by improvements in efficiency and demand response.

However, unlike conventional peaker plants that sit idle when not in use, these storage assets could be used to perform many other functions during the vast majority of the time when they were not engaged in addressing the peak demand problem.

To understand this better, in 2013, the top 100 hours of peak demand occurred over the course of 13 days. During that year, only the first 500 MW of storage would have been utilized during all 13 days. The next 500 MW would only have been needed for 9 of the days. The final 1 GW of storage would only have been employed for 6 of the days.

This storage capability would help eliminate the “100-hour problem,” would increase the system load factor, and greatly reduce the need to operate peaker plants, allowing many to be retired from service and eliminating the need to build new ones.
Having 2 GW of storage distributed throughout the grid can enhance reliability and resilience by first of all providing backup power for emergency situations. Storage that has a different primary purpose — for example, firming or time-shifting the output of renewable generation sources — is nonetheless well suited for providing resilience to critical sites when needed. Storage can provide the capability to power critical facilities (or entire critical areas) for potentially extensive periods of time. The actual duration would depend on how much load a particular storage system is serving. For example, a 1 MWh system located near a building that demands 50 kW of critical load could power that facility for 20 consecutive hours. In general, behind-the-meter storage is well-suited to providing backup power to critical circuits in buildings. Typically, these circuits constitute 10-20% of the total building load. Thus 2 GW of storage distributed across New York’s grid whose typical load is 18 GW can provide critical circuit support for a substantial portion of the system. If storage is paired with solar PV or other renewables, there is the potential at least under some circumstances to power critical loads indefinitely without grid support. Such a capability would be extremely valuable in a situation like what occurred in New York City in the aftermath of Superstorm Sandy, assuming cooperative weather conditions (i.e. sunshine). More generally, storage distributed throughout the grid can supply a variety of ancillary services when needed.
The State goal of having 50% of generation from renewables by 2030 implies that nearly 30% will likely come from solar and wind (~20% of the state’s generation is from hydro-electric power and several percent from bioenergy). According to NYISO projections, as well as the 2015 New York State Energy Plan, average demand in the state is likely to remain on the order of 20 GW and total electricity usage will be about 185,000 GWh. According to the State Energy Plan, the potential contributions for hydropower and bioenergy are 20% and 3%, respectively. The remaining 27% of renewable energy to meet the renewable generation goal could be achieved, for example, by a combination of 13.5% solar power and 13.5% wind power. With a capacity factor of 17%, producing that amount of energy from PV will require 17 GW of installed capacity. With a capacity factor of 35%, 8 GW of wind power capacity will be needed. In total, therefore, meeting the 50% renewable goals will require 25 GW of intermittent renewables in the state. Storage will be critical to provide flexibility for these resources. Based on industry use cases, storage used for firming renewables and providing flexibility typically provides 10-20% of the associated generation capacity. Thus 25 GW of intermittent renewables on New York’s grid would need 2.5-5 GW of storage to back it up. As mentioned, the NREL study identified the need for 3.2 GW of storage in New York by 2030, and did not take into account significant factors like distribution system constraints such as the limitations of the hosting capacity of the state’s distribution circuits. The rapid proliferation of residential PV in downstate suburban communities is already highlighting this problem. As another example, Agora Energiewende, a think tank funded by the European Climate Foundation and the Stiftung Mercator, believes that Germany can quadruple its current solar capacity up to 150 GW by
complementing it with 40 GW of battery storage.\textsuperscript{24} This represents over 25% of the generation capacity.

Flexibility is the capability of the system to accommodate variability and uncertainty. A recent study by the Lawrence Berkeley National Laboratory assessed the importance of having a sufficient flexibility supply in the presence of increasing amounts of variable renewable generation on the grid.\textsuperscript{25} Bulk energy storage is particularly well-suited to providing flexibility because it can provide its full nameplate capacity bi-directionally: it can both provide needed power and absorb excess power on short notice. This capability is important for eliminating the impact of short-term fluctuations in renewable output. Having storage on the grid will greatly decrease the need to turn to gas-fired generation plants to meet any short-term demand and eliminating the use of these plants is an essential part of achieving the State’s emissions goals.

Of at least equal importance is the ability to time-shift renewable energy in order to match the demand profile. This is an important consideration because a major fraction of the state’s electricity demand is in the greater New York City area. That is also where a large amount of behind-the-meter solar generation capability is being installed, for the most part in the outer boroughs. The load curve in those areas does not match up well with the generation profile, which peaks in the afternoon. People tend to work in Manhattan, so that peak demand there occurs during the afternoon. In the suburbs, peak demand occurs in the evening, when people have returned from work. Thus there is significant value in time-shifting the output of suburban solar generation by roughly four to six hours. Substantial storage resources in this region can provide this capability. In general, the ability to time-shift the output of both solar and wind generation sources using storage greatly enhances the value of those sources to the grid.

The capacity goal presented here is derived from the analysis of existing studies and extrapolations from small-scale use cases. The actual amount of storage needed in New York in the presence of high renewables penetration is very much dependent upon the detailed energy mix in the state and the changing intricacies of the grid infrastructure. For this reason, we are recommending a detailed study in the near term to quantify this need with greater clarity.
Given the added cost and delays that site-specific review imposes on storage projects, the next updates to both the fire code and building code for New York State, and particularly downstate municipalities, should include appropriate language to fully address siting for common battery types used for energy management in buildings and facilities.

The current New York City fire code does not address the use of stationary battery systems for energy management activities in buildings — though it does address the use of five types of batteries (non-recombinent, recombinent (vented and sealed lead acid, primarily), nickel cadmium, lithium ion and lithium metal polymer) used for “facility standby power, emergency power or uninterrupted power supplies”.

Because energy management is not a prescribed use in the current code, all stationary battery systems must be submitted for approval to the FDNY and to New York City Department of Buildings Office of Technology Certification and Research (OTCR). At present, every installation must apply on a site-by-site basis. This process adds significant delay and expense in attempts to site stationary storage projects — typically requiring multiple meetings, information exchanges, in-person discussions over a period of months that can exceed a year.

Regulations on participation by energy storage based on minimum capacity threshold can present a serious obstacle to broader use of the technology. The capacity threshold for resources to participate in the PJM frequency regulation market is 100 kilowatts; on the other hand, NYISO and ISO-NE require 1 megawatt systems. New York’s grid operators should lower the minimum for participation in wholesale markets to 100 kW. Behind-the-meter assets should be able to participate directly or in aggregate form. The threshold for participation at the distribution level should be much lower, for example, 10 kW.

NYISO should assemble a team to identify and consider where distributed storage can perform critical ancillary services and capacity functions to benefit the transmission system.
Current day-ahead pricing in New York’s electricity markets is based on Locational Based Marginal Prices (LBMP), which are assessed to a series of zones across the state. By collecting circuit-by-circuit distribution data across the state on a much finer scale, it will be possible to send price signals that will establish the locational value of DER like storage and stimulate the growth of storage markets. In general, DERs require the local distribution system to “host” them. The amount of distributed generation that can be interconnected to a distribution system without causing problems such as excessive reverse power flow, incorrect operation of control equipment, and malfunctioning of protective equipment is that system’s hosting capacity. Assessing the hosting capacity of the state’s distribution circuits is also an important activity.

The storage industry should set the goal of reducing soft costs by 33% by the year 2020. Soft costs can account for as much as two-thirds of the total installed cost of storage systems. Many of these costs are driven by the geographic location where storage is deployed and can only be addressed locally. Furthermore, with hardware costs dropping by 8-10% a year, the impact of soft costs has been growing. The experience of the solar power industry again provides a template for progress. The Department of Energy’s SunShot program has the goal of making solar energy cost-competitive with other forms of energy. An important part of that program is the effort to lower soft costs. The key elements of that effort are reducing non-hardware costs, lowering barriers, and fostering industry growth. Non-hardware costs include customer acquisition, permitting and inspection, metering and verification, and financing and contracting costs. Barriers that stand in the way of lowered cost include unfavorable policies and regulations as well as insufficient access to capital. Typical of all high-tech industries, industry growth and market maturity are major drivers for lowering costs. As has been the case for the solar industry, efforts in all of these areas will pave the way to lower soft costs for energy storage.
In order to achieve the goal of having 2 GW of storage on the New York grid by 2025 and 4 GW by 2030, the barriers enumerated earlier in this Roadmap must be overcome. Reducing or eliminating these barriers will require a number of specific actions and accomplishments.
**MONETIZING THE VALUE OF STORAGE**

The current electric power industry structure divides markets into generation, transmission, and distribution categories. Since storage can support all of these functions, it is challenging to classify storage from a regulatory standpoint and assess its value in comparison to traditional infrastructure. The pricing mechanism of storage also depends on its classification. Without an accurate pricing mechanism and long-term contracts, it is difficult to ensure stakeholders that they will be compensated for the various benefits energy storage provides to the grid. This compensation is necessary for stakeholders to receive a return on their investment and investors need to see a clear revenue stream. Short-term bridge incentives can help provide longer-term revenue certainty for investors as tariff design evolves.

**Regulatory recommendations**

Current regulatory policies and market rules do not capture the benefits and full value of energy storage. Under REV, New York is establishing a national model for a modern distributed electric system. The following regulatory changes are recommended:

- Allow smaller behind-the-meter resources to participate in wholesale markets, and reduce the threshold for participation.
- Modify NYISO tariff definitions to allow front-of-the-meter storage to simultaneously qualify as Energy Limited Resources (ELR) and Limited Energy Storage Resources (LESR).
- Create or modify markets for ancillary services and demand response programs to enable energy storage customers to offer those services, either individually, or in the aggregate.
- Allow storage to provide and be compensated for multiple services to both retail and wholesale markets in a straightforward fashion.
- Require utilities to evaluate storage as an alternative when planning capital investments.

- Include societal benefits in cost-benefits analyses of grid infrastructure investments.
- Update interconnection standards to ensure that energy storage systems have fair and efficient access to the electrical grid and create an expedited approval process for systems not intended to export power.
- Create rate structures that send economic signals to energy storage customers to encourage them to operate their system in a manner that benefits both the electric grid as well as the customer.
- Fully value the locational and temporal aspects of storage.

**COMMON FINANCING VEHICLES**

The rapid growth of the PV industry has benefitted enormously from the availability of financing vehicles. That industry now makes use of power purchase agreements (PPAs), master limited partnerships, asset-backed securities, community solar projects, solar bonds, and PACE financing, among other mechanisms. In principle, all of these financing vehicles can be applied to the storage industry. To facilitate this, the industry needs to establish the value of storage in enough revenue streams to provide performance and revenue certainty and reduce the perceived risk associated with storage installations.

**REDUCTION OF INSTALLED COSTS**

Energy storage technology cost continues to decline. For example, lithium-ion battery costs have dropped dramatically in recent years and are widely expected to drop another 50% over the next five years. However, reducing hardware cost alone will not adequately reduce installed system cost. The U.S. Department of Energy estimates that up to two-thirds of installed electrochemical storage cost is driven by elements other than the battery cells such as power electronics, special metering and interconnection requirements, thermal management, and integration costs. To achieve the installed storage goals set in this roadmap, installed costs must come down rapidly as well as the soft costs discussed earlier that
will be lowered through improvements in permitting, customer acquisition, financing, and increased cooperation between industry and the utilities.

RENEWABLE SUPPORT STUDY
New York has established aggressive goals for the deployment of renewable energy. There is the explicit goal of getting 50% of the State’s electricity from renewables by 2030, and the overall goal of reducing greenhouse gas emissions from all energy use by 80% by 2050, which implies nearly 100% electricity generation from zero-emission sources. Given these goals, it is important to assess how much storage and other options would be needed to firm up and time shift energy from these renewable sources and where the storage would have to be sited. It would be very valuable to make this assessment in advance of the further proliferation of renewables and utilize the findings of Integrated Resource Planning (IRP) processes.

INCREASED INFORMATION AVAILABILITY
The industry needs to work with utilities to develop analytics and data mechanisms for storage. Standardized protocols for control systems, communication with the grid, and software/control systems with the ability to direct storage towards required function (switching between user and grid for behind-the-meter, other transitions.)

Utilities need incentives to collect and share data with third parties such as providers of DER. New York utilities have not widely deployed smart meters, which can provide important data at the customer-grid interface. Utilities need to collect circuit-by-circuit distribution data and detailed hosting capacity analysis in order for the locational value of DER like storage to be determined. Distribution system planning and management would then be able to fully take advantage of the benefits of energy storage when deployed with other distributed energy resources.

SAFETY REGULATIONS
It is essential that the storage industry establish standard test methodologies and safety requirements. The BEST Test and Commercialization Center in Rochester will serve in a lead role in this process. The Center will be developing and performing safety tests in conjunction with NYSERDA and Con Edison. These standards are necessary in order for FDNY and other authorities having jurisdiction to adopt codes and regulations for storage that can facilitate continued progress. In general, the industry needs to coordinate the oversight of energy storage systems with all relevant governmental authorities to ensure safety without imposing duplicative or conflicting regulatory requirements and to establish permitting processes that do not impair the efficient proliferation of the technology.

BRIDGE INCENTIVES
The electricity grid under the REV initiative will lead to numerous opportunities for DER in general and specifically for energy storage. Monetization of all of storage’s services, a more favorable regulatory environment, and the proliferation of system information will all lead to a robust market for energy storage. REV demonstrations are already driving many near-term projects for the industry. However, even when the restructuring of the grid under REV is fully enacted, it will take some time for all of its features to be implemented and new tariff design to take effect. There may well be a quiet period before the new ways of doing business are fully realized.

In the meantime, the market for storage will continue to face uncertainties. The availability of capital will continue to be limited. Energy storage costs, while coming down steadily, will not yet have reaped the benefits of high volume and may present a barrier to many projects.

Because of all of these factors, there continues to be the need for incentives to provide a bridge to offer revenue certainty to customers and investors as tariff design evolves,
drive market demand, and to enable this sector to grow today. NYSERDA and Con Edison’s Demand Management Program in support of Con Edison customers — which provides incentives for both thermal storage and battery storage projects — is an example of the State providing incentives to drive the expansion of the storage industry. However, that program is scheduled to expire in June 2016.

While select applications are cost-effective today, in order to realize the broader benefits of distributed storage on the grid, the State should implement a declining bridge incentive that monetizes value provided to the electric system from non-utility owned energy storage systems. Such a bridge incentive should target constrained areas of the distribution system, especially those where PV interconnection can be eased, and validate non-wires alternatives to utility asset purchases. The proposed bridge incentive could require utilities to procure customer-sited storage to relieve distribution system constraints using a declining bridge mechanism that is reduced as MW are installed and tariffs are adopted. Such a mechanism would provide longterm revenue confidence to investors removing a barrier that is preventing private sector capital from deployment in this space. With a combination of battery hardware costs continuing to decline by 8-10% per year, meeting the soft cost reduction goal of 33% in 4 years, and new tariff design and regulations forthcoming under REV, a bridge incentive could be reduced annually and eliminated entirely in as little as five years.

GROWTH OF NEW YORK ENERGY STORAGE ECOSYSTEM

New York is home to companies involved in every aspect of energy storage. These include manufacturers of devices that store electric energy directly such as batteries and ultra-capacitors, components of these technologies, and systems or products that incorporate these technologies throughout the value chain. With NY-BEST, the state has an industry-led coalition whose mission is to catalyze and grow the energy storage industry and establish New York State as a global leader in energy storage. New York has established important resources including the BEST Test & Commercialization Center, advanced diagnostic capabilities at Brookhaven National Laboratory, the RIT Battery Prototyping Center, and the state hosts a broad array of research institutions and companies that are advancing energy storage technology. NY-BEST comprises over 150 entities including large and small companies as well as research institutions and has served to connect them together to form a growing ecosystem in the state.

Collectively, the storage sector in New York State employs over 3,000 and is poised for rapid growth during the next decade. Several immediate actions can harness this opportunity. First, New York State should continue supporting energy storage technology and product development to transfer the most promising ideas into New York State products. NY-BEST should continue to play a key role linking startups and established OEMs for early product testing. New York State economic development efforts should attract major battery developers, including those working to integrate PV and storage systems, thereby leveraging the State’s investments in the solar industry and existing manufacturing assets. New York’s distribution utilities are also poised to lead the nation in developing standard requirements for storage safety, performance and interoperability on the grid. Looking ahead, NY-BEST seeks to work with industry and other partners to continue to promote collaboration within the state’s ecosystem, and provide additional commercialization resources to support business growth. These actions will grow the storage ecosystem and maximize the economic and societal benefits of energy storage in New York State.
SUMMARY

As this Roadmap illustrates, energy storage is a key enabling technology to achieve the goals of a cleaner, more efficient, cost-effective, reliable and resilient electric grid. The global energy storage industry is experiencing rapid growth and is projected to grow exponentially in the next 10-15 years. By addressing the barriers to energy storage’s wide-scale adoption and accepting the recommendations contained in this Roadmap, New York State will secure its place as a leader in energy storage, realize the economic benefits of this growing industry and truly transform the state’s electric grid.

Since its inception in 2010, the New York Battery and Energy Storage Technology Consortium (NY-BEST) has been working to catalyze and grow the energy storage industry in New York State and establish New York as a global leader in energy storage. Our work is focused on the following four primary activities:

- Acting as an authoritative resource on energy storage, proactively communicating energy storage related news and information, and facilitating connections amongst stakeholders;
- Advancing and accelerating the commercialization process for energy storage technologies, from research and development, to products and widespread deployment;
- Educating policymakers and stakeholders about energy storage and advocating on behalf of the energy storage industry; and
- Promoting New York’s world-class intellectual and manufacturing capabilities and providing access to markets to grow the energy storage industry in New York.

New York’s commitment to energy storage includes a $23 million public-private investment that created the BEST Test & Commercialization Center (BEST T&CC). Located in Rochester, New York, it is the result of a collaboration between DNV GL and NY-BEST, with financial support from New York State. The Center’s unique capabilities help bring emerging technologies to the commercial market and offer companies essential product testing and qualification at a reasonable cost. The facility allows testing of the complete range of battery and energy storage technologies: from single cells to complete systems with cycle capacities up to 240 kW.

NY-BEST will continue to work with our members and partners in industry, academia, government, and the non-profit sector, as well as with other interested stakeholders and the public, to achieve our mission and to implement the recommendations of this Roadmap. We invite interested organizations and individuals to join us in growing a successful and thriving energy storage industry in New York State.
Above and beyond existing pumped hydro storage capacity.

In stating a numerical goal for installed energy storage device capacity, one needs to consider both power (GW) and energy (GWh). The roadmap goals are stated in GW, based on the assumption that in order to be installed, storage devices must be capable of delivering the right amount of power for the intended/required duration needed to serve particular applications. Due to the variability of the requirements across applications, stating a goal in terms of power is most appropriate.

STAFF PROPOSAL — DISTRIBUTED SYSTEM IMPLEMENTATION PLAN GUIDANCE. Proceedings on Motion of the Commission in Regard to Reforming the Energy Vision, Oct 2015

http://energyplan.ny.gov

http://www.eei.org/issuesandpolicy/distribution/Pages/default.aspx; http://www.eei.org/issuesandpolicy/transmission/Pages/default.aspx


Diagram based on the NYSERDA presentation, Clean Energy Fund Forum, January 14, 2015


http://about.brief.com/research-notes-sp/

http://tinyurl.com/psfu7uz

https://www.greentechmedia.com/articles/read/breaking-sce-announces-winners-of-energy-storage-contracts

http://www.rmi.org/electricity_load_defection

Bloomberg New Energy Finance Summit, New York, April, 2015

Courtesy General Electric with source material from EIA, IEA, NREL, GWEC EPA, BNEF, Lux Research, Navigant Research, HIS CERA, and GE Analysis.

https://www.moodys.com/research/Moodys-Declining-battery-prices-could-lead-to-commercial-and-industrial--PR_335274


http://www.dec.ny.gov/energy/71394.html


http://www.nrel.gov/analysis/re_futures/data_viewer/


http://www.agora-energiewende.de/en/topics/-agotherm-/Produkt/produkt/231/Get+Ready+for+150+Gigawatts+of+Solar+Cwww/capacity+and+40+Gigawatts+of+Storage+In+Germany

http://www.lbnl.gov/sites/all/files/lbnl-1003750_0.pdf

PHOTO CREDITS

Pg 3 (right): Rockefeller Center ice storage installation, courtesy of CALMAC

Pg 8: New York from space, NASA photo

Pg 9: Maple Ridge wind farm, courtesy of Iberdrola Renewables

Pg 12: NYC rooftop storage, courtesy of Green Charge Networks

Pg 18: PEM energy storage installation, courtesy of Hydrogenics

Pg 20: Blenheim-Gilboa pumped storage facility, courtesy of NYPA

Pg 21: Flywheel installation, courtesy of Beacon Power

Pg 22: Laurel Mountain energy storage installation, courtesy of AES Energy Storage

Pg 24: Manhattan skyline, courtesy of General Electric

Pg 25: BEST Test & Commercialization Center, NY-BEST

Pg 28: Energy storage installation, courtesy of UniEnergy Technologies

Pg 32: Long Island solar farm, courtesy of Brookhaven National Laboratory
The New York Battery and Energy Storage Technology Consortium (NY-BEST™) is a rapidly growing, industry-led, private-public coalition of corporate, entrepreneurial, academic, and government partners whose goal is to catalyze and grow the energy storage industry and establish New York State as a global leader. NY-BEST acts as an authoritative resource on energy storage; advances and accelerates the commercialization of energy storage technologies; educates policymakers and advocates on behalf of the energy storage industry; promotes New York’s world-class intellectual and manufacturing capabilities; and provides access to markets to grow the energy storage industry in New York. NY-BEST was created in 2010 with seed funding from NYSERDA. Its diverse membership includes Fortune 500 companies, start-ups, universities, national research centers and laboratories spanning all facets of the energy sector.