NYSOLAR SMART DG Hub

New York City Resilient Solar Roadmap

March 2017

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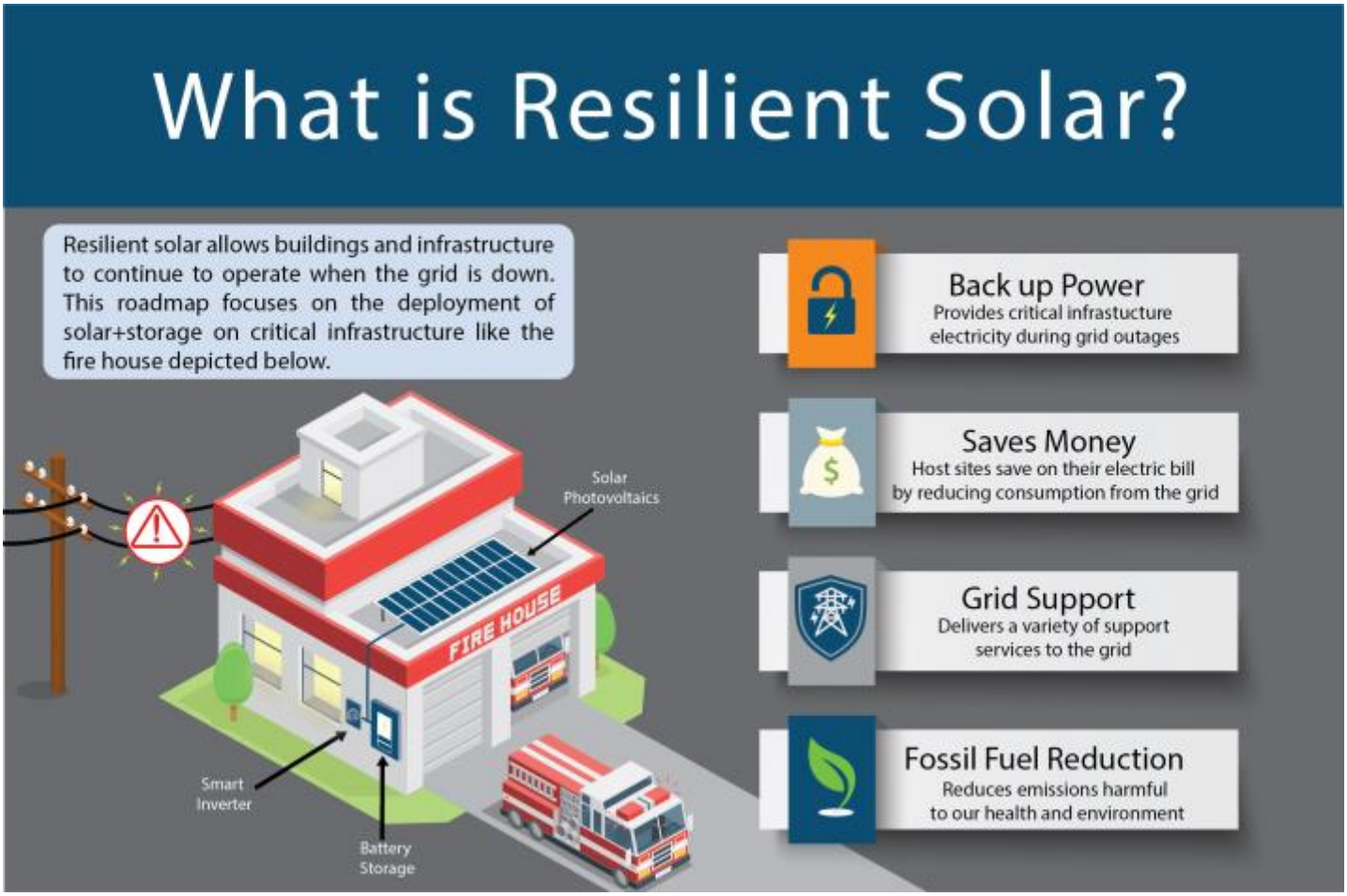
Executive Summary

Events such as Hurricane Sandy and Katrina have revealed the vulnerability of the U.S. electric grid even as Americans have increasingly become dependent on electricity for their work, entertainment and livelihoods. It is clear that 21st century needs must include next generation energy infrastructure such as distributed generation (DG). Pairing storage with renewable resources like solar can add increased reliability, local control and resilience for consumers, as well as for utility and emergency planners.

Nationwide, storage is expected to grow to 11.3 GW of installed capacity by 2020, and attract billions in investment. In Q1-Q3 of 2016, energy storage attracted $812 million in venture capital and project finance.[1] Batteries are an increasingly popular storage technology which can provide backup power (resiliency) when paired with solar or other DG, offering sustainable options for critical infrastructure. In addition, storage can play a critical energy-saving role in peak shaving and load shifting when the grid is constrained or when consumers are anticipating heavy energy usage, delivering grid benefits, and furthering economic development. However, this technology needs a pathway through regulatory, policy and financial hurdles, some of which are unique to urban environments.



[1] Munsell, Mike. *Corporate Investments in Energy Storage Reach $660 Million in Q3 2016.* https://www.greentechmedia.com/articles/read/corporate-investments-in-energy-storage-at-660-million-in-q3-2016

Sustainable CUNY of the City University of New York (CUNY) formed the NYSolar Smart DG Hub in order to develop the solutions to market barriers and create a Resilient Solar Roadmap for New York City (NYC) that can be emulated across the state. The DG Hub seeks to increase the deployment of resilient solar installations, which can operate during power outages and provide critical and grid support services to New York City. These resilient solar installations can include pairing solar with other distributed generation, an inverter-based emergency plug or energy storage. Although various forms of onsite generation can make a facility resilient, this roadmap focuses specifically on the application of solar and battery storage. Solar and battery storage is the focus of a series of research projects in cities across the country funded by the U.S. Department of Energy SunShot Initiative.

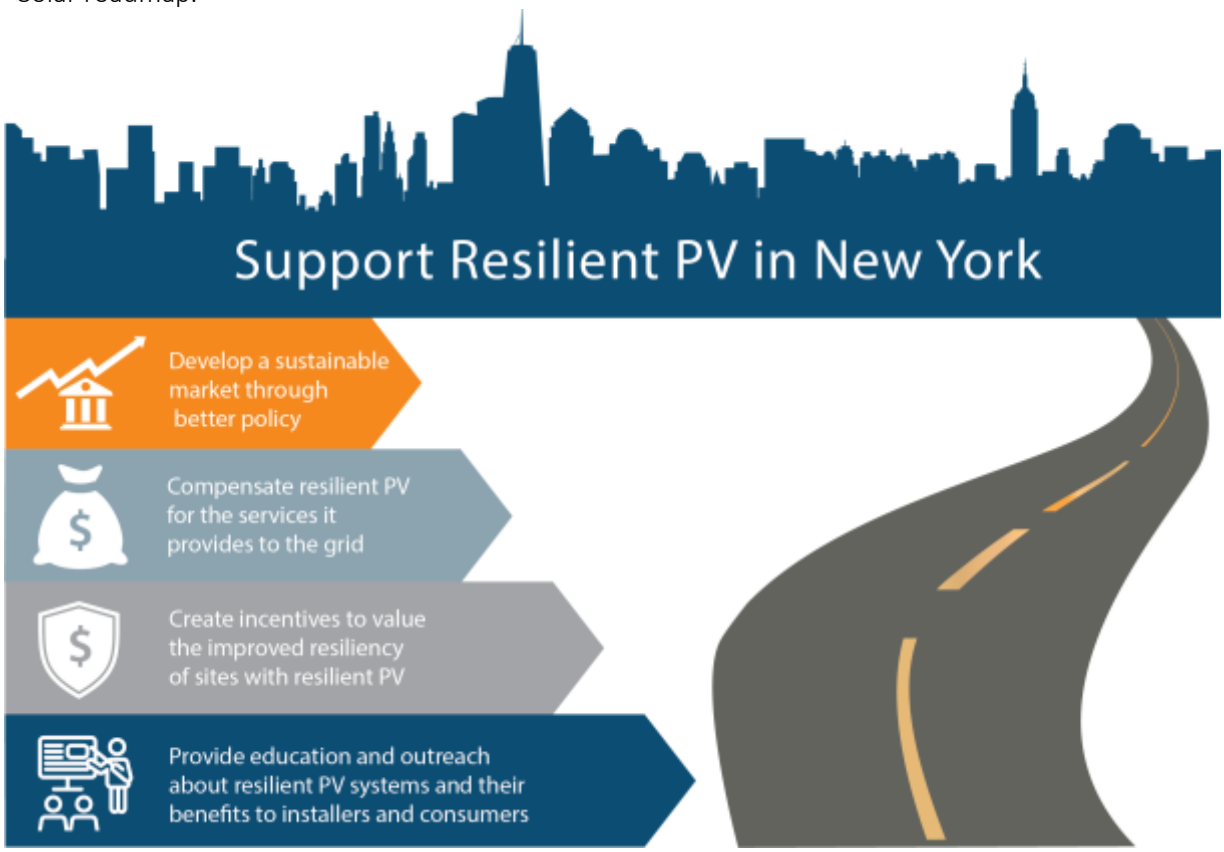
The DG Hub leveraged a diverse group of subject matter experts, ranging from electric utilities to battery manufacturers and solar installers, to chart barriers and develop the actionable solutions presented in this implementation roadmap. Through this work, the DG Hub assisted in developing New York City's and the nation's first municipal energy storage target of 100 MWh by 2020 in September 2016. Nearly 5 MWh of battery energy storage have been installed in New York City as of October 2016. However, more resilient projects will be needed to meet NYC's goals as well as New York State's goal of 50% of electricity generation from renewables by 2030. Resilient solar is unique as it can generate savings for host facilities outside of an emergency, support critical loads during emergencies, and deliver grid services and clean power.

Despite these benefits, barriers remain which have prevented large-scale deployment including:

- Lack of Compensation for Grid Services: Resilient solar can provide a number of ancillary services to the grid, but is prevented from being compensated due to the high capacity limits for NYISO's programs which preclude distributed generators from participating. Throughout 2017, NYISO will convene stakeholders to explore the integration of further DG through its Distributed Energy Resources (DER) Roadmap process. While the roadmap activities are expected to culminate in 2021, the stakeholder sessions offer a near-term opportunity to discuss pathways for additional revenue streams for DG.
- Lack of Value for Resiliency Services: Resilient solar enables critical infrastructure facilities to serve New York City's population during emergencies. These factors are currently not incorporated into cost calculus for projects or considerations for federal grant funding, but would improve the economic applicability of resilient solar.
- Policy risk and market uncertainty: While incentive programs exist for solar, there has not been an incentive program for storage in New York. Variability in the market can lead to boom-bust cycles as opposed to sustainable market development. For example, Con Edison offered the time-limited Brooklyn Queens Demand Management program, which was designed to ease load constraints on select NYC neighborhoods through non-wires alternatives. This program directly supported the development of several storage projects.
- Education and outreach: Many facilities managers are not aware that resilient solar is an available alternative to a diesel generator, and that project economics have become strong in recent years. Simultaneously, local officials need to gain more familiarity with resilient solar to enable more responsive and efficient regulatory and permitting processes.

The DG Hub Resilient Solar Roadmap introduces a series of strategies for addressing these key barriers in the categories of **hardware, software, economics** and **policy**. These strategies include innovations, such as Con Edison's Virtual Power Plant project, which will test aggregation opportunities for small-scale distributed generators to participate in NYISO markets. Additionally, advocating for market rule changes and the REV Value of DER Proceeding for location-based marginal price plus distribution value will assist in providing compensation for various forms of distributed generation.[2]

The DG Hub has also developed a methodology for valuing resiliency with a goal of developing tangible price signals for grid and host facility services provided by resilient solar. The initial methodology was used to support solar and storage feasibility studies in New York City. Through partnerships and stakeholder consultation, the DG Hub will establish consensus-based metrics to assess the threat of power outages to building facilities, and refine the methodology. After data collection, the DG Hub will assist in the creation of recommended insurance, banking, and tax incentives, directly partnering with industries which can deliver a monetary value for reductions in risks through resilience investments. The desired result of this work is to lower the cost of resilient solar by unlocking the value of resiliency as an additional revenue stream for solar+storage installations. The DG Hub is committed to continuing this work and creating educational resources for New York stakeholders on resilient solar. Materials that support pursuing resilient solar are available at www.nysolarmap.com. The DG Hub's work will continue through education and outreach trainings in 2017, and assisting with the implementation of the Resilient Solar roadmap.



[2] Matter # 15-E-0751

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ABOUT

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New York Power Authority

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Introduction to Resilient Solar in New York City

In the aftermath of Hurricane Sandy in 2012, it was determined that while the solar arrays on NYC rooftops sustained little or no damage during the storm, they were unable to supply critically needed power during the subsequent outage. At the time, virtually none of NYC's installed PV capacity had battery backup power. Even certain facilities with generators were without power due to a variety of factors including limited fuel deliveries and mechanical failures. By the end of 2016, most solar installations in the U.S. were still wired to automatically shut down during grid outages for safety reasons and lacked battery backup or other means to function during outages. Pairing solar PV with batteries can provide critical power needs and reduce dependency on delivered fuel. When applicable, resilient solar systems also provide benefits outside of emergencies such as utility bill savings and grid support services. The deployment of resilient solar across NYC, and beyond, can increase the preparedness of residents and businesses to future extreme weather and climate variability, while reducing social and economic damages.

What is Resilient Solar?

For the purposes of this roadmap, resilient solar systems are solar PV systems which can operate during electrical outages, provide emergency power to facilities, as well as provide electricity under normal conditions. The term 'resilient solar' includes technologies such as a solar PV System paired with:

1. Battery backup (the primary focus of the roadmap and also referred to as solar+storage)
2. Auxiliary generation such as a diesel generator to reduce fuel needs or a combined heat and power system
3. An inverter with emergency 'daylight' power outlets

This document focuses primarily on solar and battery backup, which was the focus of the DG Hub's work under the U.S. Department of Energy SunShot Initiative. In the near-term solar and battery storage offers an economically viable solution and increased resilience to short-duration outages (defined as a day or less, please see Case Study on page 21). In the future, the DG Hub will explore additional resilient solar and resilient energy technologies in further detail. Resilient solar will refer to solar and storage for the remainder of the document.

The NYSolar Smart Distributed Generation Hub (DG Hub) is focused on reducing costs and increasing deployment of resilient solar systems in New York City (NYC) to enhance emergency preparedness and strengthen the electric grid. Sustainable CUNY of the City University of New York (CUNY) formed the Smart DG Hub to develop a pathway to a more resilient distributed energy system, and won federal and state support for the Smart DG Hub-Resilient Solar Project in 2014. The three-year project, in collaboration with multiple partners, engages in project based change in order to reduce regulatory and financial barriers to resilient solar deployment. Barriers and solutions identified through this process are captured in this roadmap. Examples of the types of projects developed by the DG Hub – Resilient Solar Project include: an analysis for deploying resilient solar electric systems on designated critical infrastructure facilities, multiple guidance documents, and a process for tracking resilient solar systems as

they are installed. Moving forward, the DG Hub will integrate values for resiliency into the solar calculator on the NY Solar Map and Portal and develop a resilient solar training curriculum for a variety of audiences.

The growth of solar installations has continued exponentially, yet resilient solar systems remain rare in NYC despite the unique attributes of resilient solar when compared to traditional generators. A number of barriers to implementation and installation of resilient solar systems remain in NYC and New York State.

The Resilient Solar Roadmap outlines an implementation pathway to increase resilient solar systems on critical infrastructure and other facilities within NYC to support the City in achieving aggressive solar, storage and climate targets. The DG Hub includes key stakeholders such as the Mayor's Office of Sustainability. Through work during its first two years, the DG Hub helped lead NYC to establish the first municipal storage goal in the country: 100MWh of storage by 2020.

The roadmap will continue to further advancements in resilient solar and:

- Create a pathway towards sustainable development of the resilient solar market in NYC
- Identify and seek solutions to reduce non-hardware costs
- Outline the steps needed over the next 3-5 years that will lead to the development of the solar+storage systems that will help NYC achieve its storage goal.

State of Solar

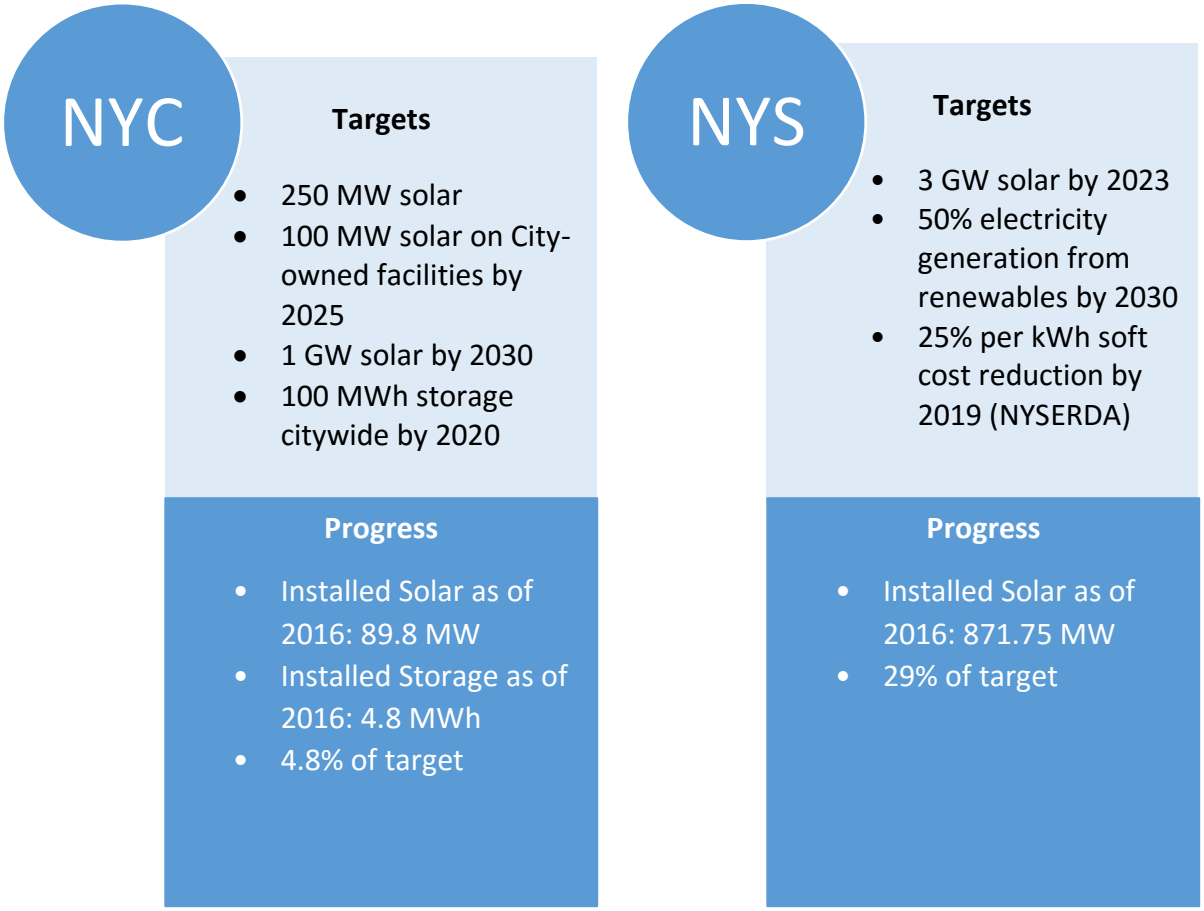
Solar installations have grown rapidly in NYC and across the State since 2011. This growth has been driven by declining solar hardware costs, strategic programs to lower the balance of system (BOS) costs, and programmatic and policy investments under the U.S. Department of Energy *SunShot Initiative*, the *NY-Sun Initiative*, and NYC's One City: Built to Last plan. From 2011 to 2016, solar installations in New York State increased approximately 1000%. New York City's solar installation growth was above the state average with an approximately 1400% increase in installed systems in five years.[3] Both NYC and State have aggressive solar goals, and more installations will be required to hit policy targets.

NYC Solar Partnership

Sustainable CUNY initially formed the NYC Solar Partnership in 2006, working collaboratively with the New York City Mayor's Office of Sustainability, and the New York City Economic Development Corporation (NYCEDC) in developing and implementing comprehensive plans for large-scale solar integration and the associated economic development in New York City. This strategic approach has resulted in Federal, State and City support for key programs to reduce balance of system costs which Sustainable CUNY implements on behalf of NYC, in collaboration with over 40 key partners. In 2014, Mayor Bill de Blasio committed to continuing the Partnership and formalized a comprehensive initiative under *One City: Built to Last* that includes a broad Solarize NYC initiative and Shared Solar NYC program led by Sustainable CUNY. The plan also included the largest solar deployment commitment by any Mayor in the country: 100 MW of solar on city-owned buildings and 250 MW of solar in the private sector over the subsequent decade. Building on previous success, NYC's solar target was expanded to 1,000 MW in 2016.

[3] NYSERDA. 2015 Solar Growth per Region, available at: http://www.nyserda.ny.gov/-/media/Files/About/SUN-GEN-solar-growth-by-region.pdf, and DG Hub Team's Data Analysis and nysolarmap.com.

Figure 1- State and City Policy Targets for Solar and Energy Storage



State of Storage

Nationwide, storage is expected to grow to 11.3 GW of installed capacity by 2020, and attract billions in investment.[4] Hardware costs have declined by over 50% for lithium-ion batteries between 2010 and 2015 driving continued growth in installations.[5] Some developers, such as Stem, have used market surpluses in 2016 to purchase batteries at a price 70% lower than previous years.[6] However, across the industry capital costs for batteries for commercial and industrial systems still range between $452-1066/kWh for lithium ion and $551-$1,151/kWh for lead acid according to analysis released by Lazard in December 2016.[7] Lithium-ion batteries are the dominant technology in new installations, and accounted for 96.2%

[4] Bloomberg New Energy Finance, http://about.bnef.com/research-notes-sp/
[5] GTM Research. The Future of Solar + Storage in the U.S., available at: https://www.greentechmedia.com/research/report/us-solar-plus-storage
[6] Lacey, Stephen. Green Tech Media. Stem CTO: Lithium-ion Battery Prices Fell 70% over 18 Months, available at: https://www.greentechmedia.com/articles/read/stem-cto-weve-seen-battery-prices-fall-70-in-the-last-18-months
[7] Lazard. Levelized Cost of Storage Analysis 2.0, available at: https://www.lazard.com/perspective/levelized-cost-of-storage-analysis-20/

of new installations nationwide in the third quarter of 2016.[8] According to recent studies by Green Tech Media, the Rocky Mountain Institute and others, New York and NYISO remain one of the few viable markets for behind the meter storage because of a combination of high demand charges, and opportunities for participation in demand response programs. NYSERDA estimates that soft costs for battery projects accounted for approximately 25% of project costs in 2016. This represents a significant opportunity for improved system economics.

Batteries provide an increasingly attractive pathway for providing resilient solar options on critical infrastructure, delivering grid benefits, and furthering the economic development of New York's Cleantech sector. By the end of 2016, 14 electrochemical battery storage projects totaling approximately 1400 kW have been completed in NYC with a capacity of nearly 5 MWh. During a 2015 market research survey completed by the Smart DG Hub, most local installers anticipated completing further storage work in 2016-17.

Figure 2 - Total Installed Energy Storage Capacity (In MW) in the U.S. (Figure not exclusive to batteries) Adapted from GTM Research

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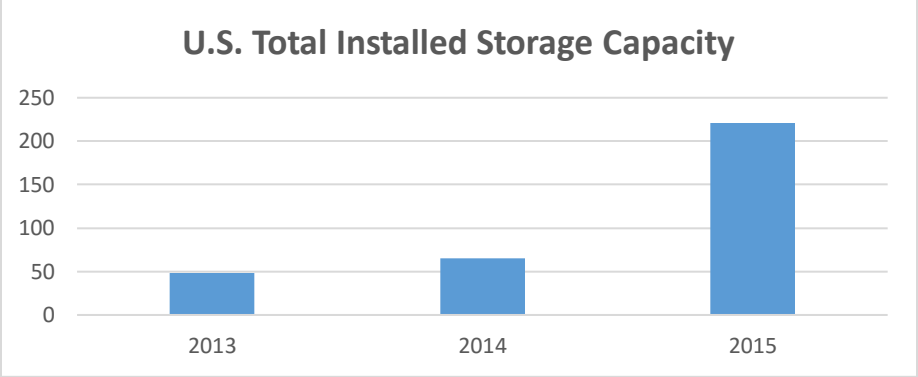


The Case for Solar+Storage

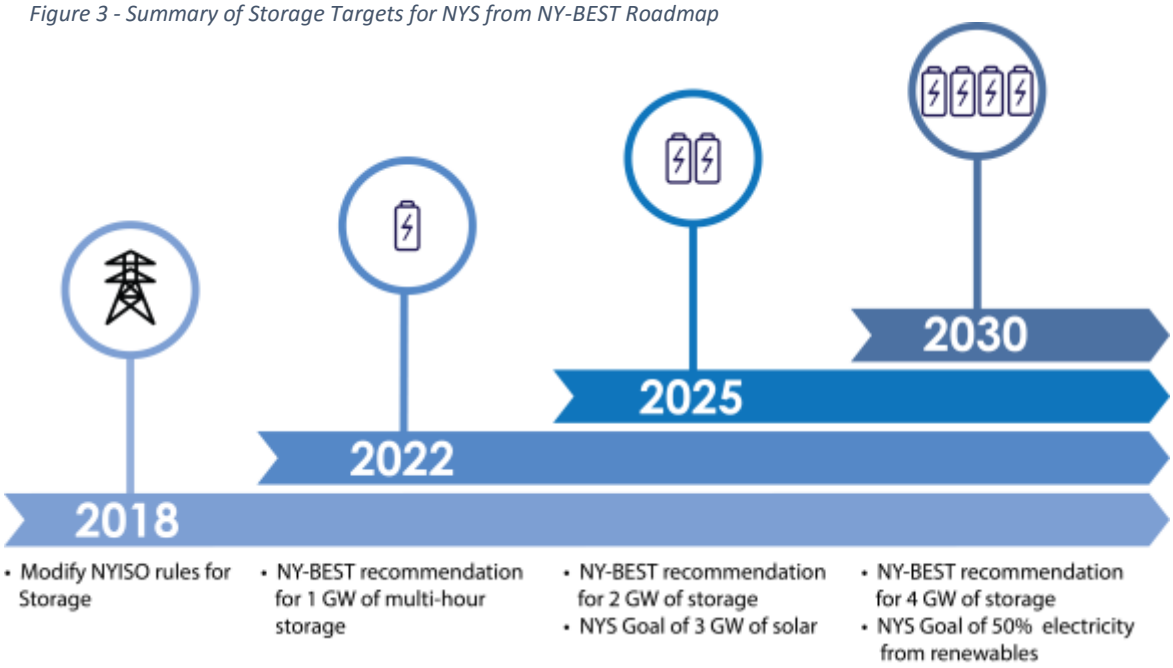
There is significant opportunity for existing and future solar PV installations to be made resilient with the addition of battery backup. Together solar and storage can provide benefits both in front of the meter and behind the meter. Behind-the-meter applications of solar+storage can enable local resiliency within NYC by providing backup power for short-duration outages, reduce consumption, and lower demand charges. In front of the meter, solar+storage can provide grid benefits and ancillary services, and enabling more renewables to be integrated onto the grid by offering "firming support." Firming, or the inclusion of storage with renewables, lessens the dependency of solar the weather making its generation profile more uniform, enabling higher levels of solar integration and electric system resilience necessary to meet state targets.[9]

[8] GTM Research and the Energy Storage Association. U.S. Energy Storage Monitor Q4 2016 Executive Summary, available at: https://www.greentechmedia.com/research/subscription/u.s.-energy-storage-monitor

[9] For further information on the potential role of storage in New York's energy future, please see the NY-BEST Storage Roadmap available at: https://www.ny-best.org/page/2016-energy-storage-roadmap-new-yorks-electric-grid

With resiliency, preparedness and sustainability being policy priorities for New York City, Mayor Bill de Blasio established the first municipal energy storage target in the nation of 100 MWh by 2020, which is critical to encouraging the integration of resilient solar into emergency preparedness. The New York

Figure 3 - Summary of Storage Targets for NYS from NY-BEST Roadmap



Battery and Energy Storage Technology Consortium (NY-BEST), an industry-led public-private coalition for storage in New York State, has developed suggested preliminary statewide targets for storage deployment that would be necessary to support New York State's 2030 electricity generation and solar goals. These include:[10]

While the Smart DG Hub's work is initially focused on NYC, guidance from the state can help inform local policies. As such, the Smart DG Hub recommends that the State conduct a robust analysis to understand the role of batteries in the state's energy future. NYSERDA is beginning conversations through conferences and convenings such as the On-Site Power Conference in December 2016 and the Clean Energy Fund.

Virtual Power Plant REV Demonstration Project

Con Edison's Virtual Power Plant is a solar+storage 'Reforming the Energy Vision' (REV) demonstration project that will place more than 300 resilient solar systems on NYC residences. In aggregate, the project will deploy about 1.8 MW of solar and 1.8 MW / 4 MWh of battery storage. Homeowners will lease SunPower PV systems and pay a monthly "resiliency fee" for access to Sunverge li-ion battery storage systems, which will be controlled by Con Edison during normal grid operations and available to the homeowners for emergency power during grid outages. When controlled together as a virtual power plant (VPP), the batteries can provide grid services, primarily peak demand reduction.

[10] NY-BEST. 2016 Energy Storage Roadmap for New York's Electric Grid. Available at: https://www.ny-best.org/page/2016-energy-storage-roadmap-new-yorks-electric-grid

Key Barriers Limiting Resilient Solar growth

In spite of the many benefits of resilient solar, major barriers exist which have prevented widespread deployment of batteries with PV systems, including:

- **Limited access to revenue streams.** Batteries can provide a number of benefits to the grid and hosts inside and outside of emergencies, but tend to be unable to access multiple revenue streams in New York. Additionally, batteries do not yet have access to consistent state incentives, yielding high policy risks for projects. This is partially driven by New York Independent System Operator (NYISO) policy, which has a high capacity floor for participation in the ancillary service market, and a lack of a long-term incentive programs. NYISO is investigating the role of DER participation in its programs through its DER Roadmap process, which will culminate in 2021. In in the interim, stakeholders can provide feedback through a series of stakeholder meetings in 2017 on the future direction of the program. Con Edison has expanded the value of demand response services provided through its Brooklyn Queens Demand Management Program (see Case Study). However, batteries have not consistently been compensated for the services they provide across the state, as is the case for solar under the NY-Sun program. This has proven to be a major barrier to increased battery deployment as a stand-alone project or when paired with solar systems. In emergency situations where the grid is not functioning to supply power, resilient solar systems will allow facilities to become rapidly re-powered. While this value has not been well-defined as a price signal, the business interruption and property damage costs of outages are typically pushed through to insurance companies, banks, and government agencies. Once these sectors recognize resilient solar systems as loss avoidance mechanisms, they can create tangible price signals for the value of resiliency.

- **Evolving regulatory processes.** Local permitting processes for dominant (e.g. lithium-ion) and emerging battery chemistries are not formally established or evolving as permitting agencies gain new knowledge, increasing project risk and lag times for resilient solar projects. This also can decrease the willingness and readiness of the energy storage industry to participate in the New York market. Addressing this barrier is one of the priorities of the DG Hub Resilient Solar Project.

- **High project costs.** Though battery costs have declined, costs remain high for end customers. With limited access to financing and limited revenue streams available, payback periods remain high. The Smart DG Hub survey results revealed limited use of debt finance, and working group conversations and interviews have indicated that identifying lenders for solar and storage projects has been a challenge as it is an emerging use case.[11] The Smart DG Hub project has focused on the potential of removing regulatory hurdles, increasing information access, and reducing customer acquisition costs to reduce balance of system costs[12] as a way of increasing affordability and access to resilient power. During a recent New York research effort conducted by the Smart DG Hub, these balance of system costs were estimated to be 73% for commercial solar+storage.[13] Nationally in 2016, this estimate is 63.9%.[14]

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[11] Smart DG Hub. New York Solar+storage Cost Survey, available at: http://cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DGHubSolarandStorageCostSurveyResults.pdf

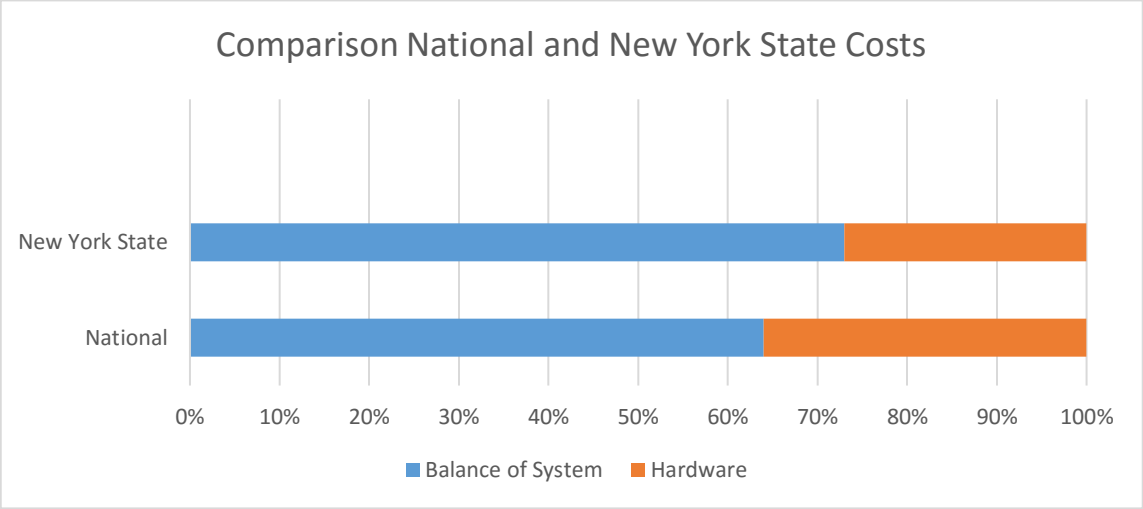
[12] Defined costs which exclude key hardware, such as solar panels, inverters and battery modules.

[13] Smart DG Hub. New York Solar+storage Cost Survey, available at: http://cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DGHubSolarandStorageCostSurveyResults.pdf

[14] Energy Storage Association Webinar by Cairn ERA. Balance of System Economics and Functions, available at: https://mc-group.app.box.com/files/0/f/7742032585/1/f_64953025429

By addressing the balance of system costs[15] through the implementation roadmap, the Smart DG Hub aims to enable a deployment strategy for resilient solar systems, with a focus on critical infrastructure in NYC.

Figure 4- Balance of System Costs for Commercial Solar and storage Adapted from DG Hub and Energy Storage



Prioritizing Deployment

Resilient solar can be utilized to power critical loads and keep elements of the built environment operable during an outage. In the later sections of the roadmap, strategies are outlined that enable market development for solar+storage.

Solar+storage can provide economic benefits through reducing consumption and demand charge management. These revenue streams can make solar+storage have competitive payback periods for commercial and industrial customers and are essential for creating an economic case for resilient solar investments, as resiliency is not currently valued by the market. Thus, these systems can offer increased resiliency and cost savings for facilities, but until resiliency is valued by the market or hardware costs decline, long-term outage support from solar+storage remains cost prohibitive. However, for facilities which are not required to have long-term outage support, and are seeking additional resilience for short-duration outage (e.g. 1 day), solar+storage can be a complementary fit to existing backup generators or a facility.

Given the importance of increased resilience, targeting critical infrastructure facilities through incentives, programs, technical assistance and outreach could quickly enhance community resilience, deliver cost savings, and provide a method for targeting grant programs or project development.

Buildings that remain operable during emergencies allow vulnerable individuals to shelter-in-place and support existing evacuation and shelter infrastructure. During Hurricane Sandy, 65,000 patients and nursing home residents had to be evacuated and 2 million New Yorkers were without power. During

[15] Balance of system costs include all system costs, excluding panels and batteries.

emergencies, access to refrigeration, life safety and support systems, and baseline levels of occupant comfort become crucial.

The Smart DG Hub project team incorporated new energy storage layers into the NY Solar Map, which display where storage and solar+storage systems are located, their technology type, and capacity. Future updates will suggest where systems should be sited based on the locations of key critical infrastructure facilities, with high solar potential and enhanced vulnerability to grid outages or flooding. The Smart DG Hub working groups and project team consulted a number of existing resources to identify and develop a broad typology of critical infrastructure facilities. These buildings provide community services for individuals who are evacuating or sheltering in place, but are not currently required to have on-site generation:

- Fire Stations
- Police Departments
- Evacuation Centers
- Cooling centers
- Community Healthcare Centers
- Communications Centers
- Radio Stations
- Blood Banks
- EMS Dispatch
- Fuel
- Food distribution centers
- Stores that sell food/recovery items

Since 2008 emergency generators have been required for these building types in the NYC building code:

- K-12 schools
- Commercial buildings with a total area over 100,000 square feet
- High rises[16]
- Hotels

While any major renovations or new construction projects since 2008 now trigger compliance with the existing code, there are many existing buildings which have not undergone major building projects and do not have generators or other means of backup power.[17] Post-Sandy, the Building Resilience Task Force led by Urban Green successfully proposed changes to the building code to make energy requirements[18] for emergency generators more flexible for small facilities in order to increase the affordability of generators.[19] In spite of this, there are still many facilities without backup power. Additionally, for those with existing backup generation, on-site fuel may not be sufficient to support building needs for longer-duration outages.[20]

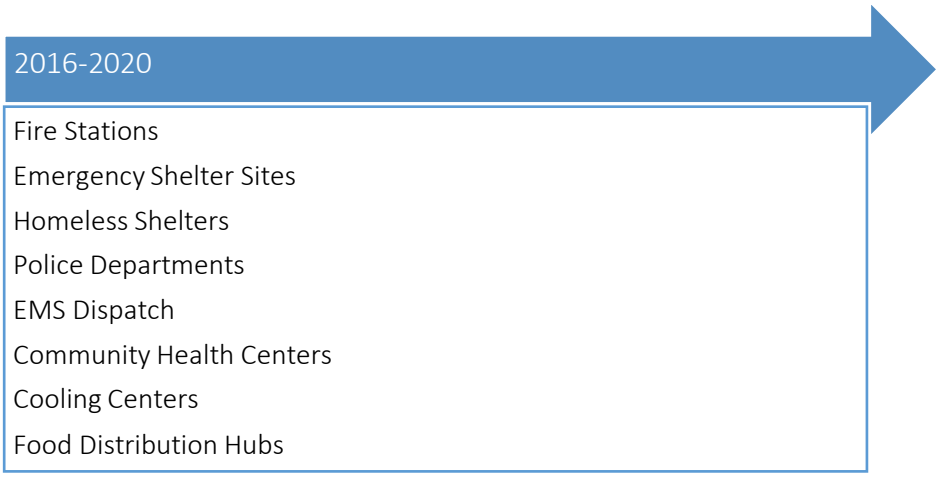
Utilizing the NY Solar Map, the Smart DG Hub proposes prioritizing potential installations and encouraging feasibility studies on critical infrastructure facilities, which have:

[16] Defined as 75 feet above vehicle access in the building code.
[17] New England Real Estate Journal. Summary of Emergency Generator Building Code Compliance, available at: http://nyrej.com/43252
[18] Previously, emergency generators had to have enough capacity to power emergency lighting, fire alarm systems, and one elevator during operations for all facilities. The elevator requirement substantially increased backup generator cost and size for smaller facilities. This requirement was waived for buildings below 75 feet, and multi-family buildings below 125 feet.
[19] Urban Green. Building Resilience Task Force Proposal Tracker- Remove Barriers to Backup and Natural Gas Generation, available at: http://urbangreencouncil.org/sites/default/files/brtf_17-_remove_barriers_to_backup.pdf
[20] At present, the New York Building code requires no more than 250 gallons of emergency fuel to be stored on-site. Based on a building's electricity load, this may only support a day or less of emergency power. Resilient solar could potentially support critical loads for longer duration outages.

- Roof space which can support at least 10 kW of solar
- No existing backup power
- Facilities which are in areas of enhanced need due to grid congestion and/areas in the floodplain with hardened infrastructure
- Anticipated size of a facility's critical loads
- Facilities which serve vulnerable populations

The Smart DG Hub team proposes targeted feasibility studies, education and outreach to facilities managers, and consideration of incentive programs with a focus on the following building-types for the next five years.

Figure 5 - Smart DG Hub Deployment Foci



- First Responders and Law Enforcement: Providing power to first responders and key components of the shelter system enables better service delivery and assistance to communities during emergencies. The Smart DG Hub has completed a feasibility assessment for a NYC fire station, a school that serves as a coastal storm shelter, and a cooling center. The findings in these feasibility assessments can serve as an education and outreach tool for additional affected facilities, and encourage the development of grants or incentive programs. These priority foci also align with a new program proposed by NYC's Department of Citywide Administrative Services (DCAS), which is prioritizing resilient solar development for public buildings.
- Community Facilities: In the aftermath of Hurricane Sandy, many individuals who were disabled or had accessibility or functional needs had difficulties during evacuation. This led to a class action lawsuit and protests by disability rights advocates. To better serve vulnerable populations, community health centers should be prioritized to receive backup power to support critical services for populations in need. Resilient solar on these facilities, in addition to the facilities identified in the 2016-2017 period, may serve to facilitate with compliance to the class action suit.[21]

[21]NYC. Notice of Settlement of Class Action Lawsuit. Available at, https://www1.nyc.gov/site/em/about/mous-settlement-docs/bcid-class-notice.page

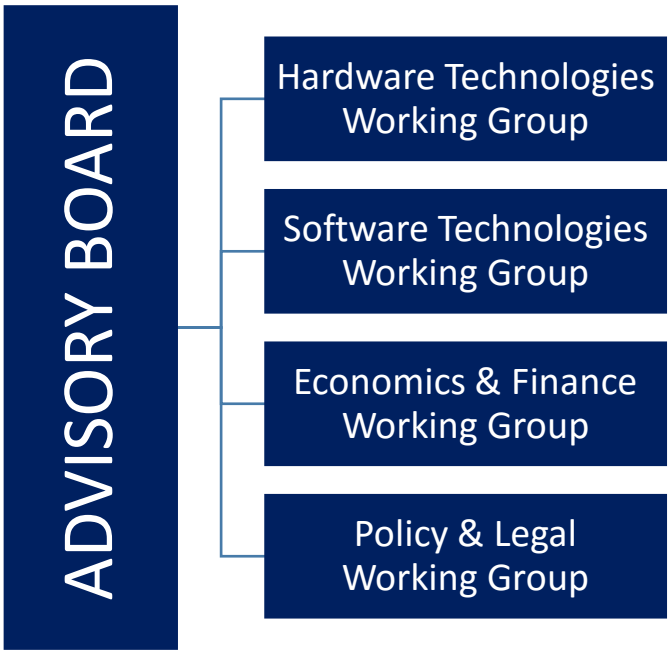
- **Community Services:** The final building foci targets facilities which provide community services, but likely do not have on-site generation. Access to cooling centers and powering food storage locations enables residents to more effectively shelter in place for longer durations and deepens community resilience.

Implementation Roadmap

Fostering successful deployment of resilient solar on these infrastructure types requires the removal of existing barriers. These barriers and recommendations were identified using strategic working groups, outreach and meetings with experts from the public, private and non-profit sectors, interviews, conversations with other Solar Market Pathways grantees, and interactions with a national team conducting research on solar+storage market conditions.

The following sections of this roadmap examine existing barriers and provide recommendations in the key areas of Hardware, Software, Economics, and Policy to enable the expansion of resilient solar in NYC. These topic areas were identified during the original convening of Smart DG Hub stakeholders as the key areas for reducing balance of system and soft costs. This roadmap is intended to support a robust resilient solar market in NYC for the next five years and to be a framework that other municipalities can build from.

Figure 6 - Structure of the Smart DG Hub Working Groups and Focus Areas



Resilient Solar PV: Hardware

The essential hardware components of a typical resilient solar system include:

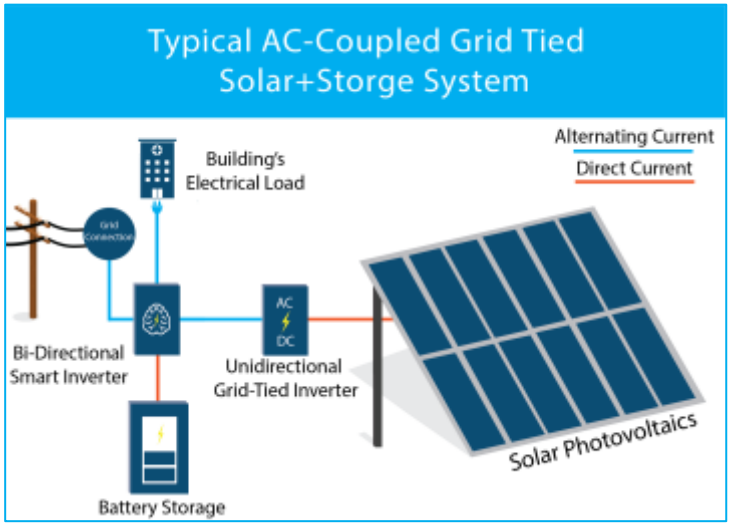
- A solar PV array
- An inverter
- A battery or energy storage system

These technologies have been widely used for decades, both separately and together. In recent years, their usage has rapidly increased. For example, solar PV first began its commercial rise in the 1950s and has grown tremendously over the last decade, with the solar industry creating jobs nearly 12 times faster than the overall U.S. economy in 2015.[22] Stand-alone stationary battery storage systems are commonly used as Uninterruptible Power Supply (UPS) systems for commercial buildings across the country to safeguard devices such as data centers and telecommunications equipment from power surges and grid outages. Mobile battery storage systems are also increasing in use as electric vehicles gain popularity.

Combined solar+storage systems have historically been used to enable off-grid power, or to supply backup power for grid-connected buildings. Today, new applications for energy storage are emerging which can provide facility resiliency, energy cost reductions, and grid services – improving the economics for investing in these systems. The more recent application of resilient solar and standalone storage systems for peak demand management and grid services is relatively new, but the equipment and system design remain the same. Additionally, the technology continues to advance – solar PV panels are increasing in efficiency, new battery chemistries are becoming commercially available, and inverter capabilities are evolving to enhance the use of both solar and batteries on and off the grid.

Design options for the components of a solar+storage system differ depending on a facility's existing infrastructure, size, location, and electrical loads. Battery storage systems can connect to either the AC (AC-coupled) or DC (DC-coupled) side of a solar PV system. Both system configurations are appropriate in different contexts. An AC-coupled system may be preferable when retrofitting existing PV with battery backup, while DC-coupled systems may be desirable for new construction. Alternatively, hybrid resilient systems utilizing additional distributed generation can be constructed to form larger microgrids. Diesel generators and combined heat and power (CHP) are commonly included, particularly for systems in need of load smoothing or added resiliency and redundancy. Due to the complexity of design configuration, standardization across the industry is currently difficult. The size and

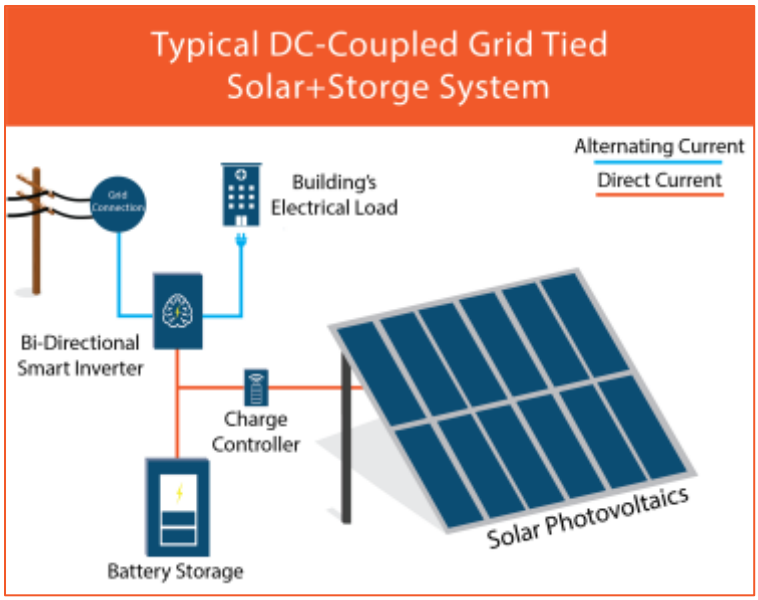
Figure 7 Example of an AC-coupled solar PV and storage system. Image taken from the DG Hub Resilient PV Fact Sheet.



[22] The Solar Foundation. National Solar Jobs Census 2015, available at: http://www.thesolarfoundation.org/wp-content/uploads/2016/01/TSF-2015-National-Solar-Jobs-Census.pdf.

type of equipment employed in resilient solar installations is dependent upon desired system functionality. Despite these factors, improved standardizations in hardware technologies and system design can lead to reduced balance of system costs and boost overall deployment.

This roadmap will focus on electrochemical energy storage, in particular, lead acid and lithium-ion batteries. Lead acid batteries are most commonly used in residential resilient solar systems where batteries are used infrequently during grid outages. In recent years, the use of lithium-ion batteries has greatly increased for demand management and ancillary grid services, and made up 96% of the deployments of energy storage in the United States in 2015.[23] Many other battery use cases and chemistries are emerging as well such as flow batteries, aqueous hybrid ion, nickel cadmium, and nickel-metal hydride. New use cases, like the examples explained in the case study below, are advancing as well.



For more technical information please see the Smart DG Hub Resilient PV Factsheet and the Smart DG Hub Resilient PV Retrofit and Storage Ready Factsheet.

[23] Vote Solar. Energy Storage Year in Review, available at: http://votesolar.org/wp-content/uploads/2016/03/Energy-Storage-2015-YIR-Votesolar.pdf

Emerging Storage Use Cases

The proliferation of battery storage has resulted in several emerging use cases, particularly in the transportation sector. In the United States in 2010, 345 plug-in electric vehicles (PEVs), which utilize battery storage, had been sold. Today, 440,000 PEVs are on the road in the United States.

This shift in the automotive industry provides supplementary economic opportunities for battery storage in the form of vehicle-to-grid power (V2G), demand response programs, and "second-life" batteries. Vehicle to grid technology, which allows two-way power flow for vehicle battery discharge and charge, can assist in managing a building's demand. This bi-directional capability can provide grid stabilization, and other ancillary services. This approach is being piloted with a vehicle-to-grid demonstration project at Queens College, a senior college of the City University of New York, in partnership with NRG and NYSERDA. The college will also host a resilient solar system to reduce utility costs and provide resiliency for the campus. This project is part of the U.S. Department of Energy's Sustainable and Holistic Integration of Storage and Solar PV program (SHINES), which has a goal of achieving a levelized cost of energy (LCOE) of less than $0.14/kWh for solar+storage.

Depleted batteries that can no longer meet the performance requirements of a vehicle effectively often still have a substantial amount of power and capacity. These "second-life" batteries have potential for stationary applications. Many policy, regulatory, and safety concerns exist, but second-life batteries remain a potential low-cost solution to the high price points of new systems. Automotive companies, battery storage developers, and other interested parties have begun buying second-life batteries, testing grid applications, and forming partnerships. Green Charge Networks partnered with Nissan to make second-life batteries commercially viable, BMW is bidding repurposed batteries into PG&E's demand response program, and both General Motors and Toyota are utilizing their batteries for solar and second-life battery pilot projects.

Modeling Resilient Solar in NYC

The National Renewable Energy Laboratory (NREL) in partnership with Sustainable CUNY of the City University of New York (CUNY) modeled resiliency projects and published the results in the report: *Economic and Resiliency Impact of PV and Storage on New York Critical Infrastructure*. The three different critical public facilities studied were:

- a high school and storm shelter
- a fire station
- a senior center that serves as a cooling center during heat emergencies

At each location four resiliency systems were modeled:

- solar+storage sized for economic savings
- solar+storage sized for resiliency
- solar+storage paired with a generator system sized for resiliency
- generator sized for resiliency

Each of the four systems above was modeled with, and without, a resiliency value. In this context, the resiliency value was defined as the 'avoided cost of a power outage'. Under best and worst case scenarios, resilient solar provided varying levels of resiliency supported, and was better suited for short outages. The following is an excerpt of analysis for a school site.

Table 13. Percent of Critical Load System Can Support

	System 1.1: No resiliency value captured	System 1.2: Short-duration resiliency value captured	System 1.3: Long-duration resiliency value captured
7-Hour Outage (Worst)	46%	46%	46%
7-Hour Outage (Best)	285%	285%	285%
51-Hour Outage (Worst)	12%	12%	12%
51-Hour Outage (Best)	50%	50%	50%

When resiliency is a priority, hybrid resilient systems were the most cost-effective means of providing sustained emergency power across all host sites, despite the upfront costs and added system complexity. Over the 25-year life of the project, the net present value (NPV) was positive or even, in all cases where resiliency was prescribed a value. When no value was prescribed to resiliency, the NPV was negative for long duration outages (22-51 hours/year) for hybrid systems at the fire station and senior center. Combining solar+storage and generators into hybrid systems can reduce the needed generator capacity and provide savings during normal grid operation. During long duration outages the generator can provide support where the installation of a large battery would be cost prohibitive. Backup generation should be modeled and considered on a case-by-case basis.

These findings were specific to NYPA territory utility rates, which are structured differently than ConEdison or other utility rates, but the findings can have important implications for hardware purchases and capital investments for new facilities or existing buildings across NYC.

For more detailed information, please see the full report: *Economic and Resiliency Impact of PV and Storage New York Critical Infrastructure*.

Barriers and Solutions

Although advancements in technology are promising, the barriers charted below must be addressed in order to encourage increased deployment of resilient solar on New York City facilities.

Barrier | COST

Hardware costs, particularly battery costs, remain the largest barrier to the deployment of resilient solar. Excluding solar PV, both in the residential and commercial sectors, the battery, module, and battery management system typically make up over one-third of the overall installed cost of energy storage systems.[28] According to Smart DG Hub surveying, installed lithium-ion battery prices average $528/kWh, while lead-acid batteries remain the cheapest technology type with an average price of $190/kWh.[29]

Solutions	Timeframe Implementation Partners
Continued Market Growth The U.S. energy storage market grew 243% in 2015 and 1.7 GW of installed capacity is projected for 2020.[24] Over the next five years, lithium-ion prices are expected to drop by 47% and lead acid by 24%.[25] The Department of Energy's goal of $0.14/kWh[26] levelized cost of energy for solar+storage, has already been reached at the utility scale in Hawaii. In the solar industry government incentives drove demand, resulting in higher volumes of manufacturing. This drove hardware costs down until the market could sustain itself. As the energy storage market similarly matures and the economies scale, hardware prices will decrease.	Near Term NYSERDA Manufacturers NY-BEST Host Sites Smart DG Hub
Technological Innovation New chemistries, materials, and improved design and manufacturing processes will lower hardware costs across most battery types. For example, reductions in the lead requirement for lead acid batteries and continued forays into new and improved lithium-ion chemistries will reduce costs.[27]	Medium Term Manufacturers NY-BEST Academic Institutions R&D Laboratories Smart DG Hub

[24] Munsell, Mike. (March 3, 2016). *US Energy Storage Market Grew 243% in 2015, Largest Year on Record*. Greentech Media. http://www.greentechmedia.com/articles/read/us-energy-storage-market-grew-243-in-2015-largest-year-on-record
[25] *Levelized Cost of Storage Analysis*. (November 2015). Lazard. https://www.lazard.com/media/2391/lazards-levelized-cost-of-storage-analysis-10.pdf
[26] Sustainable and Holistic Integration of Energy Storage and Solar PV (SHINES). http://energy.gov/eere/sunshot/sustainable-and-holistic-integration-energy-storage-and-solar-pv-shines
[27] *Levelized Cost of Storage Analysis*. (November 2015). Lazard. https://www.lazard.com/media/2391/lazards-levelized-cost-of-storage-analysis-10.pdf
[28] Jaffe, Sam. *Balance of Systems Economics and Functions.* Energy Storage Association Webinar. Cairn ERA
[29] Smart DG Hub. (December 2015). DG Hub New York Solar+Storage Cost Survey.

Barrier | STANDARDIZATION OF DESIGN

Currently, there is limited standardization in the design of resilient solar systems, requiring the custom design of each system. The variance of design among resilient solar systems, as well as unique facility characteristics, can add to a system's cost. Additionally, the incorporation of other forms of distributed generation (DG), like wind, CHP, or diesel generators can increase system complexity.

Solutions	Timeframe Implementation Partners
Plug-and-Play Equipment Developing easily integrated resilient solar PV equipment makes the design, engineering, and installation of solar+storage easier and faster. Increased utilization and deployment of smart inverters, chargers, and other plug and play equipment will decrease labor costs associated with each phase of procurement.	Near Term Manufacturers Industry Associations National Laboratories Smart DG Hub
Standardized Request for Proposals (RFP) Template Host-sites can also encourage industry standardization in proposal development by providing clear guidance in RFPs. Host facilities should understand and state their goals for resilient solar systems and provide developers with data necessary to develop strong proposals. The Smart DG Hub has supported initial efforts at the residential level with guidance for communities undergoing group procurements.	Near Term NYSERDA Engineers Installers Host Sites Smart DG Hub
Follow 'Storage Ready' Guidelines Solar PV systems have benefitted from the creation of solar ready guidelines. These guidelines enable new construction to more easily accommodate future solar systems and can reduce hardware costs. Accompanying storage ready guidelines can decrease storage hardware costs and retrofit costs for traditional PV systems. This can result in savings up to $2,500.[30] For key considerations when retrofitting existing PV systems. See the Smart DG Hub Resilient PV Retrofit and Storage Ready Factsheet.	Medium Term Housing and Commercial Developers Policymakers Municipal Officials Smart DG Hub

[30] Please reference the DG Hub Retrofit factsheet hyperlinked above for detail analysis.

Barrier | PRACTITIONER EXPERIENCE

Many installers are well versed in stand-alone systems for both solar and battery storage. Expertise is needed, however, for the installation and maintenance of solar+storage systems. As of 2016, two-thirds of solar installers do not offer storage.[31] The results of the Smart DG Hub's market research survey for New York also suggested limited overlap between solar installers and storage installers. The need for training on system integration will increase with rising market demand.

Solutions	Timeframe Implementation Partners
Attend, host, and create additional trainings and certifications To counteract any knowledge gaps, installers, engineers, architects, and municipal officials should attend available solar+storage and battery storage trainings. There are opportunities for expansion of existing technical training programs offered through NYSERDA (PV Trainers Network) and other providers. Some organizations and manufacturers host trainings currently, but more avenues are needed from government agencies, colleges and universities, or other approved organizations like the North American Board of Certified Energy Practitioners (NABCEP).	Near Term Installers Industry Associations Municipal Officials Engineers Architects NYSERDA NABCEP PV Trainers Network Smart DG Hub
Release installation best practices Online resources concerning the relevant federal, state, and local safety and fire codes and standards should be made available to installers and residents. For example, the County of Santa Clara, CA has published an interconnection checklist and their local signage requirements. All information, including links to relevant codes, standards, and additional educational information is provided in one central online location by the California Public Utilities Commission.[32] Municipalities, whether New York City or others in the state, could serve as key disseminators of best practices and installation guidelines. For more information regarding the regulatory processes surrounding battery storage systems in NYC, see the Smart DG Hub Permitting and Interconnection Guide.	Near Term Manufacturers NYC DOB Industry Associations Municipal Officials PV Trainers Network Smart DG Hub
Release step-by-step installation guides and maintenance requirements To reduce the potential for errors, manufacturers and project developers should release step-by-step installation guides for installers and host sites. These guides should clarify the safety risks, hazards, and maintenance requirements for all parties. For example, Stem, a developer, published a step-by-step installation guide for one of their battery products that covers installation, operation, maintenance, and	Near Term Manufacturers Industry Associations Smart DG Hub

[31] Clover, Ian. (April 13, 2016). *Two-thirds of US solar installers do not offer storage, study finds.* PV Magazine. http://www.pv-magazine.com/news/details/beitrag/two-thirds-of-us-solar-installers-do-not-offer-storage--study-finds_100024123/#axzz45lNtFvdb

[32] *Safety Best Practices for the Installation of Energy Storage.* California Public Utilities Commission. http://www.cpuc.ca.gov/General.aspx?id=8353

some safety considerations. Installers should also clarify any maintenance responsibilities of the host-site with customers. Local industry organizations and NYSERDA can encourage industry participants to request guidelines and disseminate best practice documents.	

Barrier | STANDARDS AND TESTING FOR HARDWARE

Codes, Standards, and Regulations (CSR) differ widely depending on battery chemistry type, and may even be non-existent. Third-party testing on select battery chemistries and fully integrated resilient solar PV systems has been limited. Satisfactory CSR is in place for traditional PV systems, but battery technologies are evolving faster than the standards that guide them. In some cases, older standards intended for other technologies and use cases may be inappropriately applied to new technologies.[35] Standards and testing are especially important for fire and safety and first responders to develop effective methods for fire suppression for emerging battery chemistries.

Solutions	Timeframe Implementation Partners
Develop applicable codes, standards, and regulations Additional standards need to be developed that are specific to new and emerging battery technologies as well as their systems and components. Performance-based standards that can be applied across technologies types and applications, rather than specific prescriptive standards could also assist with the continued emergence of new chemistries and technologies. Underwriters Laboratories (UL) is currently developing such standards. The Pacific Northwest National Laboratory along with Sandia National Laboratories have released two working protocols, the "Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems" and "Energy Storage System Guide for Compliance with Safety Codes and Standards" to guide the creation of future CSR by industry actors. When developing CSR, municipalities, government organizations, and industry should look to standards already put in place in more mature markets like Germany[33] and Australia[34]. To address these issues organizations, including Lawrence Berkley National Lab, NFPA, NEC, and UL, are actively pursuing the creation of new standards. Interim rules by local Authorities Having Jurisdiction (AHJs) may be developed until new codes and standards are established.	Medium Term MESA Manufacturers Industry Associations International & Domestic CSR Agencies Smart DG Hub

[33] *Energy Storage in Germany.* (2016). GTAI. https://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Info-sheets/Energy-environmental/info-sheet-energy-storage-batteries-certification-safety-testing-en.pdf?v=2

[34] Clean Energy Council. *Energy Storage Safety.* (2012) Australian Renewable Energy Agency. http://fpdi.cleanenergycouncil.org.au/dam/fpdi/reports/storage-safety-performance-study-report.pdf

[35] *Inventory of Safety-related Codes and Standards for Energy Storage Systems.* (September 2014). Pacific Northwest National Laboratory. http://www.sandia.gov/ess/docs/safety/ESS_Inventory_9-15-14_PNNL_23618.pdf

Barrier | WASTE MANAGEMENT

Batteries can contain chemical components which are toxic and pose health risks. When batteries need to be replaced, they must be properly disposed of. Different technologies and chemistries have varied disposal and recycling techniques and requirements. Currently New York State requires manufacturers to collect and recycle rechargeable batteries at no cost to the customer, but it does not cover batteries over 25 lbs., principal power sources for vehicles or stationary storage paired with renewables.[36] The recycling of some types of batteries, such as lithium-ion is not yet economical. However, as the market scales, recycling opportunities for certain chemistries should be re-evaluated and the safest disposal practices should be followed in the interim. Second life batteries present an opportunity for continued use of battery storage systems that can no longer effectively propel an electric vehicle, but still have useful life for electricity applications. Yet, using these batteries may create liabilities for automotive companies, void warranties, and be unfit for use depending on their capacity and duration.

Solutions	Timeframe Implementation Partners
Expand the NYS Rechargeable Battery Recycling Act The NYS Rechargeable Battery Recycling Act can be expanded to include to a wider variety of battery technologies, sizes, and applications. Requirements could be extended for manufacturers and retailers to collect and recycle larger batteries, all transportation-related batteries, and battery storage paired with all distributed generation. For example, legislators and regulators should look to the European Union's Battery Directive[37] in regard to structuring the waste management, collection, and recycling of consumer, automotive, and industrial batteries.	Medium Term Department of Environmental Conservation Smart DG Hub
Require visual distinctions for lead acid and lithium chemistries When lithium-ion batteries are recycled alongside lead acid in secondary lead smelters, fires and explosions have occurred.[38] Visually distinguishing the technologies will limit incorrect disposal and recycling and decrease fire and safety hazards.	Near Term Manufacturers Retailers Waste Facilities NFPA Smart DG Hub
Testing and reporting standards for second life batteries Clarity on safety, capacity, and power will create new use cases for old batteries, grow this market, and decrease the amount of battery waste. New York agencies and organizations should work to create minimum functionality testing and reporting standards for the use of second-life batteries.	Medium Term NYSERDA NY-BEST Smart DG Hub

[36] *NYS Rechargeable Battery Recycling Act.* New York Department of Environmental Conservation. http://www.dec.ny.gov/chemical/72065.html

[37] *Frequently Asked Questions on Directive 2006/66/EU on Batteries and Accumulators and Waste Batteries and Accumulators*. (May 2014). European Commission Directorate-General Environment. http://ec.europa.eu/environment/waste/batteries/pdf/faq.pdf

[38] Gaines, Linda. *The Future of Automotive Lithium-ion Battery Recycling: Charting a sustainable course.* (December, 2014). Argonne National Laboratory. https://www.researchgate.net/publication/272402947_The_future_of_automotive_lithium-ion_battery_recycling_Charting_a_sustainable_course#pf6

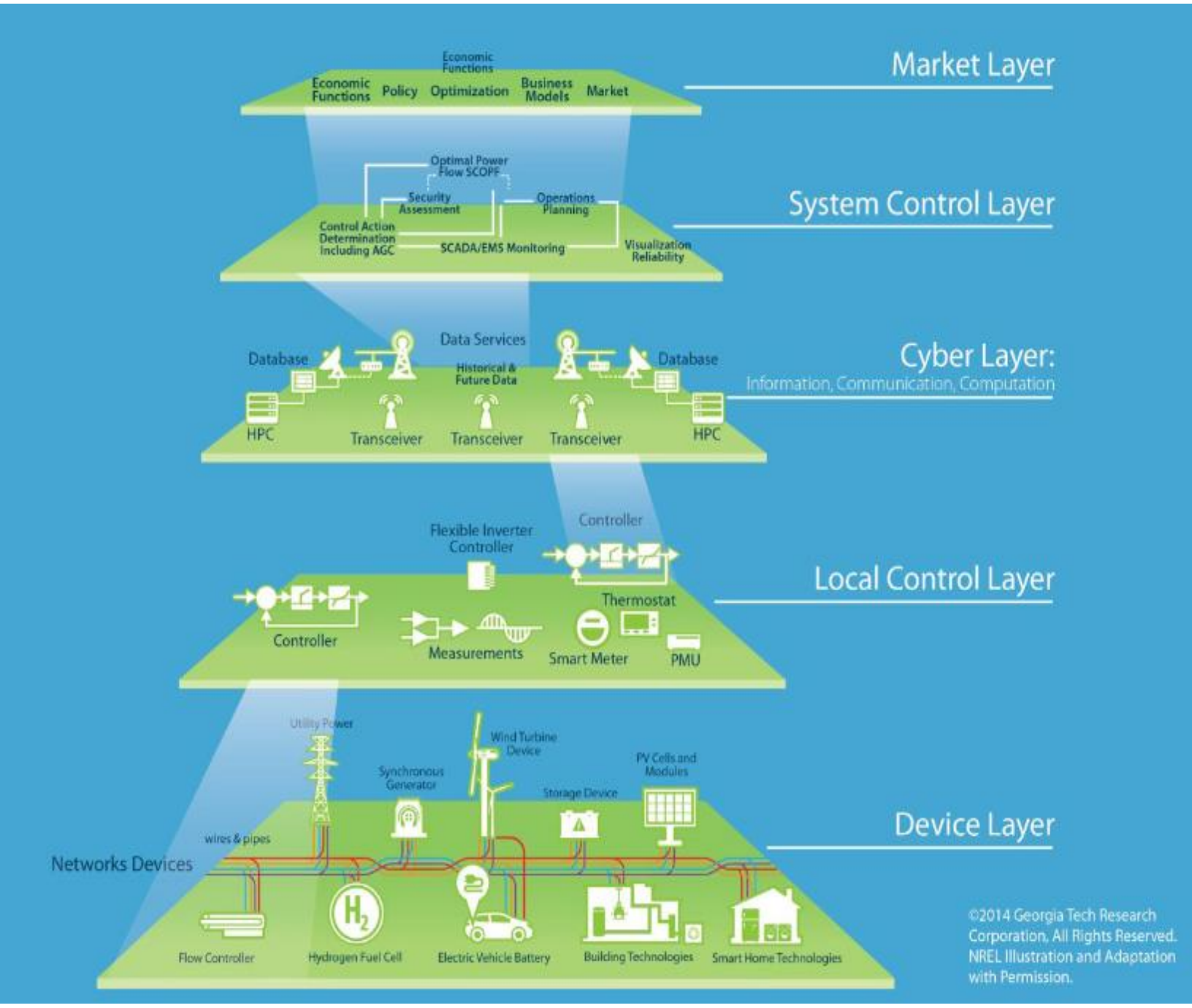
Resilient Solar PV: Software

Software is an essential component for the effective design, management and utilization of resilient solar systems, allowing resilient solar to function as part of a larger smart grid infrastructure. At present, sophisticated software exists to support solar+storage in the following ways:

Design	Project developers can use software, like NREL's System Advisory Model (SAM), to model and appropriately size resilient solar based on building loads, available roof space, utility rate tariffs, needs and incentives. Complex layouts, particularly with larger, commercial-sized solar+storage systems can be simplified by the use of software design tools.
Off-Grid & Emergency Power	Solar+storage software allows grid-connected systems to island during emergencies and blackouts. Advanced smart inverter functions allow for the management of loads, power production, and battery management, to keep the system stable in off-grid mode.
On-Grid & Energy Management	Software that monitors and controls resilient solar assets can efficiently dispatch the resources to shave peak demand, participate in demand response programs, and/or provide ancillary services. Data captured by software systems can validate the services provided to utilities, ISOs, and other bodies that compensate services offered by solar+storage.
Safety	Resilient solar must be monitored and controlled to ensure safe operation. For example, monitoring and limiting battery charge levels when nearing safety bounds reduces risk. Software systems also alert system operators when near or outside these bounds.

Different architecture and communication protocols may be required for resilient solar systems serving different functions. For example, software systems may allow islanding from the grid, but in order to capture additional value streams from ancillary markets, supplementary software systems must also be able to accept signals from the grid operator and additional layers may be required.

Image 1- Depiction of Smart Grid Software Layers (Credit: NREL)



Additionally, the scale and size of a system can affect the complexity of the software used. Residential solar+storage only used for emergency power requires less complex software than a large commercial installation that encompasses multiple buildings. Software communication is growing at a fast rate and the exchange of information requires coordination with distributed energy devices and systems that may be monitored, operated, and controlled. For further details on how software supports resilient solar functionality, please see the Smart DG Hub Smart Grid Communications factsheet.

Industry Standardization Efforts

The development of compatible controls and languages for resilient PV that takes into account the variety of systems will be a key factor in enabling widespread adoption and integration. During the commercialization of the personal computer, industry hardware and software standards were put in place to allow for effective communication between devices and components. Solar+storage will require the same. To date, these protocols have not been developed or universally applied, which leads to difficulties working across manufacturers and retrofits of solar+storage projects. Despite the many roles software can play, manufacturers and developers of solar+storage have typically created products that are only compatible with their own devices. These products do not have the necessary interoperability to communicate and integrate with equipment from other manufacturers. This can lead to system design decisions that are based on compatibility rather than functionality and optimization.

Industry efforts like the SunSpec Alliance, Modular Energy Storage Architecture (MESA), and the Smart Grid Interoperability Panel (SGIP) are actively developing software and device specifications to promote the standardization of energy storage devices, facilitate communication, and enable higher levels of connectivity. This will also provide helpful data sets for modeling solar+storage retrofits. These groups, however, are early in the process and their standards are not yet robust enough for widespread adoption. Each of these standardizations are expected to continue to advance, but until they are widely accepted, interim solutions must be flexible and should take into account the growing fleet of legacy solar+storage installations.

Interoperability Challenges for Retrofits

Case Study in Progress | The Hartley Nature Center, located in Duluth, Minnesota, installed one of the first solar installations in the region in 2003. The facility is city-owned and operated by the non-profit, Hartley Nature Center. The 13.1 kW solar system consists of a rooftop and pole-mounted tracking installation. By 2016, three of the system's six inverters needed replacement, and a decision was made to upgrade the array and retrofit the existing building with battery storage utilizing a range of grants and in-kind labor. Led by Ecolibrium 3 (a local economic development non-profit), the University of Minnesota Duluth, the City of Duluth, and Hartley Nature Center, a 14.2 kWh/6 kW lithium-ion battery was commissioned in August, 2016. In addition to an inverter for the storage system, the retrofit includes a new grid tied but island-able inverter, which can power an emergency outlet when the grid is down but the sun is shining.

The retrofit brought to light software compatibility, hardware availability, and regulatory challenges. Many of the residential energy storage systems (ESS) do not have the software capabilities to provide demand charge management, while other options were too large and exceeded the site's load. These factors limited the selection of ESS available. Additionally, once an ESS was selected, it was discovered that the storage load sensor could not be fitted to the main consumption load due to the large amount of amperage on the panel. The storage software currently cannot read the entire consumption load of the building in real time. This problem could have been alleviated with access to usage data from the on-site smart meter data, but the storage software was not able to integrate with the third-party smart meter. The manufacturer is expected to present a load sensor adjustment in the next 3 months to eliminate this situation. Lastly, the installation of a battery system was considered a major alteration rather than a repair and as such required the PV system to adhere to updated electrical code. These added project costs to incorporate rapid shutdown and AFCI.

The project team was able to design around these challenges and will work with the manufacturer for 6-12 months to optimize the solar+storage unit, building energy management system, and on-site ground-source heat pumps. However, the lack of interoperability and hardware and software flexibility have added time and costs to the project. One of the functions of this demonstration project was to uncover such difficulties, but industry-wide efforts are needed to simplify the design and construction process for retrofits.

The completed resilient solar project will assist in demand charge management for the facility, provide resilience benefits and serve as an educational tool for the community. The installation was conducted as an open continuing education class for continuing education credits for area solar installers, electricians, and others. The retrofit project will provide valuable data points, raise awareness of the benefits of storage, and allow for academic research opportunities going forward. In the event of an emergency, Hartley Nature Center will now be able to serve as a shelter to the community and is expected to be able to support small, but critical loads for over nine hours.

Adapted from 7.26 Interview with Bret Spence, Ecolibrium3

Barriers and Solutions

Despite ongoing standardizations and software advancements, a number of barriers still exist. The barriers outlined below must be addressed in order to encourage increased deployment of resilient solar on New York facilities.

Barrier | COMPATIBILITY AND INTEGRATION

Solar+storage systems have many different components, devices, and points of interconnection that must work in a synchronous manner in order to realize all of the benefits. The design and installation of solar PV is relatively standardized, yet battery storage and inverter functionality remains less systematic. Variation in design, size, and a facility's needs require resilient solar to have different controls and software layers dependent on its usage. Arizona Public Service and Tucson Electric Power Company are currently offering rooftop PV to their customers through a pilot program. The utilities own and operate the systems on customers' homes and compensate them with a fee for the use of their rooftops. This program will test communication between PV systems and the grid, and is one example the work being done improve communication and interoperability between system components and the grid.

Solutions	Timeframe Implementation Partners
Finalize and Incorporate Industry Standards Currently, no standardized open protocols exist. Different industry groups are currently working on creating communication standardizations for system components and grid wide connectivity[39]. Disseminating ongoing protocol developments by MESA, SIWG, the SunSpec Alliance, and NREL will aid energy storage's ability to communicate with the grid and between system components. Encouraging industry groups, vendors and manufacturers to leverage these existing and future standards will decrease development costs for retrofit projects. Applying like architectures across a variety of devices allows solar+storage to scale more easily and limits time spent by installers to design and integrate systems.	Near Term SunSpec Alliance MESA NREL Smart Inverter Working Group (SIWG) Industry Associations Smart DG Hub

Barrier | DATA SECURITY

Integrating multiple devices from a variety of manufacturers with utility controls and data acquisition may create cybersecurity vulnerabilities. Solar+storage systems typically use cloud-based control software that is often unencrypted. Additionally, utility programs like demand response that require communication between energy providers and end-use sites can be vulnerable to security threats. At present, these concerns are not a priority issue for consumers, but as resilient solar applications grow there may be more entry points in need of added data security.

[39] Advanced Inverter Functions and Communication Protocols for Distribution Management, A Nagarajan, NREL, IEEE,2016, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7520035

Solutions	Timeframe Implementation Partners
Support Continued Development of Existing and Future Guidelines Following existing guidelines and disseminating future guidelines to solar+storage stakeholders will mitigate future cybersecurity risks. To better protect grid-connected resources, stakeholders should familiarize themselves with evolving standards like the National Institute of Standards and Technology's (NIST) voluntary framework for operators and owners of critical infrastructure and the North American Electric Reliability Corporation's (NERC) critical infrastructure protection cybersecurity standards (CIP Version 5). Currently, NERC is implementing a transition program to aid industry adoptions of its new standards.	Near Term SGIP CIP V5 Transition Program (NERC) NIST Utilities NY-ISO Smart DG Hub
Support quality assurance guidelines and measures Monitoring and disseminating data security standards and frameworks to solar+storage stakeholders will strengthen cybersecurity across all systems. At present, NREL, HOMER Energy, and IEC are working on microgrid standardizations that can also be scaled to apply to solar+storage. Sandia National Laboratories has also released guidelines and cybersecurity recommendations specifically for Department of Defense microgrids that have applicability at other installations.	Medium Term Sandia NREL HOMER Energy IEC Smart DG Hub

Barrier | REGULATORY LIMITATIONS ON SOFTWARE

Due to policy and regulatory limitations, behind-the-meter storage can typically not participate in ancillary service markets. To get around this limitation, developers could aggregate multiple systems and use software to control the collective group of systems in order to meet minimum size thresholds.

Solutions	Timeframe Implementation Partners
Reform Market Structures Use lessons learned from "Virtual Power Plant" pilot programs that are testing the aggregation and participation of solar+storage resources by two utilities: Con Edison, mentioned in the introduction, and Pacific Gas & Electric. Market structures are not yet in place to allow for this kind of participation by utilities, but these pilots may create a path for change. For more information regarding policy barriers and actions see the policy section of this roadmap.	Medium Term Utilities NYSERDA NY PSC NY-ISO Smart DG Hub

Barrier | CUSTOMER DATA AVAILABILITY

Granular interval meter data is necessary to determine if buildings have the appropriate load profile for energy storage. Data like this is also needed to accurately design resilient solar systems that will maximize savings. However, buildings without a high peak demand (500 kW or more) are not required to have interval meters installed. Even when interval meters are available, deciphering mass amounts of data can be difficult and time consuming when it is not available in a user-friendly format. This is particularly true for municipal buildings in NYC that rely on the Energy Cost Control and Conservation (EC3) tool to download interval data.

Solutions	Timeframe Implementation Partners
Increase Use of Smart Meters Support the roll out of advanced metering infrastructure (AMI), which is needed to capture this granular energy data. Con Edison has committed to rolling out 3.5 million smart meters that are green button enabled by 2022 for all customers.[40]	Near Term NYSERDA Utilities Smart DG Hub
Enact Full Green Button Implementation for All Account Classes Green Button implementation ensures that metered used by energy service providers is available securely and privately to customers. Making this data available to all account classes will allow the residents of New York to better understand their energy usage and ways in which resilient solar can integrate into their energy profile.	Near Term NYSERDA Utilities Local Governments Smart DG Hub
Increase accessibility of energy data Encourage NYC to update the EC3 tool to provide interval data in a simple, user-friendly format. Other municipalities facing the same challenges should take similar actions in order to ensure easy data collection for critical infrastructure facilities that are municipally managed.	Medium Term DCAS Smart DG Hub

[40] https://www.coned.com/2016-rate-filing/pdf/testimony-exhibits-gas/09-ami-panel-exhibits-ami-001-ami-005.pdf

Resilient Solar PV: Economics

Resilient solar systems can deliver electricity and utility bill savings outside of critical periods, unlike traditional backup generation. However, the initial capital costs for solar+storage systems remain high in contrast to traditional backup generation. A recent analysis by GTM Research indicated that a 100 kW solar PV system paired with a two-hour 100 kW battery system would cost approximately $500,000 before incentives.[41] At present, these costs can be recouped through two primary avenues:

I. **Revenue generation:** Resilient solar systems can generate revenue savings through a variety of sources. The use of batteries can decrease the intermittency of on-site PV, and lower peak load, leading to demand charge reductions. Additionally, these systems can be compensated through utility or NYISO programs for demand response and ancillary services, in some ISO territories.[42] For a more detailed overview of opportunities, please see the Economics and Finance factsheet.

II. **Incentives:** Federal and state incentives may also substantially reduce costs for the deployment of solar+storage systems. The federal investment tax credit (ITC) can be applied to storage when installed with a solar PV system, though some studies have found foregoing the ITC for storage is more advantageous for some customers.[43] New York City also offers a property tax abatement for solar, in addition to bonus incentives from NY-SUN for the addition of storage. Storage is not eligible for the property tax abatement. For a more detailed overview of opportunities, please see the Economics and Finance factsheet.

Over the past few years, the costs of both solar PV and energy storage have declined dramatically and the trends are continuing. Lithium-ion battery prices have decreased from $1,500/kWh in 2005 to under $500/kWh in 2015.[44] Solar PV prices have declined 70% over the last decade, driving higher volumes of installations.[45] Given these cost reductions, the economics of solar+storage projects will continue to improve. Current market prices suggest that solar+storage systems may have already achieved retail rate grid parity in Hawaii, and will in other utility territories with high demand charges or appropriate tariff structures in the near future.[46] By 2021, GTM Research projects 19 U.S. states will have attractive commercial energy storage markets, compared to only 7 states in 2016.[47]

Innovative financing options have enabled commercial customers to install solar+storage through no-money down models such as leases and power purchase agreements. In these cases, the solar+storage systems are owned and operated by a third-party, and the host-site pays the third-party provider for the energy services provided by the system. Currently, almost 50% of solar+storage systems in New York are financed through third-party models.

[41] Manghani, R. (December 2014). GTM Research. The Future of Solar+Storage in the U.S.
[42] Most distributed solar+storage systems on the NYISO grid will not qualify to operate in ancillary service markets because they will be below the 1MW size threshold.
[43] Sussman, M and Lutton, J. (November 2015). Greentech Media. The Economics of Solar, Storage and Solar-Plus-Storage. http://www.greentechmedia.com/articles/read/The-Economics-of-Solar-Storage-and-Solar-Plus-Storage.
[44] NY-BEST. (January 2016) Energy Storage Roadmap for New York's Electric Grid
[45] SEIA http://www.seia.org/research-resources/solar-industry-data
[46] RMI – Grid Defection: http://www.rmi.org/electricity_grid_defection
[47] Munsell, M. (July 2016). GTM Research. Commercial Energy Storage Economics Will be Attractive in 19 US State Markets by 2021.

Even with these signs of progress, payback periods remain longer than desirable for residential and commercial projects and not all facilities are able to easily take advantage of existing financing options, incentives, or revenue opportunities. For example, debt financing provided by developers or banks or has become more common for solar PV, but not for battery storage. The DG Hub's solar and storage cost survey completed in 2015, indicated that commercial solar+storage payback periods in New York average nine years.[48] As the resilient solar market continues to mature and broaden, these payback periods will shorten, particularly as additional revenue streams such as ancillary services become available to distributed generation. Including the value of resiliency into the cost calculus can accelerate the pace of solar+storage reaching price efficiency.

Solar+storage systems can provide a number of different services for both host-sites and the grid, but it is currently difficult for systems to be compensated for multiple revenue streams. Demand charge management remains the most consistent avenue for solar+storage systems to provide value across utility territories. Residential and small commercial accounts often do not have demand charges as part of their utility bills, and thus the Smart DG Hub's market research indicates that on average these systems do not payback in New York under existing conditions.

The Reforming the Energy Vision (REV) process is working to spur clean energy innovation through tariff and policy reform, particularly through the Locational Marginal Price + Distributed Energy Resource (LMP+D) proceeding, which will determine how to compensate distributed resources like solar +storage. This will be an important step forward in improving the economics of distributed generation in New York City. In parallel with this activity, addressing a number of the barriers listed above, can support the development of a sustainable resilient solar market in New York.

[48]http://cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DGHubSolarandStorageCostSurveyResults.pdf

Using Incentives to Foster Storage Deployment

Solar is supported through the NY-Sun Megawatt Block program; however, New York currently does not have a stand-alone incentive program for storage.[1] California and Germany were able to spur the growth of storage through innovative incentive programs. California's step-down schedule for its incentive is similar to elements of the existing Megawatt block program for solar in New York. A stable, long-term incentive mechanism can send a signal to industry and financiers that storage development will be encouraged in New York. **Programs developed for New York should also consider targeting systems that provide emergency power, which are not a feature of the programs below.**

California's Self Generation Incentive Program

California's ratepayer funded SGIP program began in 2001 with the primary goal of reducing peak loads. In 2011, California's legislature reframed the program to focus primarily on encouraging greenhouse gas reductions. Eligible technologies for the incentive program include renewables and advanced energy storage. Currently, $83 million dollars are allocated to the program annually until 2019. Recently a bill doubling this amount was signed into law by the CA governor.

This money is awarded to developers through an application process. Storage systems can receive an incentive of $1.31/watt, with a step-down incentive schedule of 10% per year. The program has an incentive ceiling of $5 million per project. Incentives are paid upon project completion, but delivery can vary based on the size of the project. Larger systems can receive a portion of the incentive upfront and a portion through a five-year kWh performance payment. Residential systems can only receive incentives if they demonstrate they are providing a grid service; this means backup only systems are ineligible. An additional 20% incentive can be applied to eligible distributed generation paired with storage systems from California suppliers. Storage is supported through SGIP as a stand-alone application or paired with other forms of distributed generation. To date, SGIP has supported 280 storage projects, totaling 22 MW.

- California,Center for Sustainable Energy: SGIP Program Overview
- PG&E: SGIP Handbook
- California Public Utilities Commission: SGIP Residential Clarifications

Germany's Solar+Storage Program

In 2016, Germany announced 30 million Euros in funding to support solar+storage projects through 2018. This funding expanded an existing 50 million Euro program from 2013, which was scheduled to sunset. The incentive supports new solar+storage facilities, or retrofits for solar PV systems installed after 2013.

The program offers low-interest loans through retail banks for up to 30% of the battery system's cost for battery systems under 30 kW with credit enhancements from Germany's state-owned bank. In order to receive the incentives, the system must not feed power into the grid during the mid-day system peak, and must limit total grid exports to 50% of generated electricity. The initial 2013 program supported approximately 19,000 residential installations.

- Renewable Energy World: Solar Storage Set Market Set for Rapid Growth (Historical Program)
- KfW Bank: 2013 Program Launch Information
- PV Magazine: 2018 Program Extension Information

[1] Up to $50,000 in bonus incentives are available for large solar projects which integrate storage, but NYSERDA has indicated this incentive will need to be modified in order to attract more participation. For more information see the Economics and Finance Factsheet.

Barriers and Solutions

A number of barriers still exist despite continued cost reductions and changing financial landscapes. The barriers outlined below must be addressed in order to encourage increased deployment of resilient solar on New York facilities.

Barrier I HIGH PROJECT COSTS

Project costs for new solar+storage projects or retrofits remain out of reach for many host-sites. These costs are partially driven by high balance of system costs (BOS) (see Introduction and Policy sections.) In spite of these limitations, solar+storage systems can provide demand savings and emergency backup for commercial facilities that may allow the building to recoup project costs. Many facility managers may not be familiar with the different opportunities available for their buildings to save on energy costs using solar+storage, or opportunities to finance these systems. However, many existing revenue streams are not easily accessible to distributed energy projects. For example, NYISO currently has a 1 MW limit for participation in its ancillary services markets, which most solar+storage projects would not clear without aggregation. This threshold could be lowered to accommodate on-site distributed energy projects analogous to the 100 kW capacity limit imposed on the PJM ancillary service markets. FERC has released a Notice of Proposed Rulemaking on supporting the integration energy storage into wholesale markets and promoting greater participation of distributed energy resource aggregators.

Solutions	Timeframe Implementation Partners
Facilities Manager Education and Outreach Buildings with appropriate load profiles can see impactful utility bill savings with the installation of solar+storage systems. This could result in improved payback periods compared to state or national averages. Facilities managers at critical infrastructure sites and other locations which have appropriate load profiles as identified by feasibility assessments by the Smart DG Hub, the NY Prize program, and others should be targeted for outreach about resilient solar opportunities. Trainings and outreach could be offered as a complement or programmatic extension to the existing PV Trainers Network Program which focuses on disseminating best practices for solar PV. The NY Solar Map can be used to identify and target feasible host sites for educational efforts.	Near Term Smart DG Hub PV Trainers Network NYSERDA Energy industry Commercial Real Estate Associations and Partners (e.g. BOMA, REBNY) New York Prize NY-BEST Journalists
Financial Support for Public Facilities Public and non-profit facilities can not directly take advantage of available tax incentives for solar+storage. These incentives contribute to lowering project costs. Public facilities can be financially constrained, but may provide the most societal benefit by hosting a resilient solar system. Targeted grant, bond or loan programs at the state or local level could assist in financing resilient solar projects. The New York Power Authority's upcoming loan program may be able to support resilient solar development. Local or state-level green bonds[49] could also support project development. More	Medium Term New York Power Authority New York City Economic Development Corporation City of New York Comptroller's Office NYSERDA FEMA Foundations

[49] https://comptroller.nyc.gov/wp-content/uploads/documents/Green_Bond_Program_Update.pdf

opportunities to access low-cost finance will need to be made available to support deployment.	Smart DG Hub

Barrier I INCENTIVE DESIGN AND PROGRAM DELIVERY

At present, incentives and tariffs in New York could be further aligned to value the benefits provided by resilient solar. The REV process is working to develop new tariffs designed for distributed generation in New York State which may incentivize solar and battery storage deployment. Nationally, energy storage is eligible for the federal 30% tax credit only when installed simultaneously with solar. The tax credit is performance based and applied over five years. A minimum of 75% of the energy stored in the batteries must be produced by the onsite solar.

Although not energy storage focused, two programs, Con Edison's Demand Management Program and Brooklyn-Queens Demand Management Program (BQDM), were designed to meet load specific locational load reductions and in turn generated strong interest in battery storage projects. In the case of the Demand Management Program, system owners may be forced to choose between serving the grid peak or reducing their facility's peak, as reductions must occur during the grid peak (between 2-6 pm) which may stifle project economics.

Altogether, the industry has responded positively to these opportunities, and further incentives and policies should support locational pricing while preserving a battery's flexibility to provide multiple services to the host site and grid.

Solutions	Timeframe Implementation Partners
Leveraging the Virtual Power Plant Project to Support Aggregation Opportunities Currently residential accounts are not subject to demand charges and therefore are unable to access one of the key savings streams provided by storage. Con Edison's REV Demonstration project, the Virtual Power Plant, is working to aggregate a number of residential solar+storage systems to bid into the NYISO market. This aggregation would exceed the 1 MW cap and enable these residential systems to be compensated for demand response and ancillary services. Findings and best practices from Con Edison's aggregation can open the pathway for additional compensation for small resilient solar projects to access new revenue streams.	Near Term SunPower Sunverge Con Edison NYSERDA Smart DG Hub

Tracking LMP+D Tariff Development Methodologies for the development of new tariffs for distributed generation are being proposed under the Reforming the Energy Vision (REV) process in New York, which is focused on transforming New York's electricity system. Tariffs in development for distributed generation are focused on compensation based on the value of the location of the system as well as its delivered electricity services (LMP+D). These revised tariffs will assist in properly valuing grid services provided by resilient solar systems. As the proposal and tariffs evolve, it is important to keep key stakeholders engaged through distilled and accessible digests of proceedings to support informed decision-making. Smart DG Hub Working Groups and the Smart DG Hub Roundtable, which is a new list-serve focused on emerging policy developments in New York State, are avenues for this dissemination of proposed policies and practices.	Medium Term Smart DG Hub NYSERDA NY-BEST PSC

Barrier I POLICY RISK

The NY-SUN Megawatt block program for solar has provided transparency and visibility into future incentives for solar. Similarly, the federal investment tax credit established step-down periods for commercial and residential systems after it was renewed last year. This visibility and stability make it easier for developers to plan for system installations and secure low-cost finance. In contrast,

No consistent storage-centric incentives are currently in place in New York. Programs exist in which energy storage can participate, but have primary goals other than supporting battery storage deployment. The programs are generally short in nature, and limit participation due to their alternative focus. The Demand Management Program and BQDM had strict timelines and performance requirements that prevented some interested customers from participating. It is unclear if similar incentives will be available to support battery storage in the future. A clear, statewide programmatic storage incentive program can help the market grow and reduce costs. The rapid growth of solar in New York State and nationwide was supported by incentive programs, which have assisted in lowering costs year over year.

Solutions	Timeframe Implementation Partners
Review of existing storage incentives Several states and countries have proposed or implemented storage incentive programs including California, Massachusetts, Hawaii and Germany. Examination of the policy design choices in these incentive programs could inform the development of a program in New York which could complement existing renewable energy policies. New tariffs resulting from REV are also expected to provide a level of market security and stability once developed.	Near Term Smart DG Hub NYSERDA NY-BEST Clean Energy Group

Outreach Regarding Storage and Existing Programs The Megawatt Block program for storage currently includes a bonus for solar systems that include storage. The Energize New York program, which facilitates New York's PACE program, has suggested that storage can be an eligible measure under their low-cost finance program. Further outreach that leverages these existing programs can serve as a bridge until incentives are developed.	Near Term Energize NY Smart DG Hub NY-BEST NYSEIA The Solar Foundation (CivicPACE for non-profits and public facilities)

Barrier I LENDER RELATIONSHIPS

Solar+storage projects are currently unable to access debt finance, which can offer a lower cost of capital to projects. In contrast, the solar industry has developed many solar-specific loan products, such as offerings by Admirals Bank and Dividend Solar, which have increased the affordability of projects. At present, there is no consumer-scale debt finance available. Commercial-scale investments have been completed by specialty finance firms for companies with established track records or host-sites with strong credit worthiness.

Solutions	Timeframe Implementation Partners
Lender Education and Outreach Local and national lenders have become comfortable lending for solar. For example, some local lenders, such as Admirals Bank, have developed unique solar financing projects to support community-based Solarize programs for rooftop solar PV across Massachusetts, Connecticut and North Carolina.[50] These successes were achieved after outreach and conversations with lenders. Lender education and outreach regarding solar+storage can help lenders become more comfortable with developing consumer debt products. Solar+storage projects can provide deeper energy savings than stand-alone PV projects and reduce the risk of operational downtime for host sites.	Near Term Smart DG Hub NYSERDA New York Green Bank Industry associations
Collection and Distribution of Performance Data Solar+storage is an emerging energy management solution. As such, there is limited available data on project performance over time. A concerted effort to collect project data and share it with key lenders can assist in moving debt finance towards solar+storage. The Orange Button initiative is a Department of Energy-funded grant initiative to support efforts to standardize solar performance data and make it more readily usable by third parties.	Medium Term Smart DG Hub Orange Button Initiative SunSpec Alliance The National Renewable Energy Laboratory

[50] Solar Outreach Partnership. (2013). Local Lending for Solar PV: A Guide for Local Governments Seeking to Engage Financial Institutions. Available at: http://solaroutreach.org/wp-content/uploads/2013/11/Local-Lending-for-Solar-PV-Final-Feb-2014.pdf

Project Aggregation Opportunities Individual PV projects can be hard to finance relative to the size of an average project. This can make it difficult to develop a financing package. Best practices in standardized contracts and project classes from the solar PV industry could be used to aggregate projects and access additional finance. These standardized contracts could also assist local lenders in supporting projects more readily. The New York Green Bank, for example, tends to invest in projects between $5-50 million in value, which would require a portfolio of solar+storage projects.	Long Term Industry partners New York Green Bank Smart DG Hub

Barrier I VALUING RESILIENCY

Resilient solar is unique in comparison to traditional emergency generators as it can provide value to host-facilities outside of critical periods. However, there are currently no methods of compensating the resiliency services provided by resilient solar systems to the host-site or the grid. This exclusion lowers the perceived value of resilient solar systems.

Solutions	Timeframe Implementation Partners
Cost-Benefit Analysis: Conduct and distribute a cost-benefit analysis of resilient solar systems compared to traditional diesel generator backups. Clear, succinct analysis can reduce customer acquisition costs for resilient solar and support better prepared host sites.	Near Term Smart DG Hub NY-BEST
Determine if Resilient Solar PV is a Code-compliant Option for Emergency Power: Regulations dictate the types of equipment, such as diesel or natural gas generators, that may be used to legally supply emergency power. These codes should be reviewed to determine if resilient solar meets requirements for NYC, and if not, revisions should be considered.	Near Term NYC Mayor's Office (MOS and ORR) FDNY NYC DOB NYC Emergency Management Dept. NFPA DER Industry City of San Francisco SMP Team Smart DG Hub

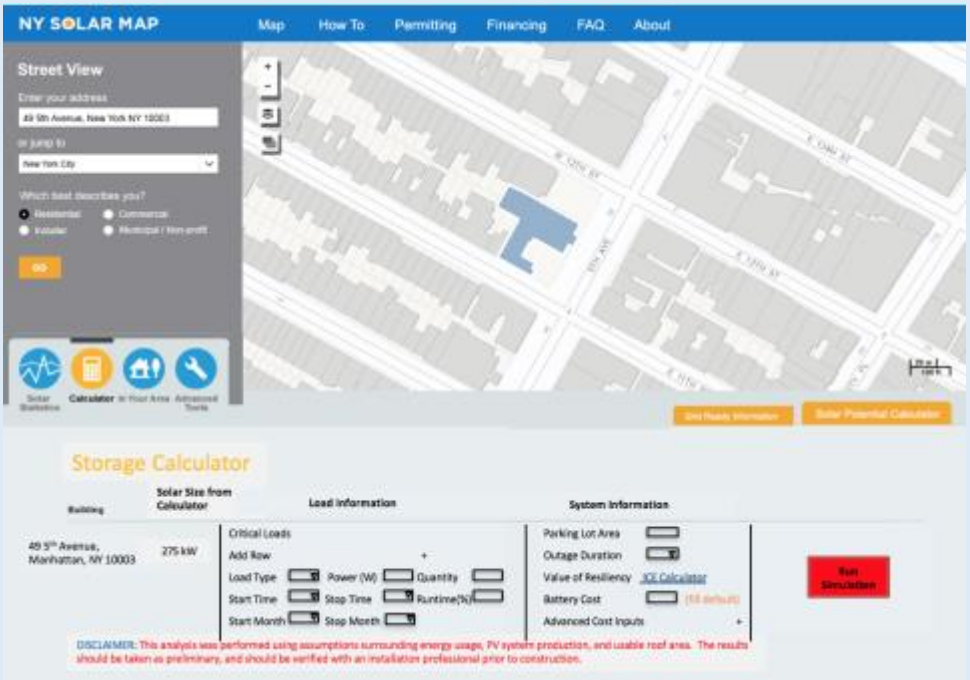
Quantification of Value: There have been ongoing efforts to quantify the value of resilient power through the Smart DG Hub and the New York Prize program for microgrids. The DG Hub will be working to develop a methodology and/or tool that quantifies the loss avoidance mechanism offered by resilient power projects. This methodology can be presented to host-sites consistently to support informed decision-making and additionally will form the basis of insurance, banking, and tax incentives. This methodology can also be leveraged for grant-making targeted at high-value resilient solar projects.	Near Term NY Prize Smart DG Hub City of San Francisco SMP Team FEMA NYSERDA DER Industry Insurance Industry
Enable Revenue Streams through Insurance Resilient solar can reduce damages and claims through property insurance to host-sites. Insurers must consistently recognize resiliency investments on infrastructure through reductions in premiums to incentivize the installation of preventative measures. Insurance industry outreach and engagement can advance this solution. There are also ongoing efforts to value climate risks through the UN ARISE initiative which includes many insurance and re-insurance industry partners.	Medium Term City of New York, Office of Recovery and Resiliency National Flood Insurance Program Smart DG Hub Insurance Industry UN ARISE

NY Solar Map Resiliency Calculator

The Smart DG Hub is currently constructing a resilient solar calculator that will be integrated into the NYSolar Map. This set of tools will give map users the ability to perform a high-level energy storage feasibility study to indicate if further investigation is warranted. Two separate analyses can be completed by the calculator: (1) energy storage sized for backup power and (2) energy storage sized for energy bill savings.

The inputs are a simple list of site characteristics that are known or easily collected. These will also be populated with default values based on common properties. The outputs will be indicators of project feasibility and will include opportunities for savings in both energy and cost.

Figure 7. Example mockup of calculator.



Resilient Solar PV: Policy

New York State and New York City have articulated their commitment to the expansion of renewable energy resources and the importance of climate preparedness and disaster recovery. This prioritization is reflected directly in the 2015 New York State Energy Plan and standards approved by the New York Public Service commission, which focus on energy reliability and resilience as core components for the achievement of New York State's aggressive target of 50% of electricity generation from renewables by 2030. This mandate will require the integration of significant quantities of intermittent renewable energy resources to the grid.[51] New York City also has ambitious targets locally, including a commitment by Mayor de Blasio to supply 100% of municipal energy needs from renewable energy and an 80% greenhouse gas emission reduction target by 2050.[52] New York City is also committed to installing 100 MWh of storage by 2020. Storage can provide two critical support functions for the integration of further renewables by firming capacity and providing resilience.

Regional Activities

The supporting role that energy storage can provide to achieve renewable energy commitments has been illustrated through the work of CUNY's NY Solar Smart DG Hub, NY-BEST, the Carbon Neutral Cities Alliance, NREL's Renewable Electricity Futures Project, and others. Clear policy guidelines and pathways are needed to encourage the development and installment of this resource to its full potential. At the state level, NYSERDA is creating the Clean Energy Fund, which once developed, will provide financial support for storage programs. Between 2016 and 2019 $24.45 million dollars are expected to be allocated to energy storage. The Clean Energy Fund will establish a series of funding resources over ten years, including bridge incentives to help distributed energy resources transition to a sustainable market. Prior to Clean Energy Fund implementation, there will be a gap in public finance to support battery deployment.[53] As of 2016, many incentive opportunities offered through utilities have been time-limited and thus have led to stops and starts in project development. In contrast, California's SGIP program has provided a longer-term, transparent support mechanism for storage and storage paired with distributed generation and has funding for 280 energy storage projects in its queue (See the incentives Case Study in the Economics and Finance Section).

In neighboring New Jersey, the Energy Resilience Bank currently provides financing support for the installation of distributed generation projects and storage on critical facilities. New Jersey's first solicitation targeted wastewater treatment plants, and supported the installation of islandable, distributed resources by covering gaps in project finance through a mix of grants and loans.[54] Targeted financial products through the Clean Energy Fund could similarly support strategic deployments on key

[51] Ecowatch. (August 1, 2016). New York Approves Clean Energy Standard Mandating 50% of Power from Renewables by 2030, available at: http://www.ecowatch.com/new-york-approves-clean-energy-standard-50-from-renewables-by-2030-1954654514.html

[52] City of New York. (July 10, 2015). De Blasio Administration Moves to Power 100 Percent of City Government from Renewable Sources of Energy, available at: http://www1.nyc.gov/office-of-the-mayor/news/478-15/de-blasio-administration-moves-power-100-percent-city-government-renewable-sources-of

[53] NYSERDA. (February 2016). Clean Energy Fund Fact Sheet, available at: http%3A%2F%2Fwww.nyserda.ny.gov%2F-%2Fmedia%2FFiles%2FAbout%2FClean-Energy-Fund%2Fclean-energy-fund-fact-sheet.pdf

[54] New Jersey Energy Resilience Bank. (October 2014). Wastewater Treatment Plant Funding Round, available at: http%3A%2F%2Fwww.state.nj.us%2Fbpu%2Fpdf%2Ferb%2FFINAL%2520-%2520WWTP%2520WTP%2520Funding%2520Round.pdf

infrastructure. New Jersey is also developing a microgrid prize program to encourage the development of islandable energy generation in addition to resilience bank finance.[55] This process is analogous to the NY-Prize program which developed microgrid feasibility studies for critical infrastructure in several communities, and will fund selected community projects.[56]

Outside of financing products, the REV process provides a unique opportunity to align rate structures to support distributed generation and energy storage. A recent report by GTM Research suggests that 19 states will have attractive markets for commercial storage by 2020.[57] This movement is driven by demand charge reductions enabled by energy storage and declining prices for solar+storage systems. However, rate structures and electricity markets can also be used to value additional services provided by solar+storage, thereby increasing economic viability. At present, distributed generation is not likely to clear the 1 MW size cap for participation in ancillary service markets for compensation by NYISO. Aggregations, such as the Con Edison Virtual Power Plant demonstration project, or a reduction in the size cap could also unlock additional value streams (see Case Study). Other states, such as Massachusetts are exploring approaches to compensate storage for peak demand services.

Peak Demand Reduction Grants in Massachusetts

In July 2016, Massachusetts solicited proposals for a new program which will provide grants to reward distributed energy projects for their contributions to peak demand management. The grant program is an outgrowth of a study commissioned by the Massachusetts Department of Energy Resources and the Massachusetts Clean Energy Center to investigate the benefits and impacts of storage for the state. The Peak Demand Reduction program is part of a suite of recommended policies and programs for storage under the Governor's Energy Storage Initiative.

The Peak Demand Reduction grant program will offer $4.5 million in grant funding to projects which defer transmission and distribution investments or contribute to peak electricity or gas demand reduction for specific areas of the distribution system or manage seasonal system peaks. The grants are limited to 50% of project costs and can range from $10,000 to $3,000,000 depending on the grid management issue addressed. The program application period closed in August 2016. The Peak Demand Reduction program represents a strategy for valuing grid benefits for distributed resources.

Massachusetts Department of Energy Resources: Peak Demand Reduction Grant Overview

Grant Program Application Details

Massachusetts Energy Storage Initiative Initial Study

[55] Microgrid Knowledge. (August 12, 2016), New Jersey To Offer Funds for Community Microgrids, available at: https://microgridknowledge.com/community-microgrids-3/ and New Jersey's Clean Energy Program, : http://www.njcleanenergy.com/commercial-industrial/programs/der-microgrid-feasibility-studies
[56] NYSERDA. (2016). NY-Prize Program, available at: http://www.nyserda.ny.gov/All-Programs/Programs/NY-Prize
[57] GTM Research. (July 2016) Commercial Energy Storage Will Be Attractive in 19 Markets by 2021, available at: http://www.greentechmedia.com/articles/read/commercial-energy-storage-economics-will-be-attractive-in-19-us-state-marke

Local Activities

Nationally, there has been an increased interest in energy storage as prices have declined and more technologies have become commercially available. At the local level in New York City, permitting processes are still being developed for battery chemistries and technologies. Currently, projects that rely on lithium-ion batteries or new or uncommon battery chemistries face delays in project approval and implementation. However, significant progress has been made to increase transparency in permitting procedures, and efforts to streamline processes for chemistries such as lead acid are being made as permitting agencies gain more familiarity with battery storage. This information is available in the Smart DG Hub Permitting Guide. Further guidance on the acceptance of lithium-ion and a handful of other chemistries, including vanadium redox batteries, is expected in 2017 upon the completion of the Con Edison and NYSERDA Battery Testing Program.

The NYC Solar Partnership (Sustainable CUNY, the Mayor's Office of Sustainability and NYC Economic Development Corporation) is working with the Smart DG Hub to develop streamlined permitting protocols for batteries and was instrumental in the City setting a storage goal that is expected to further trigger the sustainable development of the New York City resilient solar market. This could have grid benefits for congested areas of the grid within the City such as Brooklyn-Queens and provide additional protections for facilities in the event of disasters. To date, the City of New York has installed 89.8 MW of solar as of December 2016. Its 250 MW target was recently expanded to 1 GW by 2030.[58] The NYC Solar Partnership is incorporating storage elements into both the Solarize NYC (group purchasing) program as well as the Shared Solar NYC program, providing opportunities to promote the development of resilient solar projects that can help to complete the remaining balance of the goal.

The New York City Department of Citywide Administrative Services (DCAS), with assistance from the NYC Solar Partnership, is piloting energy storage projects through Innovative Demonstrations for Energy Adaptability (IDEA), leading the implementation of the municipal goal of 100MW of solar, and developing a new resilient solar program that will combine solar+storage for targeted critical infrastructure. Working with the NYC Emergency Management, these agencies are incorporating principles of municipal and community resilience into the installation and distribution of distributed energy resources. The City has set a target of 100 MWh of storage by 2020. The City's leadership is an important signal to facility owners regarding the feasibility and achievability of resilient solar projects in New York, and provides a logistical and procedural framework for private-sector projects.

[58] NY Solar Map – Solar Statistics, New York City. (August 31, 2016), available at: https://nysolarmap.com/

Con Edison and NYSERDA's Support for NYC's Storage Market

Incentives and mandates often spur new markets, and this has largely been the case for states with growing energy storage markets across the country. California's energy storage market, the largest in the country, is supported by the SGIP program. In New York, interest in storage surged in 2014 when Con Edison and NYSERDA launched the Demand Management Program, which although not energy storage focused, paid $2,100/kW for battery storage projects providing 50 kW or more in peak demand reductions during targeted peak periods. The program was a time-limited offering requiring projects to be operational by June 1, 2016, and the New York storage market continues to develop. Many storage providers plan to participate in Con Edison's Neighborhood Program, which will provide payments to projects that reduce customer loads in targeted neighborhoods, initially, specific communities within Brooklyn and Queens.

With increasing numbers of energy storage projects, NYC permitting agencies have found limited safety information is available to aid in the review of these rapidly evolving technologies. In another collaborative effort, Con Edison and NYSERDA are partnered on a Battery Energy Storage (BESS) testing program to address this knowledge gap. In January 2016, Con Edison and NYSERDA engaged DNV GL to test an initial set of lead acid, lithium ion, and vanadium-redox flow chemistries for which vendors were seeking permitting. A results report, released in early 2017, will help permitting agencies better understand the safety risks associated with energy storage systems and train first responders. This information is critical for the creation of rules and regulations that guide the installation of storage in urban environments. Once finalized, the Smart DG Hub will develop a series of training materials based on the results for key stakeholders.

Barriers and Solutions

A number of barriers still exist despite ongoing policy developments. The barriers outlined below must be addressed in order to encourage increased deployment of resilient solar on New York facilities.

Barrier I ABSENCE OF POLICY TARGETS

New York State must achieve 50% of electricity generation from renewable resources by 2030. Reliability and resilience are also core components of the 2015 State Energy Plan. In spite of this, there are no formal targets for storage at the state-level. The lack of targets increases the perception of risk to the market. Though the REV process will presumably result in market and rate reform that will encourage storage development (see Economics section), the presence of targets would send a signal that storage is a long-term priority or a technology type that will be supported by the state. New York City has taken an important step in setting a local target and committing to aligning its internal processes to support the development of the targeted 100 MWh of storage.

NY-BEST, a Smart DG Hub partner, completed an initial analysis on the level of distributed storage necessary to support the increases in renewable resources implied by the state's targets. This initial work built-off the work of another key Smart DG Hub project partner, NREL, who released a Renewable Energy Futures study for the United States.

Solutions	Timeline Implementation Partners
Policy Targets and a Comprehensive Study on Storage for the Grid A comprehensive study is needed before appropriate state level policy targets can be developed to address grid needs. The Renewable Futures study was a comprehensive look at the entire United States, and a New York specific study, which takes into account the potential implications of REV, has not been completed. New York City has already taken the lead by establishing at 100 MWh target. In addition to state targets, local targets could be refined or adapted to address particular storage technologies or targeted at certain facility types. Key questions for such a study should include the amount of storage necessary to achieve 50% renewables, provide grid reliability and resilience, and relieve transmission and distribution investments. Prior to the completion of a large scale study, policy targets for subsets of critical infrastructure or for facilities within Hurricane Sandy-affected zip codes could be developed.	Near Term NYSERDA DPS NY-BEST NYC Mayor's Office Smart DG Hub
Tracking Resilient Solar Deployment Developing policy targets necessitates an understanding of how many resilient solar+storage projects are interconnected to the grid or proposed for interconnection. The Smart DG Hub is working to develop a Tracking Protocol for these systems, which will be integrated into the NY Solar Map. Outreach and education will be needed to publicize the availability of these metrics and encourage their use to plan for staffing needs at permitting agencies.	Near Term Sustainable CUNY Smart DG Hub NYSERDA Industry NYC DOB

Barrier I EDUCATION AND OUTREACH

As the solar+storage marked grows and processes are established, so will the need for additional training. Educational opportunities for New York City stakeholders should be provided to learn about resilient solar and the benefits it can provide to host facilities. Currently end users can find information on resiliency on the NY Solar Map and Portal under Solar+Storage and consumers can connect with qualified, active solar installers. With the expansion of the storage market in particular, installers will need technical trainings as well as familiarization with varying jurisdictional processes. NYSERDA maintains a solar installer list, but a similar list does not exist for storage developers. Training protocols will need to be continually updated due to rapidly advancing technology. Up to date trainings will aid facility and site managers, and municipal staff understand the economics and basic operations of storage outside of those offered by manufacturers.

There is limited inter-industry coordination between solar+storage providers. Most developers install only storage or solar, which could result in missed project opportunities where solar+storage is an appropriate solution.

Solutions	Timeframe Implementation Partners
Expand Training Programs The Smart DG Hub and other organizations are already beginning to address the knowledge gap around storage by developing educational fact sheets and reports, and this work can be expanded to include further training. The existing PV Trainers Network program (PVTN) has successfully trained thousands of municipal officials and community stakeholders statewide on the basics of solar energy. This training program could be leveraged to add additional information outlining information for resilient solar. Discussions of such an expansion for NYC Department of Citywide Administrative Services staff is already underway. There are also opportunities to include a "Storage 101" in trainings for community-led group purchase programs under the NYSERDA Community DG grant program. Smart DG Hub has already developed guidance for communities and organizers of Solarize programs for including storage in their solicitations. In 2017, the Smart DG Hub will be actively working to produce additional trainings, webinars and factsheets, which can be used by New York State stakeholders as educational and outreach tools. The intent is for these documents to reach key stakeholders in the public, residential and commercial solar markets.	Near Term PVTN NYSERDA Community DG Program – "Solarize" Smart DG Hub NY-BEST Clean Energy Group PV Trainers Network NYC Solar Partnership

Qualified Installer Listing Consumers currently have access to a qualified installer listing for solar PV. Installers on this listing are then eligible for NYSERDA incentives. At present, no analogous structure exists for resilient solar projects. NYSERDA-developed research could assist in customer education and protection. At present, there are listings of storage providers through the NY-BEST supply chain database.	Near Term NYSERDA NY-BEST NYC Solar Partnership Smart DG Hub
Industry Communications Solicitations for Requests for Information (RFIs) and Requests for Proposals (RFPs) from municipal agencies, the private-sector and state agencies may benefit strongly from integrated solar+storage responses. This may require expanded distribution lists for RFI and RFP communications, and increased use of RFP guidance for storage. Existing solar industry groups or roundtables could also work to expand their member lists. To date, the PV Trainer's Network and DG Hub have been offering on-call technical assistance to address these needs, as they arise.	Near Term Sustainable CUNY Installer Roundtable NYSERDA NY-BEST NYSEIA Clean Energy Group NYC Solar Partnership Smart DG Hub

Barrier I PERMITTING PROCESSES

At present, permitting for solar+storage projects can add significant time to project completion. According to market research conducted by the Smart DG Hub, soft costs, which include non-hardware costs such as permitting and interconnection averaged 27% of total installed costs for commercial systems. This is analogous to the 25% contribution of soft cost reported by Department of Energy-funded research for solar-only systems.[59] Survey results also indicated that permitting was perceived as the top soft cost driver for New York State.

Clarification and streamlining of procedures for solar+storage not only impacts costs for host sites, but it can also save valuable staff time for New York City departments and installers. The New York City Department of Buildings and the Fire Department have both made significant progress in working with the Smart DG Hub to clarify permitting processes for energy storage projects, and providing specific guidelines for lead-acid batteries. Guidelines or a standards-based permitting approach are necessary to establish clear permitting requirements and timelines for battery chemistries beyond lead acid.

[59] Rocky Mountain Institute. (2014). *SIMPLE: Solar Balance of System Costs. Produced for the U.S. Department of Energy Sunshot Initiative. Available at:* http://rmi.org/simple, in which soft costs are defined as customer acquisition, permitting, inspection and interconnection and installation labor.

Solutions	Timeframe Implementation Partners
Permitting Checklist and Transparency for Approved Chemistries At present, Con Edison and NYSERDA have established a battery testing program, which will help government agencies better understand battery behavior for the tested chemistries, including lithium-ion (see Case Study). The Smart DG Hub, NY-BEST and other key stakeholders should work with these agencies to ensure the transparency and availability of information about changes and updates to procedures through revisions to the Smart DG Hub Permitting Guide, factsheets, LISTSERVs, and other forums. A first step could be disclosure of acceptable battery chemistries and their applications (i.e. indoor, outdoor, residential and commercial) as they are approved.	Near Term Smart DG Hub NY-BEST NYC DOB FDNY Con Edison NYSERDA NYC Solar Partnership
Streamline Permitting Processes In the case of solar PV, the NYC Solar Partnership identified and implemented opportunities to streamline permits for rooftop PV systems and Sustainable CUNY used this model to create a New York State Unified Solar Permit for systems meeting certain requirements. FDNY is creating a 'Sustainability Unit' to provide dedicated support to battery storage and other emerging sustainability technologies. Processes for solar+storage should be investigated that expedite review periods, encourage consistency in permitting requirements across the state, and account for projected increases in permitting throughput. The Smart DG Hub Policy Guidelines offer a first step towards addressing these areas. Additional attention should be dedicated to creating a separate, streamlined process for small (residential and small commercial) systems that are within specified thresholds, identified by code or agreed to by stakeholder consensus.	Medium Term NYC DOB FDNY Smart DG Hub NYSERDA NY-BEST New York State AHJs NYC Solar Partnership

Barrier I INTERCONNECTION PROCEDURES

At present, solar+storage projects are allowed to interconnect and net meter. The New York Standardized Interconnection Process provides clear timelines for projects throughout the state. Con Edison collaborated with the Smart DG Hub to clearly outline its procedures in the Smart DG Hub Permitting Guide.

However, there are opportunities to streamline processes for smaller scale systems, as has been the case for the fast-track interconnection process developed for solar PV. In the Smart DG Hub's survey of

solar+storage market participants, interconnection ranked second in terms of driving soft costs after permitting.

Solutions	Timeframe Implementation Partners
Development of fast-track interconnection processes Akin to residential PV, there could be opportunities for streamlining interconnection procedures for small-scale solar+storage projects, or solar+storage projects meeting certain technical parameters. This could also help utilities to respond to increases in project volume as the cost of batteries continues to decline. For example, solar PV systems under 50 kW do not require an inspection. Removing this requirement for small scale storage systems, if deemed safe, could streamline interconnection for residential and small commercial storage. The Virtual Power Plant REV Demonstration project, which seeks to aggregate a fleet of residential solar+storage systems could lay a framework for developing a fast-track interconnection process.	Medium Term ConEdison Smart DG Hub SunPower-Sunverge Other state utilities

Barrier I LIMITED INTEGRATION INTO EMERGENCY PLANNING

New York City is actively working to identify and harden critical infrastructure against future storms and other disasters that could lead to grid outages. Opportunities to improve resiliency are identified in the City's *A Stronger, More Resilient New York* as well as *One New York: The Plan for a Strong and Just City*. The use of solar+storage as a means to address the need for emergency power is not a specific focus within emergency planning agencies, but solar+storage could be incorporated into existing plans. Across the state, it is unclear if local codes allow for the use of resilient solar to satisfy emergency power requirements. At the federal level, resilient energy systems should also be more broadly accepted as a means of mitigating hazards for FEMA grants.

Solutions	Timeframe Implementation Partners
Integrated Preparedness Planning Resilient solar can be an economically viable solution for a facility's emergency management strategy. Greater outreach and communication will be needed to introduce resilient solar as an alternative to traditional backup generation to be incorporated on a wider scale into public and private sector emergency response plans. Thorough review of electrical, building and fire codes should be conducted to determine if solar+storage systems meet emergency power system requirements, and amended where appropriate to allow for resilient solar to meet emergency power needs such as exit sign lighting, fire alarm systems, and other critical loads. After this	Medium Term Smart DG Hub Industry New York City Emergency Management Dept.

review, diversification of emergency power sources, outside of traditional generator should be encouraged. The Smart DG Hub can also track new resilient solar installations through the Solar Map, and could include information of relevance to the cities, such as if the backup power from resilient solar can be used to support larger community needs during an emergency.	
Leverage Resilient Solar Tracking Layer of NY Solar Map As more data regarding the location of resilient energy systems are available, City agencies can incorporate sites into emergency and evacuation planning for the City. It is possible that these systems could qualify for hazard mitigation grant funding from FEMA if cost-effective. Smart DG Hub could leverage lessons learned from its economic and feasibility assessments to assist NYC agencies such as DCAS and NYEM understand resilient solar opportunities.	Medium Term Smart DG Hub NYC Emergency Management Dept. DCAS

Conclusion and Next Steps

The frequency and costs associated with power outages are increasing. Solar + storage could present a cost effective and environmentally friend solution to mitigate the impacts of disruption. As outlined in this roadmap, creating a streamlined and clear trajectory for this technology will further facilitate the development of a more resilient, economically efficient, and cleaner grid.

The Reforming the Energy Vision proceedings, exponential solar market growth, and continued industry innovation make it a crucial period to strive for advances in the New York distributed energy industry. The Smart DG Hub will continue to be engaged and provide educational resources to encourage further deployment of solar+storage, foster a collaborative platform for encouraging distributed generation development, and connect leaders and experts across New York State. While the barriers and solutions outlined in this roadmap represent a series of next steps to move the industry forward, the DG Hub Team recognizes that the market and policy context can change rapidly.

Given this, the Smart DG Hub will continue to keep stakeholders informed through the Smart DG Hub Roundtable, and will preserve this Roadmap online as a Living Document. As projects are implemented or policy contexts change, the team will work to update the Roadmap on a quarterly basis. The DG Hub will disseminate the roadmap through trainings, webinars and discussions with policymakers.

Throughout 2017, the Smart DG Hub will launch a series of outreach and educational efforts designed to advance core elements of this roadmap and increase stakeholder knowledge of resilient solar opportunities. Outreach tools will include the resilient solar calculator and a webinar series. There will be a particular emphasis placed on identifying pathways by which resiliency can be monetized. It is now clear that companies that insure property and business interruptions, as well as commercial mortgage banks, and government agencies such as FEMA, ultimately bear the costs of the losses associated with outages. As a result, in the fourth quarter of 2016, the Smart DG Hub began assembling a 'Value of Resiliency' Team that engages the insurance, banking, and tax sectors to identify how the value of resiliency can be added to the overall value stack of resilient systems. In 2017, this team will focus on developing potential revenue stream recommendations for solar+storage projects such as: engineering-based tax incentives, reduced insurance premiums, rebate programs, favorable lending terms and alternative third-party funding solutions.

We encourage you to reach out through dghub@cuny.edu and collaborate with the Smart DG Hub Working Groups and Project Team to foster a resilient energy future for New York City and State in 2017 and beyond.