Smart DG Hub

Storage 101

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Sustainable CUNY of the City University of New York
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Storage 101

Energy storage technologies, including but not limited to batteries, have the ability to provide backup power (resilience) when paired with solar or other distributed generation (DG). In addition, storage can play several roles including reducing consumers' electric bills, easing grid congestion, delivering grid services, and furthering economic development. Nationwide, storage is expected to grow to 11.3 Gigawatts (GW) of installed capacity by 2020 and attract billions in investment – providing power on demand and boosting jobs.

This document is intended as a primer for interested individuals from the public and private sector as well as consumers, and is intended to provide a baseline level of knowledge and understanding of energy storage for those new to this field. The introductory section provides general background information, while the FAQ sections are organized into four key areas – Hardware, Software, Policy, and Economics. This information is also designed to complement the DG Hub's reports and fact sheets and NYC Resilient Solar Roadmap, and links are provided throughout to these as well as other external information resources.

Contents

Why Energy Storage

While energy storage is not a new technology, the use of energy storage systems (ESS) coupled with solar or other distributed generation (DG) for emergency backup power and energy management, is a new application of the technology, with significant implications. Policy makers and the energy industry see enormous market potential for energy storage because of its flexible capacity to both absorb and dispatch energy in locations and time periods where it is most needed, and to operate both in conjunction with or independently of the grid. This versatility makes ESS a critical tool to help achieve broader energy sustainability, grid modernization, and resilience goals including overcoming constraints inherent to renewable energy sources and increasing the penetration of renewable energy onto the grid, replacing traditional and costly investments needed to upgrade the grid, and enabling buildings to operate when the grid is down.

For a reference guide to the technical terms used throughout the document, please reference the DG Hub glossary.

Energy Storage Types

Energy storage, in particular batteries, has traditionally been used for familiar purposes such as consumer electronics, electric vehicles, and for backup power for sensitive facilities such as data centers that require an uninterruptible power supply (UPS). However, energy storage used in buildings for energy management purposes, often referred to as "stationary storage", is a newer use case and the market for this application is still nascent in most of the US. Stationary storage is typically used to manage individual buildings' electricity needs during both normal operations and power outages; as well as to support utilities, regional transmission organization (RTOs), and independent system operators (ISOs) in operating the electric grid. The full range of uses and benefits is presented further in the Capabilities and Benefits section.

This document and the CUNY Smart DG Hub's storage resources focus on battery ESS (BESS). However, a brief overview of various types of energy storage is provided for context (for a more comprehensive list, click here):

- **Electrochemical storage** refers primarily to batteries and fuel cells. Until recently lead acid batteries were the most common type of chemistry. However, as lithium ion batteries became more commonplace in consumer electronics and cars, it is now the most utilized chemistry. Other battery chemistries on the market include: nickel cadmium, flow batteries, sodium sulfur, and electrochemical capacitors, among others.

- **Thermal energy storage** converts surplus electrical energy into heat or cold that can be used at a later time. It is most often used in HVAC applications, especially to provide air conditioning and refrigeration, but is not typically used to provide back-up electricity. In some markets such as New York City thermal storage is widely deployed, and it has great market potential across the commercial building market in the US.

- **Mechanical energy storage** encompasses a variety of technologies. Some common types are pumped-storage hydroelectricity, compressed air, and flywheels. These technologies are typically used for stationary, utility-scale applications.

Solar+Storage, Resilient Solar, and Microgrids

The terms Solar+Storage, Resilient Solar, and Microgrids share similarities but encompass different features. Typical grid-tied solar PV systems, without added storage, are required to automatically stop operating during grid outages to avoid feeding electricity onto the grid. This function is known as "anti-islanding" protection and is designed to prevent damage to the grid as well as injury to utility repair teams. "Resilient Solar" (or "Resilient PV") refers to solar coupled with storage or another type of resilience-enabling technology that can disconnect from the grid and allow it to continue operating during grid outages.

The term "microgrid" refers to an electrical network, typically across a small number of buildings, that can disconnect from the central power grid and operate independently using its own power generation. Microgrids can utilize solar+storage, although other technologies can also be used including combined heat and power, fuel cells, and diesel or natural gas generators. Many of the proposed microgrid projects submitted under New York State's NY Prize Competition include storage components.

For further information on resilient PV, see the Smart DG Hub Hardware Fact Sheet and the Smart DG Hub Retrofit Fact Sheet.

Capabilities and Benefits:

The uses and benefits that energy storage provides can be encompassed in the following categories, and additional information on specific applications can also be found here:

1. **Resilience/emergency power:**
    - Provides backup power during emergencies and grid outages for a facility's critical loads to enable the continuity of mission-critical operations and reduce business interruption losses.
    - Enables energy independence by reducing dependence on centralized power grid.
2. **Renewable energy support:**
    - Smooths out gaps in energy supply that stem from the intermittent output of solar and wind energy supplies.
    - Extends the availability of clean power supply when needed, for example during peak demand periods, or at night when solar is not generating.
3. **Demand management:**
    - Reduces the high costs associated with demand spikes on electricity bills through peak shaving.
    - Adds flexible, on-demand reserve capacity to grid electrical supply.
    - Facilitates load shifting to take advantage of lower prices during off-peak time periods for customers with Time of Use (TOU) electric rates.

- Generates additional revenues through participating in Demand Response programs (see page 7 of the DG Hub Economics & Finance Fact Sheet for descriptions of demand response programs available in NY).

4. **Grid services and support:**

    - Reduces reliance on expensive coal and gas-fired "peaker plants" that are often high-emissions source of back-up power used by utilities to meet short periods of high demand.
    - Reduces costly investments in new transmission and distribution infrastructure.
    - Provides ancillary services for the electric grid's stability such as frequency and voltage regulation.

Market Segments

Storage installations fall into three general size and customer categories:

- **Residential and Small Commercial (e.g. 1-50 kW/kWh):** Smaller storage systems are geared for mass consumers such as single-family homes or small commercial facilities and typically tied to the customer's electric meter, referred to as a "Behind the Meter" (BTM) installation. They mainly function to provide emergency backup power, as an alternative or addition to diesel or gas generators (gensets), and as an enhancement to solar PV systems.
- **Commercial, Industrial and Institutional (C&I) (e.g. 25-3,000 kW/kWh):** Larger commercial, institutional, and industrial users commonly employ medium to large systems for emergency backup as well as peak load/demand management purposes. Larger electric consumers typically pay a large portion of their energy bills to demand charges, whereas smaller consumers do not, and energy storage is the most suitable technology to reduce these demand charges.
- **Utility- or Community-scale (e.g. 1,000+ kW/kWh):** Large-scale or utility-level energy storage may also be used for emergency backup and demand management, and beyond these consumer-oriented uses, also for support and enhancement of the electric grid as outlined above. Typically utility-level storage is referred to as "Front-of-Meter" (FTM), in contrast to consumer-level BTM, as it is not tied to any single customer's electric meter.

The following FAQ sections are organized into four areas – Hardware, Software, Policy, and Economics – and provide more in-depth information within each of these categories. This information is also designed to complement the DG Hub's reports and fact sheets and NYC Resilient Solar Roadmap, and users are encouraged to explore and use these additional resources.

Hardware

The solar+storage hardware market is a dynamic environment with technologies rapidly evolving to meet new demands from various consumer segments, driving the market to provide hardware options that are more flexible and customizable.

Lead acid batteries have historically been the most common chemistry especially in UPS backup applications, but lithium ion is poised to take most of the market share in the foreseeable future as the cost of this technology is coming down, and because lithium-based batteries are generally better suited for revenue-capturing operations such as peak shaving which requires frequent (one or more daily) charge and discharge cycling (see NYC Resilient Solar Roadmap, pages 9-10). As more systems are installed and the systems are worked harder through daily cycling, the industry is developing better, safer, longer lasting, and more robust systems.

Hardware providers are also beginning to offer pre-packaged systems with integrated components, which can be deployed more rapidly. These systems offer more functionality and reduce or eliminate the need for complex, custom controls and unique software and algorithms, and can make ESS installations less technically complex since there are fewer compatibility issues between the various system components. Finally, as the market expands, further innovation and cost reductions can be expected with technologies that are able to access additional value streams within the utility market.

FAQs

1. **What battery properties should I be aware of?**
   The main properties relate to the capacity (size), performance, and longevity of the battery. The following properties are important:

   - **Capacity** – battery capacity, often used synonymously with battery size, consists of two quantifiable elements: charge/discharge rate (kW) and energy storage potential (kWh). The charge/discharge rate is a measure of how quickly the battery can provide energy to a facility or the magnitude of load that can be served, while the energy storage potential is a measure of the total quantity of energy that can be stored in the battery. These two properties together quantify the size and duration of a battery project. For example, a battery that stores 40kWh can discharge a maximum of 10kW for 4 hours, and is measured as a 10kW/40kwh battery.

   > A typical battery for home usage might be sized as 10kW/40kWh – meaning it can store 40kWh, and discharge a maximum of 10kW per hour for 4 hours

   - **Cycling/cycle life** – a cycle is one "roundtrip" charge and discharge of the battery. Batteries have a finite number of cycles that can be performed before the battery cells will need to be replaced – this is known as cycle life. As an example, a battery with a cycle life of 5,000 could do a single cycle each day for about 14 years before replacement. The cycle life of a battery is also dependent upon the depth of cycle discharge. If batteries are routinely fully discharged (below ~20% state of charge) the cycle life will deteriorate substantially.
   - **Efficiency** – the efficiency of a battery system is typically reported as round trip efficiency, and refers to the amount energy that is lost in a battery in a single charge/discharge cycle.

- **Design duty cycle** – duty cycle refers to the proportion of time a battery is used, and it is important to understand how the duty cycle for a particular application will affect battery life. Batteries used for backup applications are typically discharged only a few times per year when grid power fails. These batteries should have low standby losses, fast reaction time, and degrade very slowly when kept on standby. For revenue generating applications such as peak shaving, batteries typically undergo one or more charge/discharge cycles per day; batteries used for these purposes must have high round trip efficiency, schedulable controls, and high cycle life. These batteries are sometimes referred to as "deep cycle" batteries.

More details about battery properties and how different battery chemistries perform can be found in the DG Hub Hardware Fact Sheet. A comprehensive list of battery specifications can be found here.

2. **Can I connect energy storage to an existing solar array?**
   Yes, a properly designed battery storage system can be connected to an existing solar array, without making many changes to the solar equipment, by coupling the systems on the AC side. In order to enable the system to provide backup power, proper switches must be installed and some wiring re-configuration may be necessary. The DG Hub Solar+Storage Retrofit Fact Sheet walks through the considerations for adding storage to an existing PV system.

3. **Will my solar work during a grid outage without batteries?**
   All grid-tied solar arrays are equipped with anti-islanding protections as required by international electrical codes (IEEE 1547) – this means that in the event of a grid outage, the solar array will de-energize to avoid unintentional back-feeding of power onto the grid (which would endanger line workers repairing the outage). However, if the array includes an inverter with an "emergency plug", this would be energized whenever the sun is out and typically powers a standard 120-volt plug for use by critical loads such as a fridge or cell phone charger.

4. **Does every battery system provide resilience?**
   No, in order for a grid-connected battery system to provide resilience, meaning power during an outage, proper equipment and software must be in place to conduct appropriate switching. Some batteries are configured to provide utility bill savings during grid-tied mode only. When implementing a battery system, adding features to enable resilience is relatively simple but will add cost to the project.

5. **How long can energy storage power a building for?**
   The length of time that a building can be powered with energy storage is a function of the size of the building loads and the size of the battery system. Due to cost and sizing factors, an ESS system is typically designed to serve a subset of critical loads, rather than 100% of the building's load. The facility planner would decide what the critical loads are and how long they need to operate and use those two numbers to determine the size battery that is required. Alternatively, a facility could decide how much capital they would like to spend on a battery system, determine how long the facility needs to operate, and then use those two numbers to determine how much critical load can be supported. There are a number of software platforms that can be used to perform this analysis including HOMER Energy, REopt Web Tool, EPRI StorageVET, and others.

6. **What is the difference between grid-tied vs off-grid and how does a system behave differently between on/off grid?**
   Grid-tied and off-grid batteries have much different functions. Grid-tied energy storage is typically used to reduce utility charges by peak shaving or shifting loads to off-peak times when electricity prices are lower. Off-grid energy storage is used to provide energy either during an outage or when solar is not generating. Some systems can switch between grid-tied mode and off-grid mode in the event of a grid outage. Different control strategies are required for different grid modes, and systems must have the appropriate software required to be able to operate in grid-tied vs. off-grid mode.

7. **Will the battery reduce my utility bills?**
   Battery systems will save money on utility bills only for customers that pay demand charges, time of use (TOU) rates, or other demand-related costs, by using the ESS for peak shaving or to shift electricity usage to non-peak times. Customers on a flat rate with no demand charges (such as typical residential rates) would not see a reduction in utility bills.

8. **Should I wait until battery technology improves to invest in an energy storage system?**
   Battery technologies are robust and well proven at this time. Additionally, batteries are currently cost effective in many markets. The best way to decide if a battery system is right for you is to look at all of the benefits that the battery will provide (monetary and resilience) and determine how much a battery system for your specific application will cost. With this information you can do a cost benefit analysis and see if it is the right time to implement a battery system.

9. **What do I need to know about inverter hardware?**
   At the most basic level, inverters simply convert DC (direct current) power produced from solar PV into AC (alternating current) power for homes, buildings, appliances, etc. In most solar+storage applications, inverters are more advanced, making decisions about charging the batteries, providing electricity to the on-site load, and/or feeding electricity onto the grid. With appropriate switches, inverters can also allow for solar+storage (and/or other DG) to function as an "islanded" microgrid, providing power to an individual building or a community separately and independently from the primary electrical grid. For more information see the DG Hub Hardware Fact Sheet, *'Inverters'* section, pages 4-5.

Software

In solar+storage systems, the energy management and control software is sometimes an overlooked aspect of the design, but software is a key feature of storage projects that enables coordination between smart devices and can potentially improve system operations. For systems designed to interact with or enhance utility operations, software is a central component to enable these types of functions and unlock greater value between the battery system and the electrical infrastructure.

There are two main types of software in a solar+storage system: (1) software tools for design and sizing and (2) software used for operation of the system which includes monitoring, controls and energy management in off-grid and grid-tied systems. Some level of communication and controls to monitor set points and trigger alarms to alert operators of a problem are necessary in all projects for safety. For more information see the Smart DG Hub NYC Resilient Solar Roadmap, pages 26-28.

The complexity of the controls required for a project depends on the use of the system. A small residential system used for emergency backup requires less complex controls than a large commercial system with multiple buildings and multiple sources of energy (PV, batteries, backup generators). The complexity of the software in a grid-tied system also depends on the services and functionalities it can provide. Software that can shave the peak demand and provide ancillary services requires sophisticated software algorithms. Investments in advanced controls are often necessary to maximize benefits.

Presently, a wide variety of communication languages and protocols is used for the various layers of monitoring and controls software which can create compatibility challenges between equipment from different vendors or complicate system design. Efforts to establish greater uniformity across the industry are underway through the SunSpec Alliance, a trade group of solar and storage industry participants that is working to standardize all functions and communications protocols. Additionally, the North American Electric Reliability Corporation (NERC) has established a protocol for Critical Infrastructure Protection (CIP) cybersecurity standards.

FAQs

1. **What level of software is appropriate for my system**?
   This depends on the size of the solar+battery system, and which functions the power system is designed to accommodate. Details of the different software communication layers and their functions are outlined in the DG Hub Solar+Storage and Microgrid Communications Fact Sheet. For a simple backup system, the controls are at a basic "layer 1" (or "Device" layer). If an advanced inverter is used, the inverter functions can respond autonomously or may interface with a larger communications system for interaction with the grid.

2. **Does all of the software that I need for my system come pre-loaded**?
   Some solar+battery systems are designed and sold as a complete packaged system with software monitoring and controls included. Large systems with multiple generation sources and complex designs often require an additional layer of controls to coordinate all assets and optimize dispatch.

3. **Can I forgo software and have someone charge and discharge the battery manually?**
   No, PV systems with battery storage all need some basic type of charge controller that prevents over-charging and over-discharging which would damage the battery. Charge controllers may also have a low voltage disconnect to prevent the load from draining the batteries and maximum power point tracking (MPPT) capability. Many inverters have dual functions that allow them to control the charge on the batteries in addition to providing their standard power conversion functions.

4. **Can a cyber-attack be used to damage the battery or endanger the facility?**
   It is unlikely that damage will be done to the battery through a cyber-attack, but attempted cyber-attacks on power infrastructure have been reported. However, efforts have been made to minimize this through the NERC cyber security requirements. Utilities are tasked to identify cyber security needs based on IEEE 2030.5 cyber security specifications and utility security procedures. The cyber

security is required to include firewalls, monitoring and audit logs of all significant alarms and events.

5. **Do solar arrays automatically communicate with battery systems?**
   No. A charge controller or a dual functioning inverter/charger is required when adding batteries to a PV system. See question 3 above regarding operating batteries manually. For systems to function and communicate seamlessly, additional software is typically designed and implemented.

6. **Is my system required to have a software communication layer that interfaces with the utility?**
   No – this layer is only required if you want to interconnect with the utility. A stand-alone solar+storage system that is used in off-grid applications would have no need to interface with the utility. Large systems that produce value and reduce utility expenditures do require a utility software layer to accept and process utility signals and optimize dispatch.

7. **Can a new PV + storage system interact with the existing building management system?**
   Yes, but it must be designed to interface with the building management system's protocol.

8. **What software platforms are available for feasibility analysis:**
   Below is a list of some of the most popular software modeling platforms that are available for PV + battery renewable energy feasibility analysis:
   - NREL's Renewable Energy Optimization (**REopt**) Lite tool: A web based techno-economic energy planning platform used to optimize grid-connected PV and batteries for buildings owners to analyze their energy performance and cost savings goals - https://reopt.nrel.gov/tool
   - NREL's System Advisory Model (**SAM**): A financial modeling tool designed to calculate performance, financial, technology and incentive options of renewable energy systems - https://sam.nrel.gov/
   - Distributed Energy Resources Customer Adoption Model (**DER CAM**): A decision support tool for financial and investment planning of DG resources in buildings and microgrids - https://building-microgrid.lbl.gov/
   - Hybrid Optimization Model for Multiple energy Resources (**HOMER**): A techno-economic optimization tool used for renewable integration in microgrid design for village power, island utilities, grid connected campuses and military bases - https://www.homerenergy.com/homer-pro.html
   - **Geli** Products (Geli ESYST, EOS and GENI): Software tools designed to support an entire project life cycle from design and automation to monitoring and controls management - https://geli.net/geli-platform/

9. **What do I need to know about inverter software?**
   Advanced inverters (often called smart inverters) come factory loaded with control and communication capabilities that can provide additional benefits to the grid beyond the basic conversion of direct-current (DC) electricity to alternating current (AC). Advanced inverters can offer event logging, status report, power factor and VAR management, and storage management. Various levels of software controls also exist to handle devices and provide supervisory monitoring and controls with interconnection to the grid. However, not all of the functions of advanced

inverter software are usable in today's market due to regulatory and code limitations. Details of the functionalities of advanced inverters and an illustration of the various layers of communication can be found in NY Solar Smart DG Hub Solar+Storage and Microgrid Communications Fact Sheet

10. **Why can't all smart inverter software functions be used?**
    Not all of the functions of advanced inverter software are usable in today's market due to regulatory and code limitations, but organizations such as EPRI (Electric Power Research Institute), IEC (International Electrotechnical Commission) and IEEE (Institute of Electrical and Electronics Engineers) are working to develop common standard protocols for the industry that would allow the full capabilities of advanced inverters to be used. Currently there are unresolved issues related to implementing smart inverter functions; revisions of standards such as IEEE 1547, grid codes such as California's Rule 21, interconnection procedures and standard communication protocols are currently underway.

Economics and Finance

Battery storage is an emerging technology in the U.S. and the market is still very nascent in most states. Until recently the high cost of battery systems has made them less attractive to the market and incentive programs are just starting to become available in some states. However, some areas of the US have seen significant growth, driven largely by hardware price declines particularly for lithium-ion batteries which had a 12% reduction in median price from 2015 to 2016.

This has taken place in areas such as California and Hawaii where utility rates are sufficiently high and/or programs offered by local authorities allow for systems to partake in revenue generating programs such as demand response or ancillary services, although projects still rely on financial or policy incentives to drive system installations. New York City is seen as another market with high potential due to the region's high electricity rates and peak demand rate structures. Due to its capacity for energy savings and peak load management, solar+storage is unique compared to other types of resilient/backup power options, which cannot be used to capture these types of revenue streams.

Average electricity prices:
- ◊ NYC: 20 cents/kWh
- ◊ CA: 17.97 cents/kWh
- ◊ HI: 26.17 cents/kWh

U.S. Energy Information Administration
U.S. Bureau of Labor Statistics

FAQs

1. **What is the economic case/justification for considering storage in addition to solar PV?**
   For commercial facilities, there are three avenues of financial benefits:
   I. Reduction of demand charges of utility bills, which can comprise a significant portion (in the range of 20-30%) of electricity bills. Furthermore, these charges are typically based on the highest 15- or 30-minute energy usage period in a month, meaning a very short window of high usage sets the demand charge for the entire month. Solar PV can reduce utility bills by reducing energy purchased from the grid, but because its energy output is dependent on sunlight, PV systems alone cannot reliably reduce demand charges. With solar and storage together it is possible to both reduce overall grid energy usage **and** reduce demand charges.

II. Prevention or reduction of economic damages, such as loss of inventory or business interruption, due to power outages. While not easily quantifiable as of yet, this can have significant value.
III. Participation in demand response and ancillary service programs to earn additional revenues, which are offered through utilities as well as at the wholesale level through ISOs.

Reduction of demand charges is currently the primary value for commercial ratepayers. However, residential rate payers typically do not pay demand charges; thus, the economic value of residential solar+storage tends to be lower than for commercial systems (such as longer payback periods). Yet some consumers place a high value on having a supply of power during outages and see storage as a viable and emissions-free alternative to a generator, which has the further advantage of not being reliant on diesel or gas supplies that can be disrupted during an extended emergency.

For a primer on the economics and finance considerations of solar+storage, see the DG Hub Economics and Finance Factsheet.

2. **What types of pricing should I expect? What other costs are involved?**
Prices of energy storage system installations vary significantly based on their intended use case – for example, retrofitting existing PV installations can add additional system costs, and larger battery system sizes to support higher level of resilience can also increase costs.

Prices of the battery component itself are based on the size as well as duration – for example, a 10kW battery with a one hour duration capacity will be less costly than a 10kW battery with a four hour capacity. Estimates can be found on the NREL REopt calculator website.

There are other categories and components that make up the total cost of a system. These include additional non-battery equipment and materials such as inverters and wiring; engineering, design, and labor costs; and soft costs including permitting, inspections, and interconnection. Further cost information can be found on the DG Hub's Solar+Storage Cost Survey.

A typical home might use a system size of 1-50kW; a commercial building 25-1000kW and the largest applications 500kW or more, depending on the facility size and electricity demand.

3. **Can an entire facility's power needs be met with an ESS or solar+storage system?**
In almost all cases, it is currently not economical to provide back-up power for an entire facility's electrical load, but solar and storage can support mission critical loads in most cases for a short duration outage (e.g. no more than one day). For a more detailed exploration of project economics, please see the DG Hub feasibility analyses for three facilities.

4. **What other resilient solar options are available, and how do they compare to solar+storage?**
Aside from solar+storage, other types of resilient PV include:

- **Solar paired with an inverter and emergency plug**: As an alternative to a battery installation, solar PV can be paired with smart inverters with an emergency power outlet. This provides much more limited emergency power support, but is a lower cost option than a solar+storage installation, and an alternative when there is not sufficient space for an energy storage system.

- **Solar paired with a diesel or natural gas generator**: Solar can be used to augment existing backup generators, which may or may not include an energy storage component as well. Diesel generators have lower up-front costs than battery storage, but provide no opportunities for revenue generation. The comparative economics between solar+storage and solar with a generator will be driven by the facility's utility rate class, critical power needs, and building load.

This paragraph is adapted from the DG Hub's Resilient Solar Roadmap, which contains additional information. For further information on current or upcoming installations which have utilized all three approaches please see the Solar for Sandy case study.

5. **What financing options are available for solar+storage?**
There are two primary models for solar+storage financing: direct ownership and third-party ownership. Under direct ownership, the host facility finances and pays for the system directly, and receives all the utility bill savings from solar+storage as well as all compensation/revenues from participating in demand response and ancillary services programs.

Third-party ownership models are also available and can reduce or eliminate the amount of money required to be paid up-front. At present, third-party models are the dominant mode of system finance. Common applications include shared savings models, in which the host facility can receive a system for little to no-upfront cost in exchange for sharing any savings, tax incentives or revenue from the solar+storage system with the third-party developer or financier.

6. **Do storage systems receive net metering compensation similar to solar?**
The way ESS and solar+storage systems are compensated is rapidly evolving in many places, especially New York State. Solar+storage is a qualifying technology for the newly-established Value of Distributed Energy Resources (VDER) tariff. VDER will change the rate of compensation for electricity produced from DG assets from current net metering rates to an amount that more accurately reflects the value of the energy resource to the grid, which takes factors including location and time of generation into account.

VDER tariff details and implementation are still being finalized by the New York State Department of Public Service. Currently, residential and small commercial (or "mass market") customers that pair storage with solar or some other DG technology can qualify for net metering (under certain conditions), earning utility bill credits for excess energy not consumed on-site, and net metering enrollment will continue for mass market customers until January 2020 for 20 years. For more information on the net metering program, please see DSIRE. However, larger solar and storage projects are in a transitional value-based program. For more information on the ongoing proceeding, please see the New York DPS website which contains notes from current discussions.

7. **What tax or other incentive programs are available to support ESS projects?**
Currently the primary tax incentive for solar and storage available nationwide is the federal investment tax credit (ITC) which can account for up to 30% of the total capital costs of a project, but the landscape of incentives and programs, especially at the state level, is rapidly evolving. In New York State, there are incentives available for solar PV through the NY-SUN Megawatt Block program that offers bonuses for the addition of storage, and NYSERDA recently announced a

funding opportunity to support storage projects as well. For further information on available programs and incentive levels, please see the DG Hub Economics and Finance Factsheet.

8. **What utility programs are available to support ESS projects?**
   Programs for solar+storage systems are offered from individual utilities as well as regional independent system operators (ISOs). They typically include different variations of demand management and demand response, which enable these systems to help utilities and ISOs manage system-wide peaks in demand, as well as ancillary services programs which are designed to provide other grid-support functions such as frequency regulation. Additionally, in some regions ESS can receive compensation through "Non-Wires Alternatives" (NWA) programs, which aim to help the utility reduce the need to use or build supplemental electricity generation assets (e.g. peaker plants) and also to defer costly investments in additional transmission and distribution infrastructure. See an updated list of NY State programs here.

   However, it is important to note that individual storage systems often do not meet the size requirements for participation in many of these kinds of programs. Many ISOs, including New York's NYISO, are developing plans to integrate more DG resources and accept aggregations of smaller systems so that they can participate. More information is in Q5 of the Policy FAQ section.

9. **What are other resilience values and benefits that solar+storage can provide that are not currently formally valued or monetized?**
   The "Value of Resilience" is a fairly new concept that seeks to capture the monetary value of avoiding business interruption and losses and being better able to address the needs of a facility and its occupants during a power outage or emergency. These values are complex, difficult to quantify, and not yet widely recognized by insurers and the banking industry. The DG Hub has undertaken research to attempt to quantify this value and begin discussions with insurers and other stakeholders about how to monetize the resilience benefits of storage, for example, through reduced insurance premiums. More information is available in the DG Hub's Value of Resilience study.

Policy and Legal

Due to the anticipated growth of the stationary energy storage market, regulations and policies are evolving quickly. Policies vary greatly by state and local government, but are typically aimed at delineating siting and permitting requirements, reducing capital costs, and enabling participation in revenue-generating programs and markets.

Solar+storage can both supply and absorb energy from the grid, posing unique questions to regulatory bodies. At the local level, municipalities are beginning to incorporate appropriate permitting, fire and safety, and interconnection requirements. At the state level, utilities and state agencies are identifying appropriate methods to incentivize and utilize solar and storage projects within the context of their renewable energy, energy efficiency, and climate programs and goals. The Federal Energy Regulatory Commission (FERC) and regional ISOs are identifying policy pathways to enable DG and ESS resources to participate in regional grid programs, as described in the Economics FAQ section. These programs were originally designed around large, conventional power plants and policies are not in place in most wholesale energy markets to allow small-scale generators to participate, but in the medium term regulations are expected to become more permissible. Additionally, emergency management planning is just beginning to integrate the resilience capabilities of solar and storage technology. All new energy policies will require balancing the needs of consumers, government and regulatory agencies, utilities, and industry.

FAQs:

1. **What should I know about permitting and inspections processes for battery storage?**
   Permitting and inspection processes encourage safe construction and operation of battery storage equipment. Local Authorities Having Jurisdictions (AHJs) – typically building, zoning, and/or fire departments of municipalities and counties – administer these regulations during the construction and commissioning of systems to ensure safety of installations. However, most municipalities lack a defined or streamlined permitting and inspection process for storage projects which has been a significant impediment to deployment of these systems in some regions.

2. **What are the primary concerns around permitting battery storage?**
   The primary concerns revolve around fire and safety hazards, as using batteries for stationary storage is new and there is not a long history of performance data to inform risk analysis. Batteries store large quantities of energy, making the risk of fire greater than for non-fuel energy sources like solar and wind. Specific concerns may vary by the battery storage chemistry, but common concerns for all battery types include incorporating appropriate safety protocols and fail safes, designing for sufficient spacing and ventilation in the event of a fire, and establishing communications, monitoring, and response protocols.

3. **Why haven't permitting regulations been developed more widely?**
   Permitting regulations for battery storage have not been widely developed because storage is a new industry. There is not a wide body of research, testing, and performance data on which permitting standards and codes could be based – though much is currently underway – and there are few existing templates or guidelines available that municipalities can easily adopt.

   Select municipalities have begun developing and adopting permitting approaches, for example Santa Clara, CA has released safety best practices and installation guidelines for storage. Additionally, a state bill mandating a clear, streamlined, and standardized permitting process for energy storage passed in California in 2017. In New York City, the CUNY DG Hub has lead an effort with the Fire Department of New York (FDNY) and the NYC Department of Buildings (DOB), under the support of the New York State Energy Research and Development Authority's (NYSERDA) Energy Storage Soft Cost Reduction Initiative, to conduct a rigorous review of their battery storage permitting processes. This effort will finalize permitting guidelines for outdoor Li-ion battery installations, to expand on NYC's current permitting guidelines for lead-acid batteries.

   Additionally, with the release of updated national fire codes in early 2018 (NFPA 855), as well as newly-released third party certifications (UL 9540A), the pace of development of permitting guidelines is expected to increase more rapidly.

4. **What is interconnection and how is it changing in New York?**

Interconnection is the act of connecting energy generation sources to the electrical grid. The local utility manages the interconnection process for smaller DG assets, which typically involves submitting an application to the utility, a detailed interconnection study that is completed by the utility, and payment to the utility for any necessary electrical infrastructure upgrades that may be needed, since existing networks and substations cannot always accommodate new power sources. These upgrades can be costly and can extend project timelines. New York State has undertaken initiatives to streamline and lower costs associated with interconnection of DG assets, including:

- Standardized Interconnection Requirements (SIR) set forth by the Department of Public Service to enable streamlined interconnection.
- Interconnection Earnings Adjustment Mechanism (EAM) will incentivize utilities to streamline interconnection, enable DER integration, and increase developer satisfaction with the interconnection process.
- The Interconnection Working Group set in place by the Department of Public Service to provide feedback and advisory support for crafting new interconnection guidelines, including solar and storage. These discussions are ongoing.

The Resilient Solar Roadmap released by Sustainable CUNY Smart DG Hub contains more detailed information on the barriers and opportunities regarding interconnection. Additionally, the ESS Permitting and Interconnection Guide for New York City contains more detailed information about the interconnection process.

5. What new policy efforts are underway that pertain to financial aspects of energy storage?

Several efforts are underway to accommodate, incentivize growth of, and open up new revenue opportunities for energy storage resources in New York State. These include:

- VDER (Value of Distributed Energy Resources) Tariff: Properly values the electricity supplied by distributed energy resources, as explained in Q6 of the Economics and Finance FAQ. This electricity tariff provides a nuanced reimbursement for electricity produced from DG assets and incentivizes deployment where it is most crucially needed. Currently, energy storage must be co-located with DG to be eligible.
- NWA (Non-Wires Alternatives): Programs in which utilities procure DG resources instead of investing in traditional ("wired") electrical infrastructure. Programs vary by utility, but awarded projects receive payments from the utility. Storage is a commonly proposed technology when these program opportunities arise.
- Aggregation: The NYISO is currently exploring opportunities for energy storage to participate in its wholesale market programs, such as demand response and ancillary services, through aggregation of small systems across multiple sites. Aggregated systems are sometimes referred to as a "Virtual Power Plant". Aggregation of these systems allows them to meet the minimum size capacity that is needed in order to participate.
- Incentive programs: Policy makers are looking toward modifying existing incentive programs for renewables to include extra incentives and bonuses, or even requirements, for energy storage.

6. **What policy efforts exist or are on the horizon to promote and facilitate energy storage, in New York or elsewhere?**

    - Targets: New York City passed a policy target in 2016 for 100 MW of installed battery energy storage by 2020, and NYS passed a law earlier in 2017 requiring a statewide target to be set for storage deployment by 2030, to help smooth regulatory barriers and facilitate more market activity.
    - New York State's REV (Reforming the Energy Vision): aims to achieve greenhouse gas reductions, expand the use of renewables, ensure resilience of the state's energy system, and enable cleaner transportation. Energy storage is a critical technology to achieving these goals. REV is currently supporting several demo projects that incorporate storage, in order to test new approaches for assessing value, explore revenue streams, and stimulate innovation before state-wide implementation. Many of the programs, initiatives, and incentives that result from the NY REV process will enable further deployment of energy storage.
    - New York's Clean Energy Standard: this renewable portfolio standard is one of the core components of REV and sets a goal for 50% of New York's electricity to originate from renewable sources by 2030. While energy storage is not specified, it will play a key role in facilitating and supporting additional renewable energy deployment.
    - Resilience and Emergency Planning: local level policy like resilience and emergency plans can include provisions for deploying energy storage or solar+storage at critical facilities such as hospitals, or in areas that are especially susceptible to weather-related emergencies. The City of San Francisco has completed this type of planning through its Solar+storage for Resilience project that aims to integrate solar and energy storage into the City's emergency response plans.

7. **How will REV impact utility customers with either storage or solar+storage?**
    Most utility customer experiences for procuring solar and storage, engaging solar and storage developers, and managing these assets are unlikely to change. Customers will engage the same utility and receive monthly electric bills that account for their solar and storage systems. However, the rates of compensation are evolving, as described in Q6 of the economics section, with a shift away from current net metering rates to the new VDER rates.