Resilient Solar Retrofits: Adding Storage to Existing PV and Making New Installations Storage Ready

August 4, 2016
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Submit your questions at any time by typing in the Question Box and hitting Send.

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You will find a recording of this webinar, as well as previous Resilient Power Project webinars, online at:

www.resilient-power.org
Who We Are

www.cleanegroup.org
www.resilient-power.org
Resilient Power Project

- Increase public/private investment in clean, resilient power systems
- Engage city officials to develop resilient power policies/programs
- Protect low-income and vulnerable communities
- Focus on affordable housing and critical public facilities
- Advocate for state and federal supportive policies and programs
- Technical assistance for pre-development costs to help agencies/project developers get deals done
- See www.resilient-power.org for reports, newsletters, webinar recordings
www.resilient-power.org
Today’s Speakers

• **Erica Helson**, New York State Solar Ombudsman, Sustainable CUNY

• **Kari Burman**, Senior Engineer, National Renewable Energy Laboratory

• **Lars Lisell**, New York State Solar Ombudsman, Sustainable CUNY
CEG Webinar
Retrofit Fact Sheet
August 4th, 2016
AGENDA

I. Introduction – Erica Helson: Sustainable CUNY

II. System Overview – Kari Burman: National Renewable Energy Laboratory

III. Development Considerations – Lars Lisell: Sustainable CUNY
NYSolar Smart DG Hub

Objective

A more resilient distributed energy system in NYC, with a path for expansion across the state and country

Develop Platform
Engage Stakeholders
Create Strategic Pathways
Increase Deployment of Resilient PV Systems
State of NYC Solar PV During Sandy Recovery

Solar in affected area in 2012:
- 5,500 kW
- 281 installations
- Nearly 50% of NYC installations

Estimated untapped solar energy per day after the storm:
6,500 kWh

Solar in affected area in 2015:
- 15,500 kW
- 1,571 installations

Solar arrays in NYC with daylight emergency power plug via SMA inverter in 2015:
177
Solar and Storage Projects in New York

<table>
<thead>
<tr>
<th>All storage NYS: 16</th>
<th>All storage NYC: 9</th>
<th>Solar + Storage NYC: 2*</th>
</tr>
</thead>
</table>

Over 2,682 solar installations in NYC – great potential for resilient power!

*There are additional storage projects that have not been reported or verified by the U.S. DOE for the Global Energy Storage Database. For example, the Brooklyn Army Terminal project developed by NYC EDC.*
Retrofit and Storage Ready Guidelines

Retrofitting existing solar with storage

Considerations to make new solar “storage ready”
System Overview- System Components

System Components for PV with Battery Back-up

- **Solar Array**
  - Solar Photovoltaic (PV) arrays generate on-site direct current (DC) energy

- **Inverters**
  - **Stand alone** inverters are used for off-grid solar systems
  - **Grid-tied** inverters (GTI) or micro-inverters are unidirectional inverters that are used for grid-tied solar systems. Can not function in off-grid mode
  - **Dual inverters** (also called bi-directional or inverter –charger) are used for solar systems that function both on and off grid. Dual inverters that assist with regulation of both voltage and frequency during an islanded or microgrid scenario are referred to as grid forming inverter (GFI)

- **Batteries** (commonly used for PV with Battery Back-up systems)
  - Lead Acid
  - Lithium Ion (Li-ion)
  - Flow batteries
System Overview- System Components

• Batteries
  Choosing batteries that are both economical and provide sufficient emergency power depends on:
  • Cost
  • Energy density (size)
  • Cycle life
  • Thermal stability/safety

A comparison was done between the following types of batteries (*Resilient Solar PV Systems Fact Sheet)*:
• Lead Acid – Valve regulated (VRLA)
• Lithium Ion (Li-ion)
  • lithium iron phosphate (LFP),
  • lithium nickel manganese cobalt oxide (NMC),
  • lithium nickel cobalt aluminum oxide (NCA),
  • lithium manganese oxide (LMO) and
  • lithium titanate (LTO)
• Flow Batteries: Liquid electrolyte flow batteries

Note: The full comparison table can be found in the *Resilient Solar PV Systems Fact Sheet*: [www.nysolarmap.com/resources/reports](http://www.nysolarmap.com/resources/reports)

Source: ConEdison & SUNPOWER
### Battery Comparison Table

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Lead Acid</th>
<th>Battery Chemistries</th>
<th>Flow Batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VRLA (Deep-Cycle)</td>
<td>LFP</td>
<td>NMC</td>
</tr>
<tr>
<td>Usage¹</td>
<td>Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS</td>
<td>Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS</td>
<td>Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS, Bulk power management</td>
</tr>
<tr>
<td>Energy density (Wh/kg)</td>
<td>30-50</td>
<td>90-120</td>
<td>150-220</td>
</tr>
<tr>
<td>Lifetime cycles (80% depth of discharge)</td>
<td>50-100⁷</td>
<td>1000-2000</td>
<td>1000-2000</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>85-90²</td>
<td>90-95</td>
<td>90-95</td>
</tr>
<tr>
<td>Charge rate</td>
<td>8-16 hrs¹</td>
<td>2-4 hrs</td>
<td>2-4 hrs</td>
</tr>
<tr>
<td>Cost</td>
<td>$150-$300/kWh⁵</td>
<td>$400/ kWh⁶</td>
<td>$425-$750/ kWh⁷</td>
</tr>
<tr>
<td>Advantages</td>
<td>Well-known and reliable technology, able to withstand deep discharges, relatively low cost, and ease of manufacturing.</td>
<td>High energy density, able to withstand deep discharges, and long cycle lives.</td>
<td>Relatively safe, well suited for bulk storage, long cycle life (cycling 10,000-20,000 cycles), and easy to scale up the amount of energy stored by simply making the tanks larger.</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Relatively low number of life cycles (must be replaced more often) and lower energy density (larger size for less energy storage).</td>
<td>More expensive than lead acid systems and may become thermally unstable. Overheating or short circuits in Li-ion cells may cause thermal run-away—a phenomenon where the internal heat generation in a battery increases faster than it can dissipate. This heat can damage or destroy the cells and is a potential source for fires. Electronic protection circuits are added to the battery pack to prevent thermal run-away.</td>
<td>Relatively high cost, low efficiency (less than 70%) and low energy density; high maintenance with pumps that often leak and precipitate out.</td>
</tr>
<tr>
<td>Safety (Thermal Run-away)²</td>
<td>Considered thermally safe</td>
<td>High thermal stability</td>
<td>Increased thermal stability</td>
</tr>
</tbody>
</table>

Full comparison table can be found in the Resilient Solar PV Systems Fact Sheet: [www.nysolarmap.com/resources/reports](http://www.nysolarmap.com/resources/reports)
System Overview- System Components

Usage of solar and energy storage system (ESS) will influence the design components:

*Emergency power:*
  - Dual function inverter
  - Batteries with high efficiency

*Demand Management:*
  - Batteries that are deep cycle and have high number of lifetime cycles
  - Battery banks with sufficient capacity

*Grid Services:*
  - Batteries that have quick response or low charge/discharge rate
  - Need control software to communicate with the service organization

Source: ConEdison & SUNPOWER
http://www.sunpower.com/ny-solar-storage
TYPICAL PV GRID-TIED SYSTEM

- PV Array
- DC Disconnect
- Combiner Box
- Grid-tied Inverter
- AC Disconnect
- Non-critical AC Loads
- Main AC Distribution Center
- Utility Meter
System Overview - System Configuration

TYPICAL DC-COUPLED PV GRID-TIED SYSTEM WITH BATTERY BACKUP

- PV Output
- Combiner Box
- PV Array
- Backup AC Distribution Center
- Critical AC Loads
- Non-critical AC Loads
- Main AC Distribution Center
- Utility Meter
- AC Disconnect
- Battery Bank
- Backup Generator (Optional)
- Dual-Function Inverter
- Automatic Transfer Switch (ATS)
- Battery

DC Disconnect
Charge Controller/MPPT
DC Disconnect
System Overview - System Configuration

TYPICAL AC-COUPLED PV GRID-TIED SYSTEM WITH BATTERY BACKUP

- PV Array
- Backup AC Distribution Center
- Critical AC Loads
- Non-critical AC Loads
- Utility Meter
- Battery Bank

System Configuration Diagram:

- DC Disconnect
- Grid-tied Inverter
- Combiner Box
- Dual-Function Inverter
- Automatic Transfer Switch (ATS)
- Backup Generator (Optional)
# System Overview - System Configuration

<table>
<thead>
<tr>
<th>AC-COUPLING</th>
<th>DC-COUPLING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two inverters</td>
<td>Single inverter</td>
</tr>
<tr>
<td>Can keep existing inverter</td>
<td>Fewer power conversions (more efficient)</td>
</tr>
<tr>
<td>May be preferable for an existing 3rd party owned solar system</td>
<td>More complex electrical reconfiguration</td>
</tr>
<tr>
<td>Increased potential for communication challenges</td>
<td>Can be more costly for retrofits due to re-design costs, re-wiring, etc.</td>
</tr>
</tbody>
</table>
Project Development Checklist

Pre – Project Scoping
• Establish project objectives

System Design
• Location for equipment
• Ensure capture of ITC
• Battery sizing
• Equipment Compatibility

Implementation
• Paying for the system
• Work specification language to solicit project proposals
• Finding a good developer

Source: NREL
Pre-Project Scoping

ESTABLISH PROJECT OBJECTIVES

• Emergency Power
  • What critical loads will be supported?
  • How long do the loads need to be supported?

• Demand Management
  • How much demand can be offset?

• Grid Services
  • Does utility offer compensation for grid services?
  • How are signals sent from operator?
  • Are there system size minimums?
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System Design

SITING/PRACTICAL CONSIDERATIONS
- Physical space for equipment
- Location of equipment
- Regulatory considerations
- Interconnection agreement
- Communications compatibility

INVESTMENT TAX CREDIT (ITC)
- Batteries must be “integral” to the operation of the system
- Must be charged by RE 75% of the time or greater to qualify

Source: NREL
System Design

SIZING AND CRITICAL LOADS

• Example Critical Loads
  • Refrigerators
  • Lighting
  • Computers
  • Sump Pumps

• Example Non-Critical Loads
  • Exterior Lighting
  • Irrigation pumps
  • AC units

• Calculating Size Requirements

\[
\text{Rated Battery Capacity} \ (kWh) = \text{Total Critical Load} \ (kW) \times \text{Run Time} \ (hrs)
\]

• Example: 5 overhead lights at 300 watts per fixture need to be run overnight (12 hours)

\[
\text{Rated Battery Capacity} \ (kWh) = 5 \times 0.3 \ (kW) \times 12 \ (hrs)
\]

\[
\text{Rated Battery Capacity} \ (kWh) = 18 \ (kWh)
\]
Project Development Checklist

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Source: NREL
Implementation

FINANCING

• 3rd party financing
• Direct ownership

WARRANTIES

• Ensure component warranty will not be voided

DEFINING REQUIREMENTS

• Example language in Attachment A of the Fact Sheet
• Select a contractor with technology experience
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Source: NREL
Storage Ready

What is Storage Ready?

- Build a PV system now that allows for “plug and play” storage later on.
Storage Ready

How much does solar ready cost?

• Components that add cost, switching, extra wiring, more expensive inverter, etc. Will increase the project cost between 12% and 17%.
  • Example Residential System: $2,000 - $3,000 increase in cost

How much can solar ready save?

• Opportunity to save between 18% and 27% of project cost.
  • Example Residential System: $3,000 - $4,500 cost savings
Resources

- Full report can be accessed at nysolarmap.com/resources/reports
- Stay up to date with Sustainable CUNY initiatives with the NYSolar Smart Newsletter

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