RESILIENT POWER

A project of CleanEnergyGroup

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

CleanEnergyGroup

Innovation in Finance, Technology & Policy

August 4, 2016

Housekeeping

All participants are in "Listen-Only" mode. Select "Use Mic & Speakers" to avoid toll charges and use your computer's VOIP capabilities. Or select "Use Telephone" and enter your PIN onto your phone key pad.

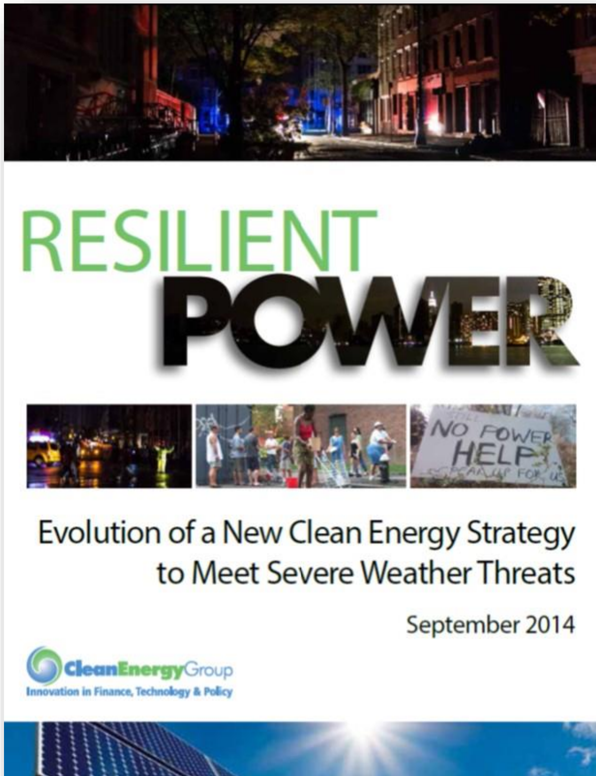
Submit your questions at any time by typing in the Question Box and hitting Send.

This webinar is being recorded.

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

CleanEnergyGroup
Innovation in Finance, Technology & Policy

Meridian Institute
Connecting People to Solve Problems

CleanEnergy States Alliance

THE JPB FOUNDATION

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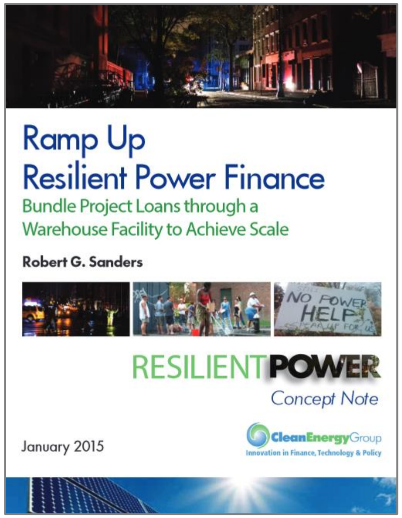
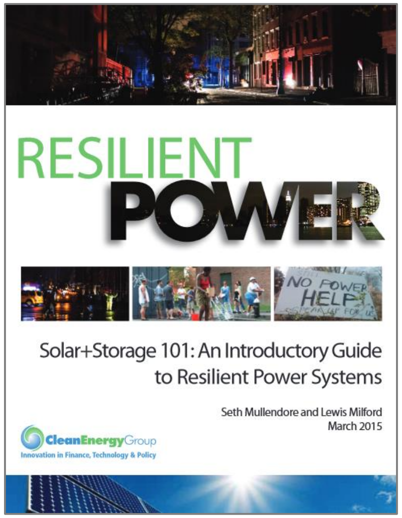
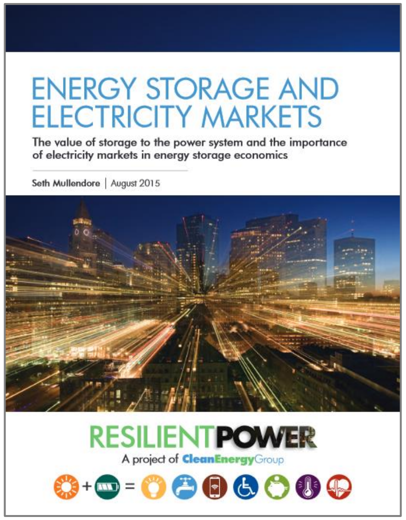
SURDNA FOUNDATION
Fostering sustainable communities in the United States

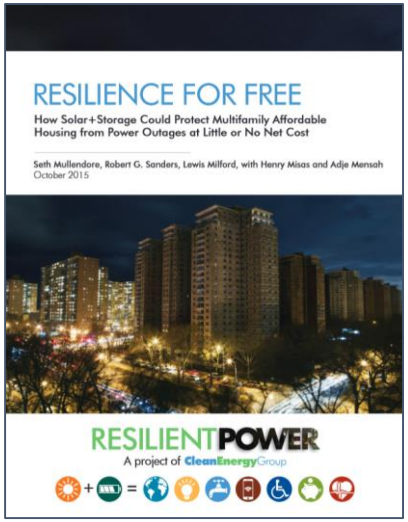
Resilient Power Project

- 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

CUNY The City University of New York

NREL NATIONAL RENEWABLE ENERGY LABORATORY

NYSOLAR SMART DG HUB

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

- Develop Platform
- Engage Stakeholders
- Create Strategic Pathways
- Increase Deployment of Resilient PV Systems

NYSOLAR SMART DG HUB

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:

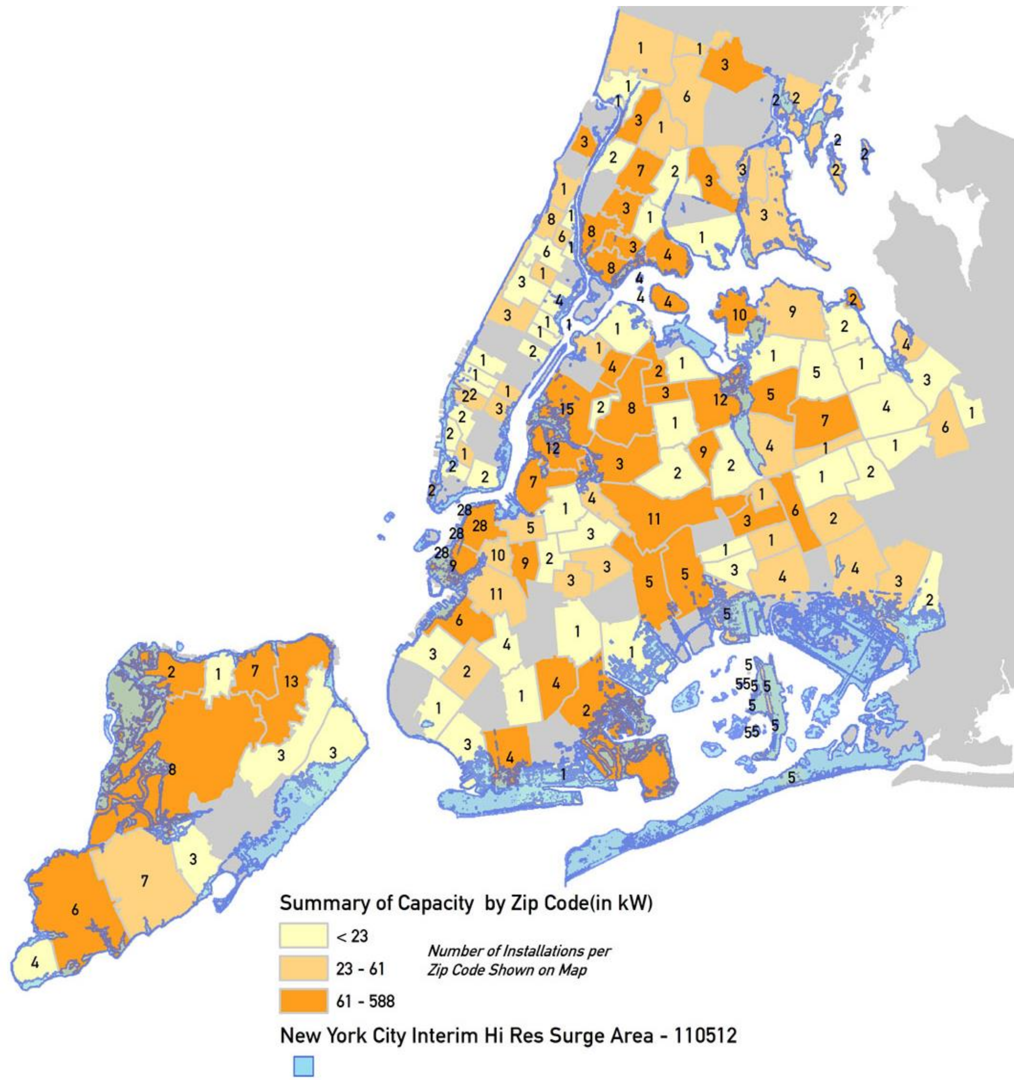
6,500 kWh

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



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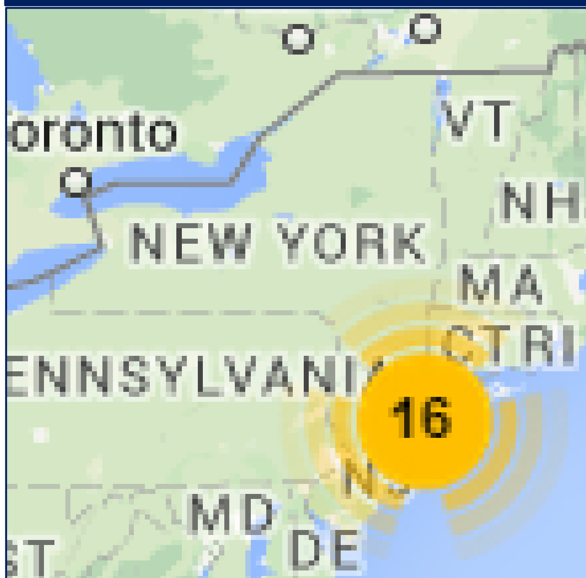
CUNY

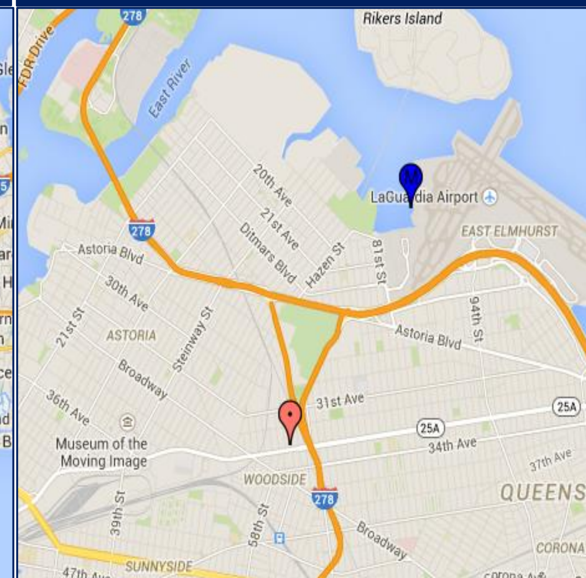
Solar and Storage Projects in New York

All storage NYS: 16



All storage NYC: 9

Solar + Storage NYC: 2*



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**](www.nysolarmap.com/resources/reports)

Source: ConEdison & SUNPOWER
http://www.sunpower.com/ny-solar-storage

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CUNY

Battery Comparison Table

Specifications	Battery Chemistries						
	Lead Acid	Lithium-Ion					Flow Batteries
	VRLA (Deep-Cycle)	LFP	NMC	NCA	LTO	LMO	Redox
Usage[1]	Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS	Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS					Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS, Bulk power management
Energy density (Wh/kg)	30-50	90-120	150-220	200-260	70-80	100-150	10-20
Lifetime cycles (80% depth of discharge)	50-100[7]	1000-2000	1000-2000	500	3000-7000	300-700	10,000+
Efficiency (%)	85-90[2]	90-95	90-95	90-95	90-95	90-95	65-85
Charge rate	8-16 hrs[1]	2-4 hrs	2-4 hrs	2-4 hrs	1-2 hrs	1-2 hrs	Depends on size of tanks & cell stack[5]
Cost	$150-300/kWh[4,7]	$400/kWh[7]	$428-750/kWh[3,6]	$240-$380/kWh[3,6]	$2,000/kWh[7]	$250-300/kWh[7]	$680-800/kWh[6,7]
Advantages	Well-known and reliable technology, able to withstand deep discharges, relatively low cost, and ease of manufacturing.	High energy density, able to withstand deep discharges, and long cycle lives.					Relatively safe, well suited for bulk storage, long cycle life (claim 10,000-20,000 cycles), and easy to scale up the amount of energy stored by simply making the tanks larger.
Disadvantages	Relatively low number of life cycles (must be replaced more often) and lower energy density (larger size for less energy storage).	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.					Relatively high cost, low efficiency (less than 70%) and low energy density; high maintenance with pumps that often leak and precipitate out.
Safety (Thermal Run-away)[5]	Considered thermally safe	High thermal stability	Increased thermal stability	Thermal instability	Highest thermal stability	Increased thermal stability	Very safe since storage of electrolyte is separate from power generation unit

Full comparison table can be found in the *Resilient Solar PV Systems Fact Sheet*: 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

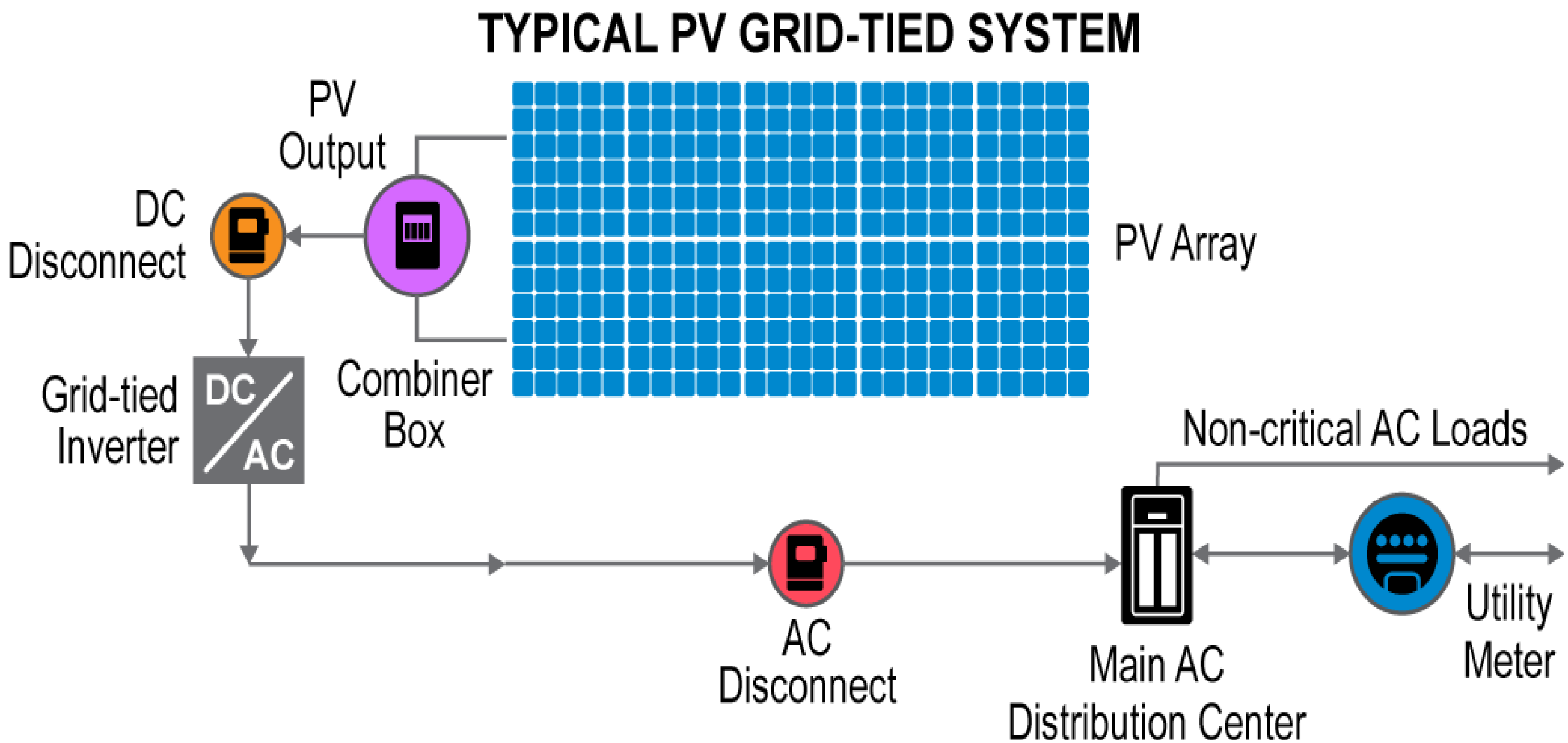
Grid Services:

- 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

NYSOLAR SMART DG HUB

System Overview- System Configuration



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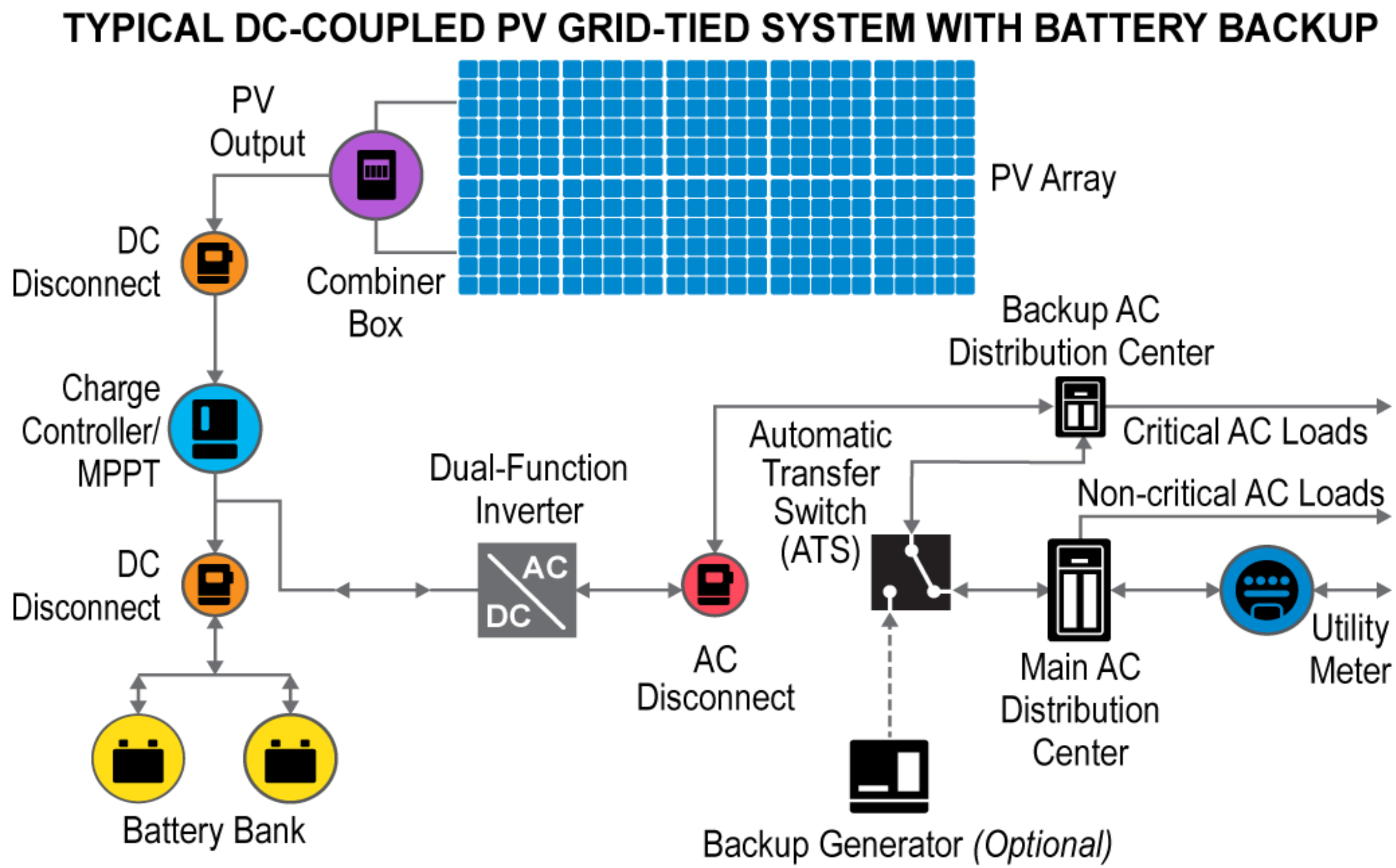
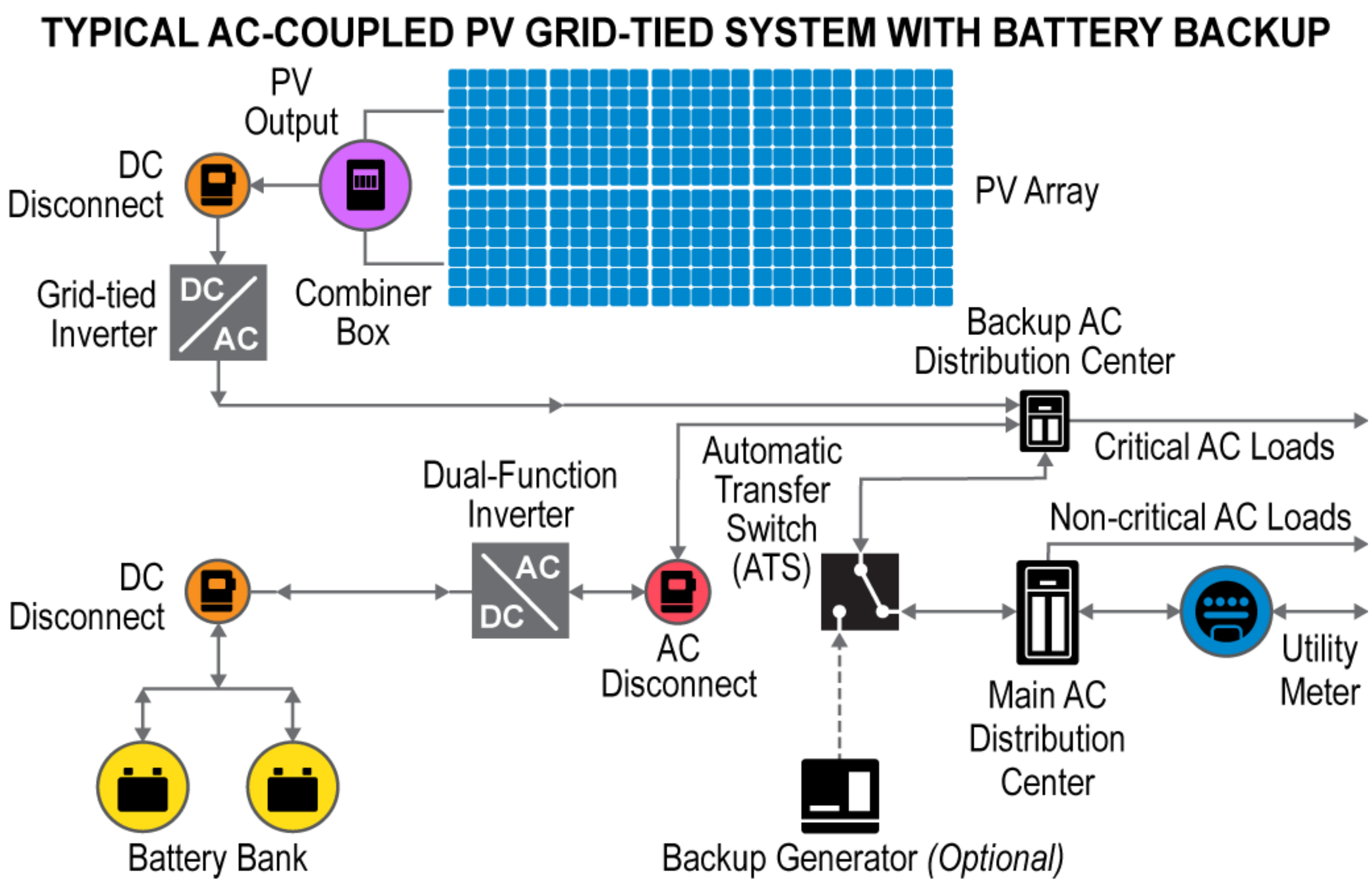
System Overview- System Configuration



System Overview- System Configuration



System Overview- System Configuration

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

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?

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
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- Finding a good developer

Source: NREL

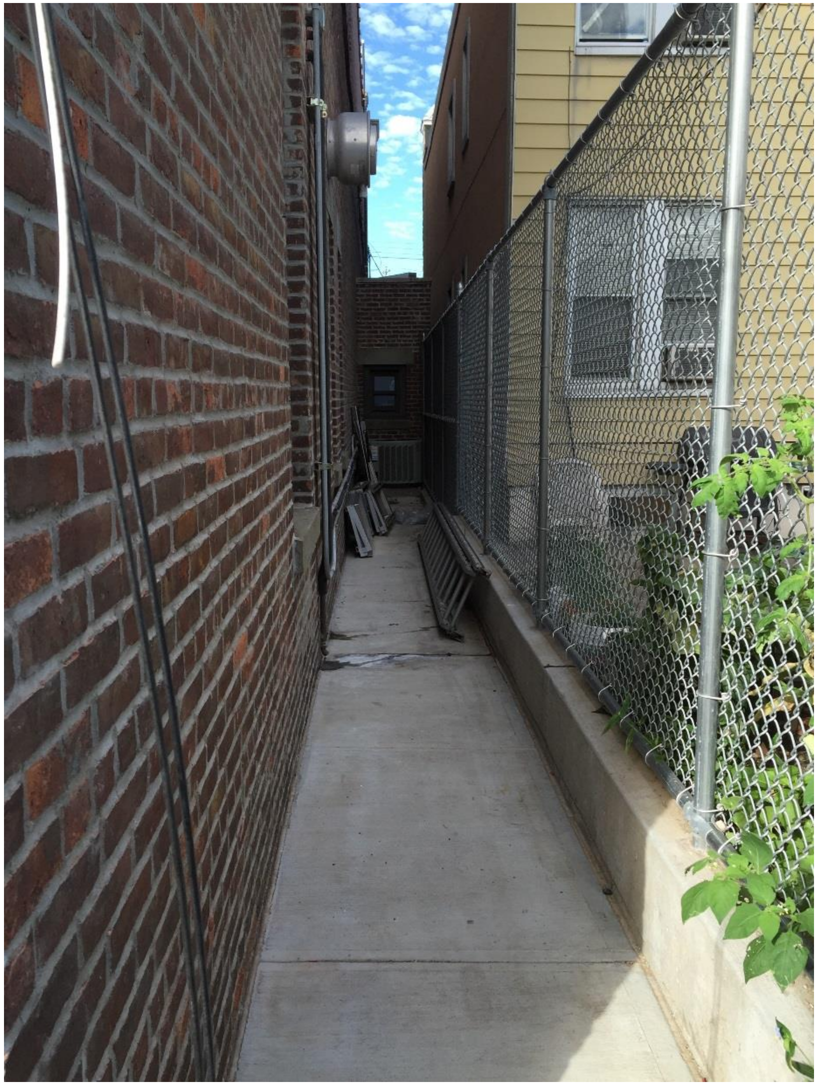
System Design

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

Rated Battery Capacity (kWh) = Total Critical Load (kW) X Run Time (hrs)

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

Rated Battery Capacity (kWh) = 5 X 0.3 (kW) X 12 (hrs)

Rated Battery Capacity (kWh) = 18 (kWh)

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

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

NYSOLAR SMART DG Hub

FACT SHEET

Attachment A

General How-to Guidelines and Work Specification Language

This section includes example language from RFPs for procuring an ESS that is integrated with solar.

WORK SPECIFICATION

The contractor is required to design, construct and effectively demonstrate a resilient PV system that is capable of powering the essential loads in back up or emergency mode with utility service compromised or unavailable. The resilient PV system shall provide the ability as needed or desired to black start during utility disturbances/interruptions or system testing. The system will integrate existing renewable energy and energy storage systems, and generation systems. Use of generators should be reduced in favor of the renewable energy technologies, where feasible. The resilient PV system shall be controlled by a central control system that will balance generation and load to provide power to the critical loads during a grid outage. The system shall also be used in grid-connected mode to further optimize installation energy use and provide cost savings where feasible. This project shall be designed to be scalable and systematically expandable to include new loads, generation sources, and SunSpec compliant control systems.

<Insert site characteristics with images, available space, electrical connection location, etc.>

The contractor shall be responsible for all necessary analyses, forms, applications, and fees required for the customer to obtain an interconnection agreement (IA), permits, and incentives, for the project.

Project Development Checklist

Pre – Project Scoping ✔

- Establish project objectives

System Design ✔

- Location for equipment
- Ensure capture of ITC
- Battery sizing
- Equipment Compatibility

Implementation ✔

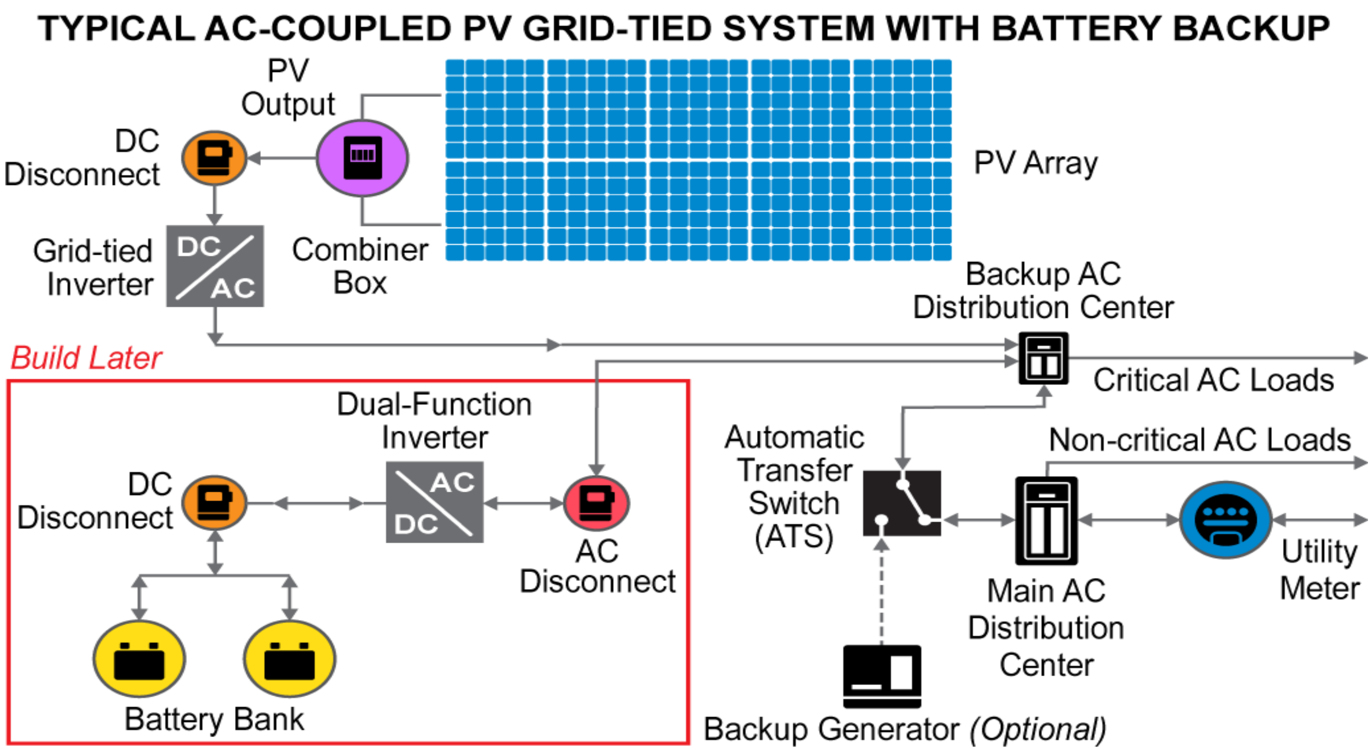
- Paying for the system
- Work specification language to solicit project proposals
- Finding a good developer

Source: NREL

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

Contact Us

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