Strategies for Integrating Solar and Distributed Generation for Emergency Power & Resiliency Deployment

Meeting Summary Report and Recommendations

Contents

Impetus ........................................................................................................................................ 2
Meeting Participants .................................................................................................................... 2
Addressing the Four Dimensions of Integrating Resilient DG Energy Systems .................. 3
  Software & Communications Technologies ........................................................................... 3
  Hardware Technologies .......................................................................................................... 4
  Finance/Economics Models .................................................................................................. 5
  Policy and Legal .................................................................................................................... 5
Informed Project-Based Change ............................................................................................... 6
  Solar PV Smart Inverters: Retrofits and Dynamically Controlled Inverters ......................... 7
  Resilient Islanded Systems: Policy Clarity of Terms and Conditions ................................. 8
  Integrative Modeling of Hybrid DG Systems: PV + Batteries + Generators .................... 9
CUNY Recommendations ........................................................................................................ 10
Impetus
The City University of New York (CUNY) serves as one of NYC’s prime partners in its emergency shelter operation. Sustainable CUNY leads the implementation of Federal, State and City initiatives creating a comprehensive and streamlined infrastructure for the wide scale adoption of solar technology in NYC. In the aftermath of Hurricane Sandy it was determined that while the 672 solar arrays currently on NYC rooftops sustained no damage during the storm, they were unable to supply critically needed power during the subsequent outage due a myriad of barriers including design, costs, technology, lack of incentives for storage, codes and regulations.

Meeting Participants
In January of 2013 CUNY convened a working meeting for local, regional and federal agencies as well as key industry partners to discuss energy infrastructure resiliency in the aftermath of Hurricane Sandy, the third storm to seriously compromise NYC’s power supply in less than 2 years. It was the consensus, that NYC, and other at-risk areas, would benefit from a coordinated focus in order to incorporate emergency functionality within existing and future distributed generation (DG) deployment. In addition, with the prolonged and extensive interruption to several key energy services, general sentiment reflected a need to strengthen and extend energy planning and design towards more resilient energy infrastructure, and reinforce options for integrating emergency distributed power generation in a more comprehensive manner. Correlated with the outages seen in Sandy and past storms, the participants tended to focus on the electric grid, while acknowledging similar challenges for transportation fuels and services as well as regional areas that experienced natural gas interruptions or more broadly the loss of heating system functionality.

This report summarizes the many discussion points raised as well as the varied perspectives that need to be considered for implementing energy resiliency projects. The concept of a Smart Distributed Generation Hub was recognized as a useful tool and the focus of this document is to detail and structure the ideas and suggestions to serve as a launching point for the Hub to organize continuing conversations and market innovations. Discussions throughout the meeting centered around four areas of project deployment:

- **Hardware Technologies**
- **Software Technologies**
- **Policy, legal and regulatory barriers**
- **Economics & Finance**

The sections below review each of the ideas or issues raised through this framework, followed by exemplary projects that could be implemented to foster the transition to a more resilient energy infrastructure. Ultimately, the Hub can provide a platform for informed project-based change and ensure that cleantech solutions can appropriately and rapidly deploy in to the marketplace.

For example, PV inverter retrofits for emergency power could be deployed to move dynamically controlled inverter technologies to the market in order to combine resiliency with smart operation. Below are examples that demonstrate technology deployment and their connection to policy and finance.
A Four Dimensional Approach to Integrating Resilient DG Energy Systems

CUNY utilized the framework depicted here to facilitate meeting conversations. This four dimensional approach can serve to guide the formation of a Smart DG Energy Hub. This framework illustrates how pilot projects can bridge the needs of market innovation and deployment across legal and policy decision-makers, finance institutions, and the software and hardware companies bringing solutions to the market. Graphically, this is demonstrated in the figure to the right. As an example, deploying dynamically controlled inverters, which are emerging technologies for smart and resilient DG applications, draws heavily upon research and development teams in coordination with software and communication protocols, finance and the regulatory environment.

Software & Communications Technologies

Shown below are software and communication technologies that were identified by the participants at the working meeting. Participants recognized the importance of integrating digital technologies into distributed generation technologies.

<table>
<thead>
<tr>
<th>Software or Communication</th>
<th>Deployment Ideas or Issues</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenant/Customer notification applications</td>
<td>• Building/utility status</td>
<td>• Smart phone notifications</td>
</tr>
<tr>
<td></td>
<td>• Integration with social media</td>
<td>• Address privacy concerns</td>
</tr>
<tr>
<td></td>
<td>• Actions or steps available to help or support</td>
<td></td>
</tr>
<tr>
<td>Off-grid software transferred to grid-connected systems</td>
<td>• Technology transfer opportunities for emergency operation</td>
<td>• Meet demand management and power quality requirements for on-grid operation</td>
</tr>
<tr>
<td></td>
<td>• Communication to BAS systems</td>
<td></td>
</tr>
<tr>
<td>Utility SCADA integration</td>
<td>• Communication with emergency DG systems</td>
<td>• Address scales of microgrids and control/communication</td>
</tr>
<tr>
<td>Two-way transactive network communication and control</td>
<td>• Pilot systems regionally</td>
<td>• Cost and valuing of systems in nearly real-time basis</td>
</tr>
<tr>
<td>IT packaging based on building typologies</td>
<td>• Sizing software solutions appropriately to building sizes and market segments</td>
<td>• Use open protocol data architecture and exchange standards</td>
</tr>
</tbody>
</table>
**Hardware Technologies**

Shown below are hardware or systems technologies that were identified by the participants at the working meeting. Participants recognized that these solutions require intelligent design and deployment with consideration of resiliency.

<table>
<thead>
<tr>
<th>Hardware or System</th>
<th>Deployment Ideas or Issues</th>
<th>Notes</th>
</tr>
</thead>
</table>
| **Grid infrastructure resilience & DG** |  - Microgrids: facility, network, lateral, circuit, substation bus, secondary  
  - Demand Response during and after an event  
  - Energy storage for grid islanding  
  - Resilient DG for strengthening communications systems: cell phone/internet |  - Significant policy and regulatory issues for islanding beyond facility sub-panel  
  - Significant policy and regulatory issues for ownership models of grid-level energy storage for islanding |
| **Integrative hybrid design** |  - Design guides and pilot projects for market segments  
  - Solar, wind, fuel cells, micro-turbine, CHP, tidal/wave, storage, etc |  - Varied technology options for many market segments with need to diverse requirements to foster market development  
  - Fuel savings with hybrid DG design (e.g. solar + energy storage + generator) |
| **Dynamically controlled Inverters and field retrofits** |  - Islanding capability for facilities: requires black start, synch with generator/DG, ATS  
  - Grid-safe connector for generators: intelligent and fail-safe transfer switch  
  - Grid support functions could provide voltage regulation/frequency support at the point of interconnection |  - Islanded power quality: voltage, frequency, surge  
  - Critical load following and matching: prioritization and load shedding  
  - Field retrofits for emergency operation: conversion kits |
| **Emergency power/lighting for evacuation routes** |  - Facilities: hallways, stairwells  
  - External: walkways, roads, street lights, etc. |  - E.g. Boston deploying evacuation route solar lighting system |
| **Locate hardware to reduce vulnerabilities** |  - Retro-commissioning to move basement hardware to 2nd or 3rd floor  
  - Flood resistant quick connectors and panels  
  - Sub-room flood resistant isolation of equipment |  - Connect with updated planning and zoning |
| **DC to DC systems deployment** |  - DC adaptor for AC equipment  
  - DC outlets |  - Options for rapid field deployment |
| **Existing and emerging energy storage system** |  - R&D and pilot projects |  - Assess performance, reliability, cost, commercialization, safety, and sustainability (toxicity, environmental performance) |
Finance/Economics Models

Shown below are finance and economic models and schemes that were identified by the participants at the working meeting. Participants recognized that deployment must make commercial sense and be viable for securing loans and insurance.

<table>
<thead>
<tr>
<th>Finance/Economic Models</th>
<th>Deployment Ideas or Issues</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Bankability models for energy storage with emergency functionality | • Target market segments tiers; critical zones for most cost effective T&D deferment  
• Value to facility vs. value to utility  
• Cost of response/rebuilding | • Ownership models for broader deployment: PPAs, co-owned with utility, etc. |
| Emergency power finance models for extended power interruptions | • Value of power vs. loss productivity  
• Insurance  
• Willingness to pay/willingness to accept modeling | • Marginal cost differential acceptable to market tiers |
| Mobile solar generators with battery storage | • Generator/hybrid ready  
• Rapid deployment | • Meets technical energy load needs and power quality requirements |
| Integrate DR/DSM with emergency power valuation | • Combine energy service valuation for integrated systems | • Demand and ancillary services might be sufficient alone for bankability |
| Economics of DG/storage options for variety of extreme events | • Hurricanes vs. brownouts, etc. | • Deployable systems for market segments |
| Economic incentive analysis of marginal policy costs to incorporate emergency power functionality | • Assess available incentive systems for increasing deployment | • Suggest targeted incentives for critical infrastructure and key social groups |

Policy and Legal

Shown below are the policy and legal models and schemes that were identified by the participants at the working meeting.

<table>
<thead>
<tr>
<th>Policy/Legal/Regulatory Ideas</th>
<th>Deployment Ideas or Issues</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Policies for critical infrastructure emergency power | • E.g. shelters, OEM centers, communication centers, hospitals, transportation fuels & fuel stations, potable water pumping and/or purification, etc. | • Consider options for site installations as well as rapidly deployable systems  
• Balanced for diversity of interruption events |
| Large/public housing needs | • Lighting, elevators, water pumps, commons spaces HVAC, etc.  
• Meter configuration(s) | • Policy schemes to deploy for communities without many financial options |
| Communication standards for grid integrated emergency power | • Utility SCADA integration?  
• Integration with BAS systems and smart equipment control | • Ensure safety of utility personnel and equipment |
<table>
<thead>
<tr>
<th>Policy/Legal/Regulatory Ideas</th>
<th>Deployment Ideas or Issues</th>
<th>Notes</th>
</tr>
</thead>
</table>
| “Code Red” regulations for rapid emergency DG deployment | • Establish policies and agency requirements  
• Publish guidelines and distribute before event occurs | • Establish now in preparation for possible future events  
• Equipment and warranty concerns related to switching inverters/equipment |
| Review/Update zoning and building codes, required insurance | • Smarter building/re-building with integrated DG | • Assess against national and international standards and best practices |
| Combined incentives: PLM, grid services and emergency power | • Make emergency systems more financially viability with combined services | • Role of energy storage |
| Safety on/off controls standardization | • Standardization of specific components for operation/shut-off by emergency/first responders | • Labeling, communication, and functionality requirements |
| Net metered storage during outages on microgrids | • Certain allowances during emergency situations | • Find balance of net metering allowance while improving options for energy resilience |
| Security/privacy/customer concerns of personal data | • Consistent with latest Homeland Security protocols | • Ensure customer privacy of personal data |
| Regulation of utility scale microgrids with customer owned DG in emergency | • Rate tariffs when net metering  
• Dispatch communication & control | • Pilot project options for small scale examples |
| Incentives for critical grid zones or facilities | • Facility islanding to support grid services: DR, area power quality  
• Supportive solar if generator fuel/day > threshold value | • Connect incentives to critical applications with emergency operation  
• National best practices |
| Standards and regulatory clarity | • Different definitions used for ‘islanding’ in IEEE 1547.4 and NY SIR | • Need comprehensive review to achieve consensus of terms/scope |
| Bankability and insurance for long-term projects | • Options for reducing loan risk | • Aggregation and securitization options |

**Informed Project-Based Change**

Below are project ideas that illustrate how informed project-based change can help move cleantech energy solutions to the market. Current Sustainable CUNY projects and tasks are driven by informed reports that were conducted with a large group of collaborators and stakeholders. Stakeholder engagement and partnerships throughout the project process facilitates innovation and adoption.
Solar PV Smart Inverters: Retrofits and Dynamically Controlled Inverters

**Project 1:** Convene and work with PV inverter companies to benchmark the current and emerging technologies that support facility islanded emergency solar energy. Assess power generation and power quality requirements, such as synchronization methods and load matching. Determine hardware and firmware options for field retrofits, and if applicable reach out through the existing NY Installer’s Roundtable for pilot installations. Assess marginal cost differences and financial models for incentives or investments. Evaluate policy or regulatory barriers to initial deployment, including New York State Standardized Interconnection Requirements and Utility safety, reliability and economic impacts.

**Background:** Historically, distributed generation (DG) energy system deployments on the NYC electric grid have been governed by a regulatory and legal framework that favors a design whereby the DG system shuts down if it detects an electric grid power interruption. The rational for this is historically related to safety and reliability concerns regarding worker and equipment safety under reverse power flow situations. This issue is compounded by the lack of visibility of reverse power flow during service restoration efforts. Consequently, the current design precluded solar photovoltaic (PV) systems from generating energy if they were located in the areas of the grid that suffered from extended power outages in hurricane Sandy’s aftermath. Therefore, a project to consider alternative designs is required to ensure resilient solar installation.

### Hardware or System

<table>
<thead>
<tr>
<th>Deployment Ideas or Issues</th>
<th>Notes</th>
</tr>
</thead>
</table>
| **Dynamically controlled Inverters and field retrofits** | • Islanding capability for facilities: requires black start, synch with generator/DG, ATS  
• Grid-safe connector for generators: intelligent and fail-safe transfer switch  
• Grid support functions could provide voltage regulation/frequency support at the point of interconnection | • Islanded power quality: voltage, frequency, surge  
• Critical load following and matching: prioritization and load shedding  
• Field retrofits for emergency operation: conversion kits |

**Hurricane Sandy’s Impact on PV:** In the aftermath of hurricane Sandy, CUNY conducted an analysis of NYC solar installations summarized by zip code (see figure). Counting only zip codes that were flooded and zip codes with known outages, CUNY found that 281 installations (5,500 kW) are in these zip codes: close to half of the solar installations in NYC. After accounting for the cloudy and rainy weather for the first 3 days immediately following Sandy, these solar systems would, on average, generate electricity at 35% of their full sunny day capacity. This corresponds to 6,500 kWh of solar energy per day that could have been used to power critical loads in their respective buildings. This project aims to evaluate the hardware, software, finance and regulatory barriers to work towards having these and future PV systems available for emergency power operation during extended grid outages.

**Next Step:** Convene Inverter’s Roundtable (date 3/13/13)
Resilient Islanded Systems: Policy Clarity of Terms and Conditions

**Project 2**: Engage industry, regulators and utility experts in the terms, conditions, and circumstances when purposeful islanding can take place and the policies needed to support such action for a more resilient electric grid and a more responsive and flexible emergency power network.

**Background**: The current New York State interconnection standard (SIR) only allows distributed generation to operate under very specific conditions when grid power is interrupted – that the point of common coupling (PCC) is a disconnected open circuit and therefore the generator will not send power back to the utility grid (i.e. anti-islanding to the grid secondary, distribution circuit, substation or adjacent distribution circuit).

Specifically, the SIR of 2012 states: The generator-owner shall not supply power to the utility during any outages of the utility system that serves the PCC. The generator-owner’s generation may be operated during such outages only with an open tie to the utility. Islanding will not be permitted. The generator-owner shall not energize a de-energized utility circuit for any reason. (NY SIR, April 2012, www.dps.ny.gov/distgen.htm)

The SIR provides the following definitions: Islanding: A condition in which a portion of the utility system that contains both load and distributed generation is isolated from the remainder of the utility system. (Adopted from IEEE 929.) Point of Common Coupling: The point at which the interconnection between the electric utility and the customer interface occurs. Typically, this is the customer side of the utility revenue meter.

NY SIR qualified inverters are required to satisfy the following: Direct current generation can only be installed in parallel with the utility’s system using a synchronous inverter. The design shall be such as to disconnect this synchronous inverter upon a utility system interruption.

This regulated design requirement for synchronous operation has resulted in a scenario where the typical grid-connected PV systems turns off when the grid power goes down.

**However, an emergency power system is allowed** to operate for a facility (and therefore is an island) when there is an open PCC, and it is in this manner that an emergency sub-panel with critical equipment is allowed to utilize distributed generation during a power loss event. This style of design and operation is a “facility island,” and is recently covered in the IEEE 1547.4 standard for purposeful islanding regardless of whether for emergency power, power quality or other reasons. Broad implementation of this allowance has been hampered due in part to differing use of terms with the NY SIR and its favoring of “anti-islanding.” Specifically as stated in the IEEE 1547.4, interconnection agreements “will need to be amended to reflect the area EPS’s (Energy Power System’s) dependence on the DR (Distributed Resource) to support the needs of the planned intentional island. Each party to such an amended agreement will likely seek remedies for non-performance by the other party that are not adequately addressed in the existing IA language. Utility tariffs will need to be established to identify the financial parameters under which these agreements will operate” (pg 41).

**CUNY Suggested Next Step**: Convene Policy Working Group for the DG Hub to clarify and determine appropriate policy and associated language.
Integrative Modeling of Hybrid DG Systems: PV + Batteries + Generators

**Project 3:** Perform engineering and finance modeling of integrated hybrid systems that would be capable of supplying on-grid power as well as off-grid power in emergencies. Modeling output could include system design diagrams and equipment specifications for targeted market segments and end-use technologies. Cost and revenue modeling could likewise evaluate existing technology & fuel prices and project market diffusion scenarios based on typical deployment models.

**Background:** Many emergency DG power systems are only used during periods of area power interruption or extreme constraints on energy infrastructure. An effort to integrate system designs would capture the value of typical or normal energy service requirements. Resilient DG energy systems could be designed to integrate emergency functionality into systems with demand management, peak shaving, reduced energy bills based on time-of-use/day pricing, operate based on environmental quality signals, and deploy grid ancillary services (e.g. voltage/frequency control, reactive power) where appropriate. Shown in the table below is a combination of ideas displaying the many modeling dimensions and perspectives.

<table>
<thead>
<tr>
<th>Systems Modeling</th>
<th>Deployment Ideas or Issues</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrative hybrid design</td>
<td>• Design guides and pilot projects for market segments</td>
<td>• Varied technology options for many market segments with need to diversify requirements to foster market development</td>
</tr>
<tr>
<td></td>
<td>• Solar, wind, fuel cells, micro-turbine, CHP, tidal/wave, storage, etc</td>
<td>• Fuel savings with hybrid DG design (e.g. solar + energy storage + generator)</td>
</tr>
<tr>
<td>Integrate DR/DSM with emergency power valuation</td>
<td>• Combine energy service valuation for integrated systems</td>
<td>• Demand and ancillary services might be sufficient alone for bankability</td>
</tr>
<tr>
<td>Combined incentives: PLM, grid services and emergency power</td>
<td>• Make emergency systems more financially viability with combined services</td>
<td>• Role of energy storage</td>
</tr>
</tbody>
</table>

**Using integrative modeling of Hybrid DG Power Systems** allows for alternative technologies evaluation. Furthermore, sensitivity and marginal costs studies can be performed to determine fiscal and economic risk in terms of fuel types and market opportunities for the range of energy services that resilient DG could support. Hybrid designs must consider the combined interaction of the (1) loads, (2) generator, and (3) DG/energy storage size in an integrative manner, including operation and safety under typical, uncommon, and emergency situations.

**CUNY Suggested Next Step:** Establish modeling and pilot projects with clean tech partners.
Summary

The energy lessons learned from Hurricane Sandy as well as the other recent storms and catastrophic events suggest that the prolonged power outages experienced might happen more frequently and that New York will need to better prepare going forward. With CUNY as one of the largest suppliers of emergency shelters for the City, and with Sustainable CUNY’s leadership in establishing enterprise frameworks for the adoption of solar technology throughout NYC, it is clear that CUNY has a responsibility to support a coordinated and direct focus on incorporating emergency functionality with existing and future distributed energy systems.

Resilient energy systems require energy planning and design to allow for dynamic and more flexible DG energy systems that are adaptable and interconnected. DG systems must provide general energy services and have the ability to integrate as emergency distributed power generation in a more comprehensive manner. A resilient energy infrastructure integrates both of these perspectives and will provide economic stability and opportunities for the future.

The participants at the working meeting agreed on the need to establishing a platform to realize the goals of a more resilient DG infrastructure. Accordingly, CUNY agreed to continue convening this group and to assisting with developing the projects proposed in partnership with the group. The **Smart Distributed Generation Hub** will gather together and foster deployment of the innovations required to realize the vision of a more resilient energy grid. The significant ideas and issues discussed by the thought leaders at this initial meeting can therefore serve as seeds to grow projects for implementing change and creating next generation technologies. The ideas and issues will continue to structured into four working areas: (1) hardware technologies, (2) software and communication technologies, (3) policy, legal and regulatory schemes, and (4) economic and finance modeling. Sustainable CUNY, through the Smart Distributed Generation Hub, will share these ideas in an effort to create partnerships for implementation and is committed to continue its leadership in transforming energy markets and innovation pathways.

For additional information or to provide additional feedback on the Smart Distributed Generation Hub please contact Sustainable CUNY at: sustainablecuny@mail.cuny.edu