

20 - Two Bridges (Manhattan)

Notice

The opinions expressed in this report do not necessarily reflect those of the New York State Energy Research and Development Authority (hereafter “NYSERDA”) or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, NYSERDA, the State of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. NYSERDA, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

NYSERDA makes every effort to provide accurate information about copyright owners and related matters in the reports we publish. Contractors are responsible for determining and satisfying copyright or other use restrictions regarding the content of reports that they write, in compliance with NYSERDA’s policies and federal law. If you are the copyright owner and believe a NYSERDA report has not properly attributed your work to you or has used it without permission, please email print@nyserda.ny.gov



Two Bridges/Beyond the Grid

NY Prize Stage 1

Community Microgrid Feasibility Study

Final Report

Prepared for NYSERDA by:

Two Bridges Neighborhood Council

The Louis Berger Group

Morrison & Foerster LLP

Milestone Architecture

WiFi-NY

Lockheed Martin

Stout Risius Ross

1.0 INTRODUCTION TO SITE 20

The urban area being served is highly dense and vertical as shown in the photo below.



Figure T1-1: Looking north east across the Two Bridges/Beyond the Grid Community Microgrid Project Area, with participating sites outlined.

At a recent international energy conference in Houston, Jeff Immelt, Chairman and CEO of General Electric, and Stanley Fischer, Vice Chairman of the Federal Reserve, spoke highly of a new book by Robert Gordon titled, “The Rise and Fall of American Growth.” The following passage from the book’s introduction crystallizes the importance of the *Beyond the Grid* project:

There is no greater example of the importance of the inventions of the special century [1870-1970] than the aftermath of Hurricane Sandy, a freakishly powerful storm that devastated much of New York City and the seacoast of New Jersey in late October 2012. Floods have been common throughout human history, but interaction between the weather and the Great Inventions had not previously occurred on such a scale. Sandy pushed many of its victims back to the nineteenth century. Residents of New York City below Thirty-Fourth Street learned what it was like to lose the elevators that routinely had carried them to and from their apartments. Not only was vertical movement impeded, but the loss of the subways

to flooding, along with the electrical blackout, eliminated the primary means of horizontal movement as well. Anyone who had no power also lost such modern inventions as electric lighting, air-conditioning and fans to ventilate dwelling spaces, and refrigerators and freezers to keep food from spoiling. Many residents had no heat, no hot food, and even no running water.... Moreover, communication was shut off after batteries for drain on laptops and mobile phones.

1.0.1 Defining the Need & Potential for the Microgrid

Low-income urban populations suffer disproportionately from negative impacts of energy policy, climate change, and pollution, while contributing least to the root causes of these problems. On the Lower East Side (LES), vulnerable, low-income populations are housed along a waterfront at risk for flooding, and burdened with air pollution from transportation infrastructure and inefficient heating and power generating technologies.

Our project area falls within an environmental justice community—a low income population directly impacted by the particulate loads and greenhouse gas emissions from power generation. Piloting innovative, low-carbon and sustainable power and heat generation in this community is more than symbolic; it will be a noticeable improvement for the quality of life in the LES.

In addition to the direct local impacts of power generation, increasingly disruptive climate change related impacts are also felt acutely on the LES. All of the Two Bridges/Beyond the Grid Community Microgrid sites were flooded by Hurricane Sandy, and all lost power and sustained damage to critical infrastructure, including boilers (Sandy occurred during a cold snap in late October, and outages continued into early November); and elevators – the residential multifamily elevator buildings are home to many vulnerable individuals, including the elderly and infirm, many of whom were trapped in upper floors.

Systemic social and economic issues also impact local residents: high unemployment rates; low income; lack of educational and professional opportunities; poor air quality; aging infrastructure; and a digital/technological divide.

Strengthening economic, ecological, social, physical, communications and energy networks is essential to resiliency in fair-weather as well as during crisis. The need to reduce carbon emissions, lower energy costs, and bridge the technological divide that inhibits low-income communities from fully participating in the 21st century economy is not limited to the East Village neighborhood of the Lower East Side. Our proposal (relying on building new and strengthening existing networks, enhancing existing social assets, creating new economic development opportunities, and deploying tested technologies in innovative ways) is designed to be scalable and replicable.

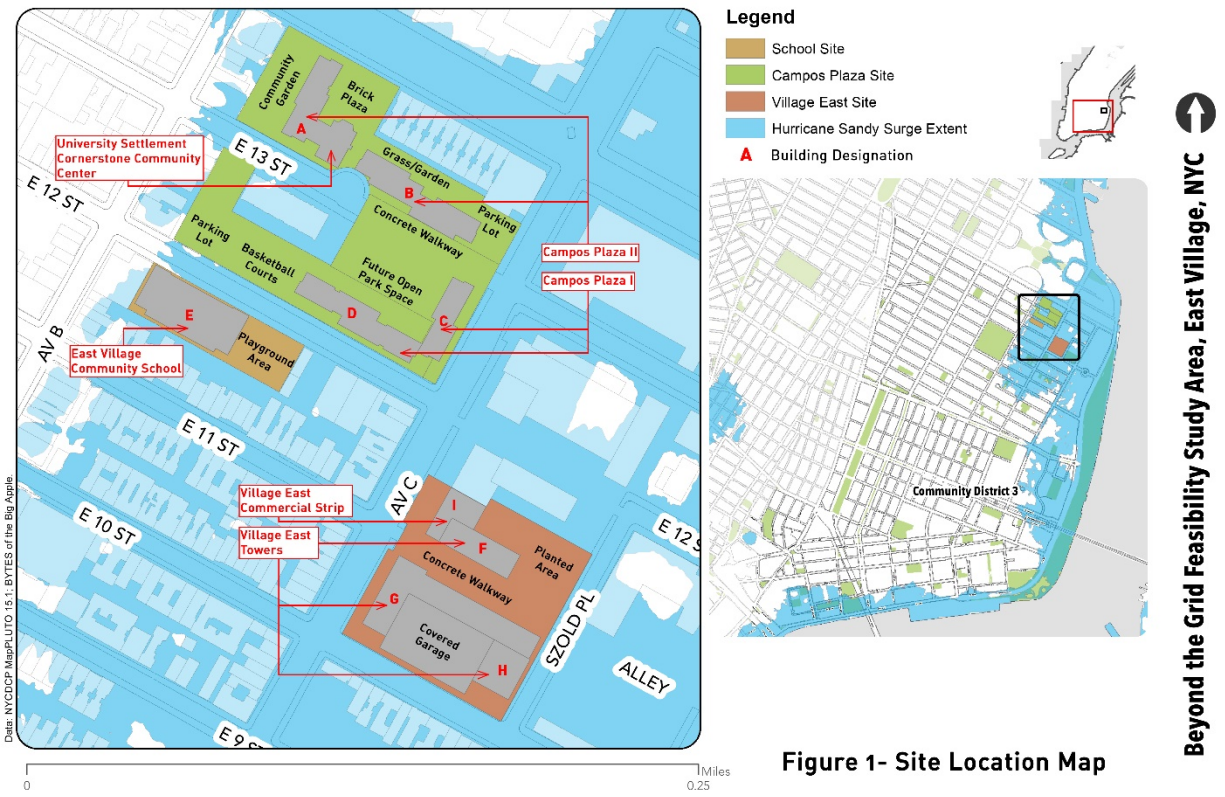


Figure T1-2. Site Location Map

Members who have committed to the project and those that are working with management to form an agreement with the project are excited about participating in an energy co-op, serving as a testbed for equipment innovation, and developing a business template for use in other dense, urban microgrids.

1.0.2 New York Prize

The Two Bridges Neighborhood Council, Inc., along with its earliest partners, The Louis Berger Group, Inc., Schneider Electric, WiFi NY, Morrison & Foerster, and Milestone Architecture, submitted a proposal titled “Beyond the Grid Community Microgrid” for the NYSERDA NY Prize RFP 3044 Stage 1 Feasibility Assessment. The proposal was accepted. Lockheed Martin took over for Schneider Electric. This is the final report.

The Two Bridges/Beyond the Grid Community Microgrid will serve a mix of public and private residential, institutional, and commercial sites along Avenue C between East 10th Street and East 14th Street in the East Village, all of which were impacted by flooding and/or electrical outages as a result of Hurricane Sandy.

The proposed microgrid will include a mix of natural gas and renewable generation sources, including combined heat and power, energy storage, and demand-side efficiency measures, and

will serve three public schools, a community center, a pharmacy, a supermarket, and a variety of apartment buildings.

The goal of the proposed project is to study the feasibility of building and operating a community microgrid for the purpose of maintaining electric services for the participating customers/facilities and the community at large in the City of New York Lower East Side area at times when weather events or other emergencies severely disrupt the capacity of the local distribution and transmission system to serve essential community needs.

Data collection was achieved with cooperation from the site partners. Schneider Electric and Louis Berger Group assessed existing utility infrastructure and how it can interface with the microgrid. The energy efficiency measures and demand reduction strategies analyzed are:

- LED lighting – Interior and Exterior – with controls
- Building Automation Systems
- HVAC replacement and/or retrofit (high efficiency boilers, heat recovery)
- Building envelope upgrades (weatherization, window replacement, window film, cool roofs, etc.)
- High efficiency appliances or solutions, especially provision of chilled air for retail.



Figure T1-3: Project Area (aerial overview)

1.0.3 Project Background & Site Partners

Site partners are New York City Housing Authority (NYCHA), New York City Department of Education, L+M Development Partners, and Village East Towers (Mitchell Lama middle income housing cooperative). Figure T1-3 shows the outlines on an aerial map.

1.0.3.1 New York City Housing Authority (NYCHA) & L+M

Campos I & Campos II consist of the following buildings, owned jointly by NYCHA and L+M Development Partners. Details provided in table that follows. Note that the two properties are managed separately. They do have similar connection hardware.

Table T1-1. New York City Housing Authority Buildings

Development Name	Bldg #	Address	# of Floors	SQ FT	Units
Campos Plaza I	1	635 East 12 th Street	10	128,780	93
Campos Plaza I	1	205 Avenue C	23	174,310	176
Campos Plaza II	2	643 East 13 th Street	9	126,800	96
Campos Plaza II	2	612 East 14 th Street	17	208,928	128



Figure T1-5 Example fuse panel corroding post-Sandy

Many of the electrical distribution systems were affected by flooding during superstorm Sandy and may need to be replaced and relocated above ground to prevent future issues. Under the

existing electrical system tenants pay for their own electricity and are metered separately. To incorporate these buildings into the proposed microgrid, an advanced metering system may be installed on the feed coming from Con Edison; each tenant will have its own sub-meter

1.0.3.2 New York City Department of Education

The East Village Community School - Public School 315. This building actually houses three schools in one facility: East Village Community School, Children's Workshop School and Spectrum School. The 72,200 SQ FT building is a 5-story historic school building.



Figure T1-6 PS 315 was built in 1911 as PS 61

1.0.3.3 Village East Towers

Mitchell-Lama¹ Moderate Income Co-op comprised of three buildings, 25 stories, 21 stories and 10 stories. 439 limited equity (ownership) units with 436,435 square foot of residential space plus private covered garage. Common areas at Village East include a management office, swimming pool area, laundry room, lobby, compactor room, and utility room.



T1-8 These two views of VET show the pharmacy from above and at street level.

¹ The Mitchell-Lama Housing Program is a non-subsidy state governmental housing guarantee to spur the development of affordable housing for middle-income residents.

1.1 DESCRIPTION OF MICROGRID CAPABILITIES

For this feasibility study, different types of renewable sources and distributed energy resources were evaluated for the implementation in the Beyond the Grid Community Microgrid project. The following list comprises the technologies deemed sufficiently mature and applicable to specific conditions of the proposed microgrid, based on the results of the evaluation:

Table T1-2 Technologies Studied

Studied and incorporated into the technical design	Studied and not included
<ul style="list-style-type: none"> • Solar (PV) • Storage (Lithium-ion; i.e. Lithium Titanate Oxide (LTO) Battery based) • Cogeneration Microturbine (Natural Gas, CHP configuration) • Inverters • Local control and slow islanding for a simpler, more economical set of system controls 	<ul style="list-style-type: none"> • Wind (Vertical Axis) • Fuel Cell (Natural Gas, CHP configuration) • Fuel Cell (Natural Gas, High-Efficiency Electric Only) • Advanced Metering • Automated Load-Shedding • Predicative software options (to optimize energy arbitrage) • Rotary UPS (Flywheel) • Storage (alternate Lithium-ion Battery based) • Storage (Gel Battery based) • Storage (Conventional Battery based) • High security remotely hosted system controls • Absorption chillers

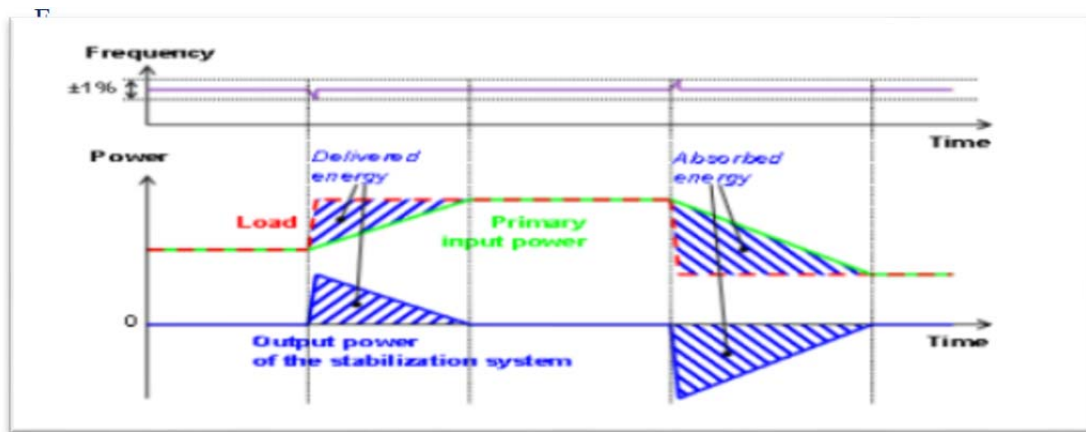
Section 1.2 below provides the minimum required microgrid architecture and interconnection. (The particularities of the specified DER components are discussed in Task 2.) Section 1.3 describes in more detail the desired Microgrid configuration and application of the above technologies at the participating properties.

1.2 MINIMUM REQUIRED CAPABILITIES

The proposed microgrid will need to provide power and in some cases heat, to a diverse group of customers, including two (2) residential complexes, critical facilities consisting of three (3) community schools co-located in one facility, one (1) community center, and a commercial center. The combination of generation resources is proposed that can provide on-site power in both grid-connected and islanded mode, with the ability to form an intentional island and as a minimum cover the critical loads at all participating properties. Should there be a loss of utility source, the microgrid will automatically separate from the grid and restore connection to the grid after normal power is restored and stable.

The *Beyond The Grid* microgrid consists of different types of loads in separate locations. The microgrid will be served by its own closed-loop transmission circuits, interconnected to Con Edison at multiple points directly into the secondary network (for incoming power from the utility) and to the high-tension connection (for outbound power sold to the utility).

The final proposed generation asset size and mix details are described in Task 2.



Voltage and frequency stabilization system with bidirectional energy storage during load fluctuations in an isolated microgrid

Additional FEMA-provided natural gas powered generators planned for installation at the NYCHA properties could provide N+1 capability as backup for loss of microgrid generation or scheduled maintenance of the sources.

The microgrid control system will manage generation to assure optimum voltage and frequency control. The loads will be evaluated for real and reactive requirements as part of sizing the synchronous generators plus a generous margin. The PV inverters can be capable of providing reactive power if needed. These measures will help assure the requirements of ANSI C84.1 are met. The N+1 generator(s) can serve as emergency backup but will not be considered in the design basis.

1.2.1 Microgrid Architecture

Facilities will be electrically tied together, even during grid-parallel operation. This will enable larger base load generation to be deployed, maximizing economies of scale and minimizing the number of generators that will need to be operated in tandem during Island Mode. Thermal load requirements are being met by CHP systems where requested; heat will not be shared between buildings. Battery storage will also serve as a peaking plant.

1.2.2 Island Mode Capability and Operation

During island mode, this distributed generation will become the backbone of the microgrid and will be supplemented with stored power and backup generation sources (primarily natural gas fueled generators) and/or shedding of non-critical loads.

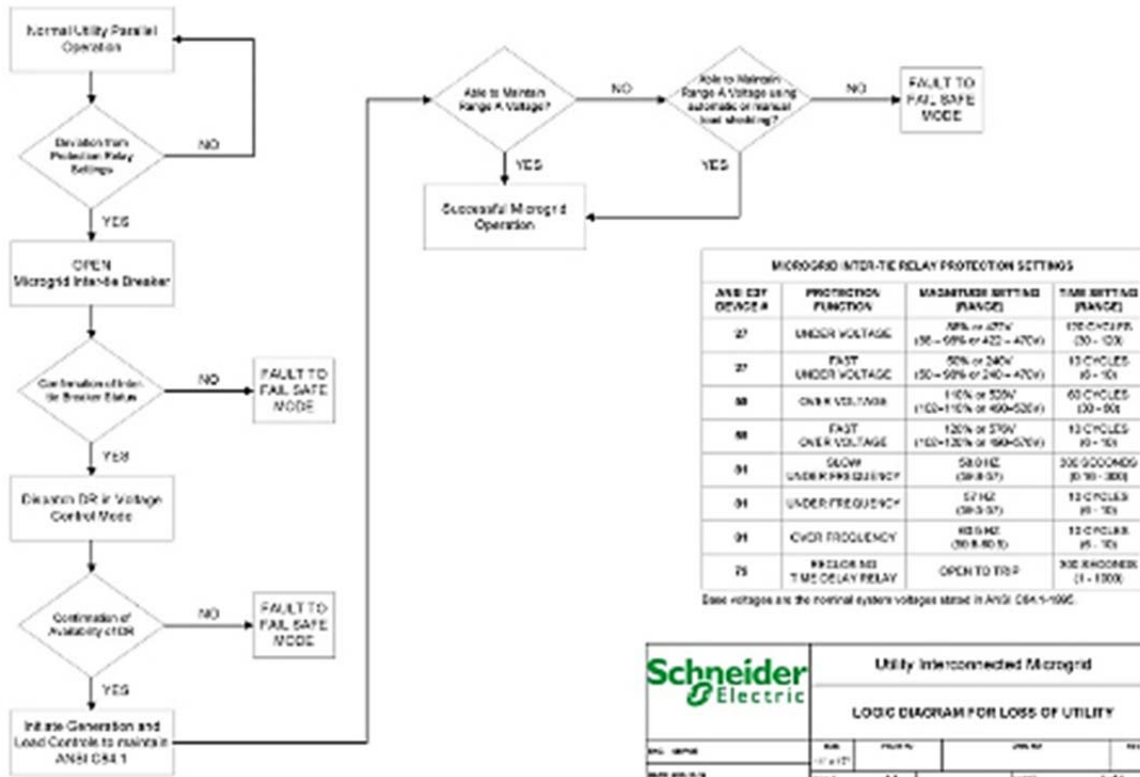


Figure T1-10: Logic Diagram for Loss of Utility

Load shed schemes considered may include limiting the loads during islanded operation to critical systems only (i.e. one elevator/building, some water pumps, heating, sump pumps and common area lighting). The load shedding would be implemented at each building’s main electrical panel. Task 2 includes details.

1.3 MINIMUM REQUIREMENTS FOR POWER GENERATING EQUIPMENT

The power produced by the renewable resources will be paired with proper generation and/or energy storage to allow for 24 hours per day and seven (7) days per week utilization. The generation will follow the load while maintaining the voltage and frequency when running parallel connected to the grid. It will also follow system load and maintain system voltage within American National Standards Institute c84-1 standards when islanded.

The system includes a means for two-way communication and control between the community microgrid owner/operator and the local distribution utility (Con Edison) through automated, seamless integration. The processes to secure control/communication systems from cyber-intrusions/disruptions and protection of the privacy of sensitive data are included.

1.3.1 Risk for Disruption

Historically and anecdotally, the risk for disruption and degradation-of-quality of the LES electrical grid is high. See data provided in Task 3, section 3.3.5. Regular loss of power is a chief motivator for the East Village community to install a microgrid.

At the subject facilities the biggest threat is flooding² leading to physical damage to unprotected equipment positioned at/below the flood level. The loss of grid power greatly exacerbates the situation at the subject facilities as dynamic flood control (e.g. through the use of pumping equipment) becomes impossible.

According to FEMA, area of the microgrid is designated as “Zone AE,” indicating that it is “an area of high flood risk subject to inundation by the 1% annual-chance flood event.”

All proposed new power generation, electrical storage, and microgrid control assets will be placed above the historic flood line. Proper operation of the proposed microgrid will require implementation of certain flood hardening and other resilience measures to protect power infrastructure presently located at the subject facilities. This may include: installation of flood barriers; upgrades to doors; electrical duct seals; sewer line backflow preventers; sump pumps; and relocation of certain power control equipment above the flood line. The requirements for such upgrades will be provided in the conceptual design, however, the cost and detailed design

² NYC's Risk Landscape: A Guide to Hazard Mitigation. The major hazards listed in the report result in flooding of the East Village and LES in general. The report was retrieved Dec, 2015 from http://www.nyc.gov/html/oem/downloads/pdf/hazard_mitigation/nycs_risk_landscape_a_guide_to_hazard_mitigation_final.pdf

of such measures will not be included in the anticipated project budget as the majority of the flood hardening measures are already under consideration by the management of the subject properties, with separate sources of funding.

Appropriate mitigation will be used throughout the microgrid. Examples of mitigation steps include: use of elevated equipment pads; installation of redundant equipment; installation of sump basins and pumps; robust weather-proof enclosures for generation and electrical equipment or installation of equipment indoors and moving of equipment to elevated floors of buildings.

Gas supply in the project area has not been historically disrupted during severe weather events, including the largest recent storm (Superstorm Sandy). Not only is the natural gas supply extremely reliable, unlike liquid fuels, it is not subject to limitations of on-site storage³ nor is the gas supply affected by disruption of transportation networks⁴.

Theoretically, a major threat to the gas supply can come from an earthquake. NYC is in a “moderate” risk category for earthquakes^{2,5}, based on the severity of the consequences despite low probability. The project area is at risk due to soil liquefaction during a quake.⁶ All major structures on the participating properties were built prior to 1995 and so do not include seismic protection in the design of buildings. A dark, but pragmatic perspective is taken for our microgrid’s design criteria: assume no fuel disruption by earthquake, because if we’re wrong, we have much larger problems than lack of natural gas for the microgrid; i.e. a doomsday scenario.

These considerations led the project team to a conclusion that natural gas is a reliable fuel supply for the project area within the range of inherent (as well as upgraded) resiliency of the subject properties. For further discussion, see Task 2, section 2.3.5.

The solar energy potential within the project area is somewhat limited in capacity due to limitations of available roof area and urban shading. We have removed the issue of vandalism by placing models above street-level.

³ Volumetric capacity, regulatory limitations or other.

⁴ Which can occur for many reasons other than coastal storms. In Manhattan a visiting dignitary can freeze transportation, as can a terrorist threat.

⁵ NYC’s Risk Landscape. Earthquakes are discussed in Chapter 4.8, page 131.

⁶ The LES is built on low-laying, formerly inundated area with a historic fill constructed prior to adoption of modern requirements for structural fill, which presents an elevated risk of damage in the event of an earthquake. The risk is soil liquefaction, meaning that any building not anchored to bedrock is likely to collapse.

However, considering the major risk factors, solar energy has a much higher value in the aftermath of a severe weather event due to:

- Independence from fuel of any kind.
- High insolation rates associated with the period of the first several days after the passing of a major weather system.

In sum, the risk for disruption of the electric grid has historically been high due to vulnerability from storms and attendant flooding. Designing for flood waters was critical among the design criteria for the project. Risk of disruption to the natural gas grid is historically low. Solar energy availability is predictably episodic and disrupted by weather, yet is also especially valuable after storms when floodwaters are being pumped out of basements.

1.4 PREFERABLE MICROGRID CAPABILITIES

We discuss in this section design considerations from the grid viewpoint.

1.4.1 Considerations for Locating Power Generating & Energy Storage Technologies

Microgrid technologies selected for this project must provide the following capabilities:

- Maximize on-site power production.
- Startup on demand. Natural gas is considered to be available.
- Provide storage to regulate for non-power producing periods of highs and lows of power production, enable load-shifting to reduce customer rates during peak demand, maximize available power for utility buy-back during peak demand periods.
- Minimize maintenance.
- Control emission (air pollution and noise) points given the residential location.
- Structural stability analysis for some locations will be required, but are not evaluated in this study.
- Renewable power is considered a plus to minimize emissions and assure energy supply during fuel supply disruptions.

When locating power generating equipment initial considerations are:

- Size and weight of equipment (includes all generating asset types).
- Requirements for fuel or power generating medium and interconnections (i.e. CHP/microturbines, fuel cells).
- Noise generated by equipment.
- Air emissions of the equipment.

- Accessibility of natural gas to minimize the expense of running new gas lines.

1.4.2 Availability of Space for Microgrid

This section discusses rooftop and interior space for assets. Opportunities such as canopies, basements, elevated platforms and sides of buildings may be considered for future expansion, but they were not within the scope of this feasibility study. Considering the future expansion of the microgrid, it should be noted that these spaces are representative of spaces in nearby properties, so asset placement discussed herein could be replicated elsewhere in the area. Wind turbine and fuel cell information is left in for informational purposes.

An overview of which areas WILL be utilized is provided in Task 2 Table T2-6: Site Suitability and Installation Area.

1.4.2.1 NYCHA Campos Plaza II and Community Center – Buildings A and B (Figures T1-14 and T1-15)

The 2.14-acre campus bordered by East 14th and East 13th Streets, from Avenue B to Avenue C has two residential buildings and a community center on site; a 9 story building (Building B) and a 17 story building with a 1 story community center and boiler/utility building attached (Building A). Building B's footprint is approximately 13,843 sf and Building A's footprint is approximately 14,185 sf. The potential usable space for solar panels (based on NYC Solar Map online tool) on the rooftops of each building is 7,007 sf for Building B and 3,757 sf for Building A. The practical available rooftop space is approximately 20% less due to future installation of back-up power generators already planned by NYCHA as of inception of this project. Therefore, the practical usable space for solar panels on the rooftops of each building is 5,606 sf for Building B and 3,006 sf for Building A.



T1-14 Campos Plaza II West Side – Building A

The site has a small L-shaped parking lot to the east of Building B. The total area of the parking lot is approximately 9,575 sf. There is an approximate 25'x60' area available in this parking lot for an elevated platform for placement of CHP fuel cells (Estimated up to 500 kW generating capacity).

On the roof of the 17 story residential section of Building A is an enclosed water tower. On the top edges of the enclosure, there is potential for placement of 4 small VWATs. On the roof of the 1 story community center/boiler section of Building A, there is an approximate 60'x45' (upper roof) and 45'x12' (lower roof) area that may be suitable for CHP microturbines (estimated 200 kW generating capacity) and CHP fuel cells placement (estimated 800 kW generating capacity).

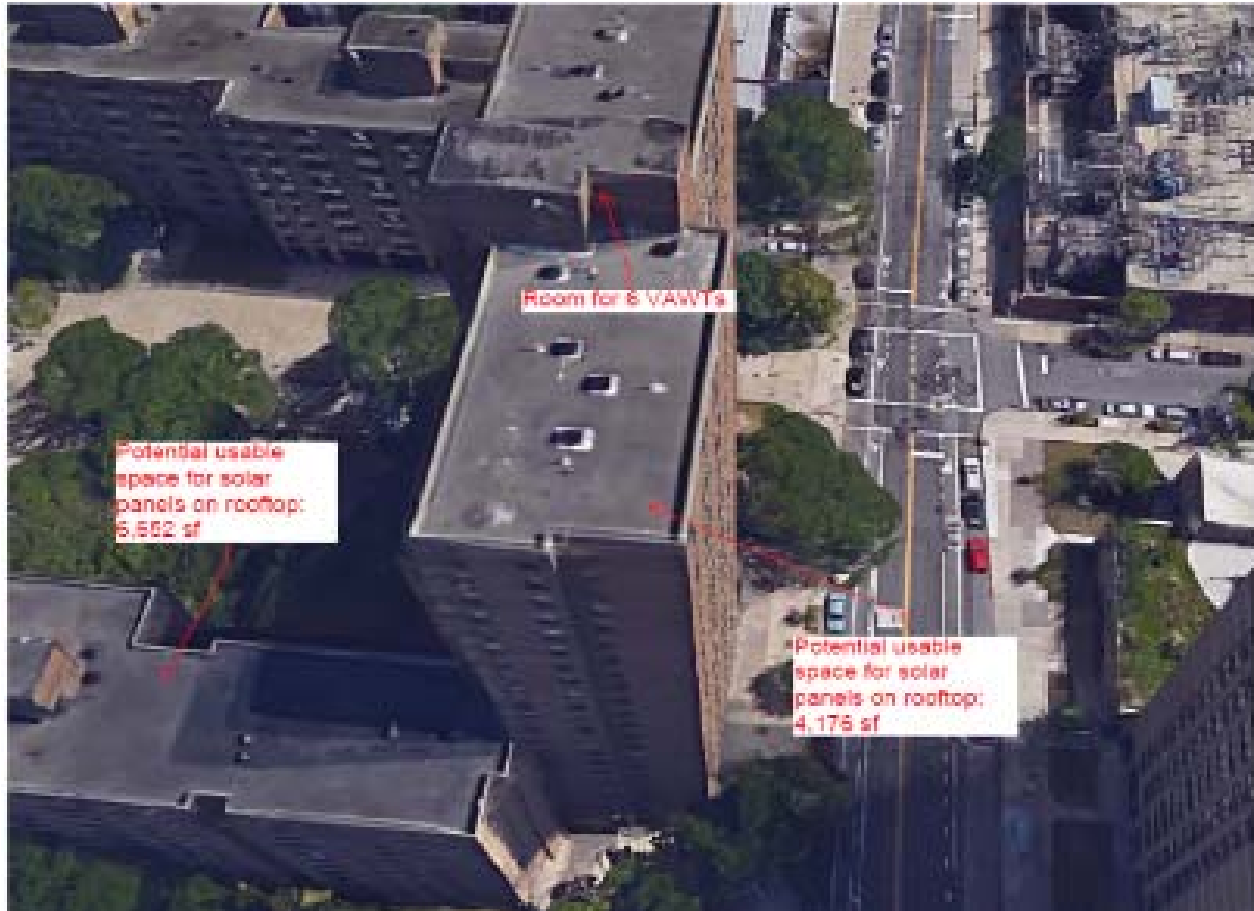


T1-14 Campos Plaza II (East Side) Building B

T1-16

1.4.2.2 NYCHA Campos Plaza I – Buildings C and D (Figure T1-15)

The 2.25-acre campus bordered by E 12th and E 13th Streets, from Avenue B to Avenue C has two residential buildings on site; a 10 story (Building D) and a 23 story (Building C). Building D's footprint is approximately 12,727 sf and Building C's footprint is approximately 7,432 sf. The potential usable space for solar panels (based on NYC Solar Map online tool) is 6,652 sf for Building D and 4,176 sf for Building C. On the roof of Building C, there is available space for placement of 6 VWTs, if this technology becomes economically attractive.



T1-15 Campos Plaza I (East Side) – Buildings C and D

1.4.2.3 East Village Community School – Building E (Figure T1-16)

The community school (Building E) is a 5-story building with a footprint of approximately 19,245 sf. The potential usable space for solar panels (based on NYC Solar Map online tool) on the rooftop is 8,557 sf.

The school's basement has high ceilings (ca. 18 – 20 ft) where CHP microturbines or fuel cells can be located. Areas now occupied by now-defunct mechanical ventilation systems can accommodate generating facilities when old equipment is removed.



Figure T1-16 East Village Community School, Building E

1.4.2.4 Village East Towers and Commercial Strip – Buildings F, G, H & I (Figures T1-17 and T1-18)

The Village East campus bordered by E 10th and E 12th Streets, from Avenue C to Szold Place has three residential buildings, a private covered garage, and a commercial strip; a 10 story (Building F), a 21 story (Building G), a 25 story (Building H), and a 1 story commercial strip (Building I). Building F's footprint is approximately 8,050 sf, Building G's footprint is approximately 20,925 sf, Building H's footprint is approximately 7,300 sf, and Building I's footprint is approximately 5,800 sf. The potential usable space for solar panels (based on NYC Solar Map online tool) on the rooftops of each building is 4,413 sf for Building F, 5,177 sf for Building G, 3,853 sf for Building H, and 0 sf for Building I. Also being considered is installation of a vertical solar array on the ascending southern faces of buildings 170 Ave C and 411 East 10th St.

On the roof of Building I (commercial strip), there is an approximate 60'x15' and a 20'x15' area that may be suitable for non-CHP fuel cells (and/or storage). Directly to the east of Building I and north of Building F is an approximate 20'x20' space for an elevated platform to house a microturbine. The site has a one story covered garage directly between Buildings G and H totaling approximately 26,000 sf. This area is a mix of raised grass and plant boxes, sitting benches and concrete walkways. There are four 60'x8' areas that may be suitable for CHP microturbines, fuel cells or storage. Within these four areas, there is a potential need to reposition some of the fencing to provide sufficient access to equipment as per NYC Fire Code.

An additional 30'x60' area is available over the pool roof, which may be suitable for non-CHP fuel cells or storage. On the roof of Building H, there is available space for placement of 4 Vertical Axis Wind Turbine's (VWTs) if this technology becomes economically attractive.

Village East Towers plans to install 3 x 65kW CHP microturbines independently as of the time of this study.



T1-16 Village East Towers (North) – Building F



T1-17 Village East Towers (South) – Building G and H

T1-20

1.4.3 Proposed Generating Equipment Type

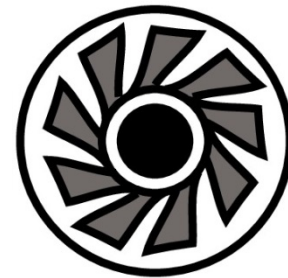
A summary of the generating equipment type and proposed capacity by property is provided in Task 2. The table illustrates initial design assumptions based on available space, potential interferences and sensitive receptors, as well as (in some cases) local thermal energy demand, stated priorities and constraints from property owners and operators as they were made known to the design team at the time of this report. The detailed discussion of these topics is not included in this report at this time as this is a “work in progress” and will be subject of on-going discussions between the engineering team, property owners and financial team during subsequent tasks in this feasibility study.

All natural-gas generators will follow Con Edison’s interconnection process and will comply with New York State’s Standardized Interconnections Process for 50kW-2MW generator interconnections⁷.

Capacity by property is provided in Task 2, Table T2-6: Site Suitability and Installation Area.

1.4.3.1 Cogeneration Microturbines (CHP)

Both heat and electrical power are planned to be captured from the microturbines in combined heat and power (CHP) mode where their combined efficiency approaches 90%. The following considerations were used for selecting/locating microturbines:



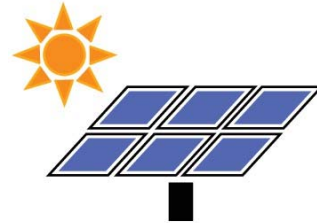
- Can be installed indoors or outdoors. Indoor installation requires air flow and exhaust.
- Units available between 65 kW and 1 MW generating capacity, can be stacked for up to 30 MW generating capacity. The 200 kW and 65 kW high-efficiency, recuperated, CHP-configured units were assumed for this project
- Microturbine CHP modules come in a variety of sizes. The 200 kW unit is 67” wide x 150” deep x 98” high and on the smaller end are 65 kW units that are 30” wide x 77” deep x 77” high; they generally require 3’ to 5’ of access space on all sides for maintenance.
- Although the units assumed for this project feature relatively low noise levels, the noise profile was a consideration in selecting appropriate locations.

⁷ New York State Standardized Interconnections Process:
[http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/dcf68efca391ad6085257687006f396b/\\$FILE/61576243.pdf/Final%20SIR%207-21-15.pdf](http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/dcf68efca391ad6085257687006f396b/$FILE/61576243.pdf/Final%20SIR%207-21-15.pdf)

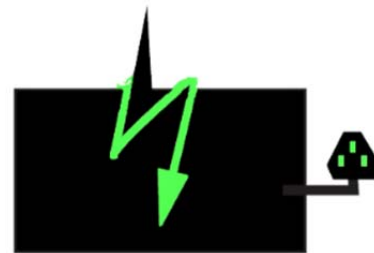
1.4.3.2 Solar Photovoltaic (PV)

Solar photovoltaic panels convert solar energy into grid power. The following considerations were used when selecting and placing the PV panels for power generation:

- The locations must maximize daily direct sunlight as PV panels will not produce power or will produce diminished power when in shadows or at night.
- Both the space constraints and the potential for damage due to vandalism rule out ground-level installation in urban areas.
- Shadowing from surrounding structures is a concern in dense urban environment.
- Warranty of 25 years on most panels.



1.4.3.3 Inverters



Although they are still a relatively new technology and hence the performance is not standardized, many are well proven in the developing world. Lockheed Martin has experience successfully deploying one US-made unit which enables an elegant, streamlined architecture. This systems architecture has been key to *Beyond The Grid* achieving positive NPV.

The bi-directional DC-DC converters chosen for this microgrid use a combination of a DC-link with magnetic coupling. In this way, multiple sources can be interconnected without the penalty of extra conversion stages or additional switches.

The resulting converter features a simple topology, minimum conversion steps, low cost and compact packaging. With a sufficiently powerful digital controller, the control and power management of a complex converter is possible with a multiple PID-loop structure.

The merits of this configuration are presented in the table and figures to follow.

Table T1-3 Attributes of Inverter

Metric	Multi-port	Conventional
Needs a common DC bus?	No	Yes
Conversion Steps	Minimized	More than One
Power Flow Management	Single, simple, fast	Complicated, slow, multiple
Transformer	Single, multi-winding	Multi
Implementation Effort	Low	High

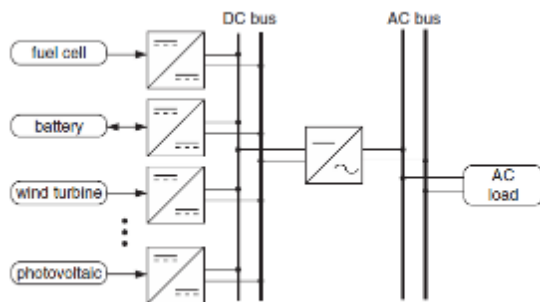


Fig. 1 Conventional structure

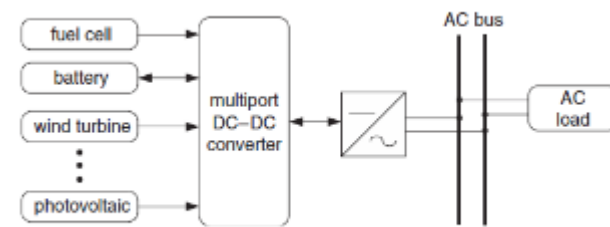
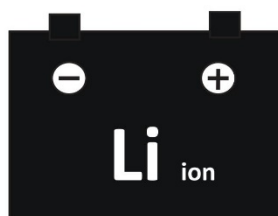


Fig. 2 Multiport structure

T1 – 12 Pair of Figures comparing Conventional and Multiport Inverters

1.4.3.4 Batteries for Storage and Peaking Plant

Battery storage is routinely used to regulate the flow of power from renewables and to span periods of time when renewable facilities are not generating power. The normal choice, anticipated and allowed by building codes is lead-acid based. The most robust of the conventional technologies, gel-based, deep-cycle batteries were carefully considered for the design, but (to the team’s surprise) were found to drive cost, even though they are nominally less expensive.



The technology chosen obviates the need for a considerable amount of detection and switching hardware. Given the multiple nodes intrinsic to true community microgrid designs (as opposed to a campus microgrid design) minimizing 1980’s issue distribution hardware at each node is an extremely important aspect of the electrical system’s architecture. Its added cost vis-

a-vie conventional batteries driving the overall system cost far lower than a conventional microgrid configuration.

The design-of-record battery choice is a lithium-ion variety, specifically, a lithium titanate oxide (LTO) battery.⁸ There are at least five suppliers of this battery type, so sourcing will not be a problem. LTO are known to have long life, supporting three times cycles prior to system degradation than conventional lead-acid batteries. See figure T1-13 for details.

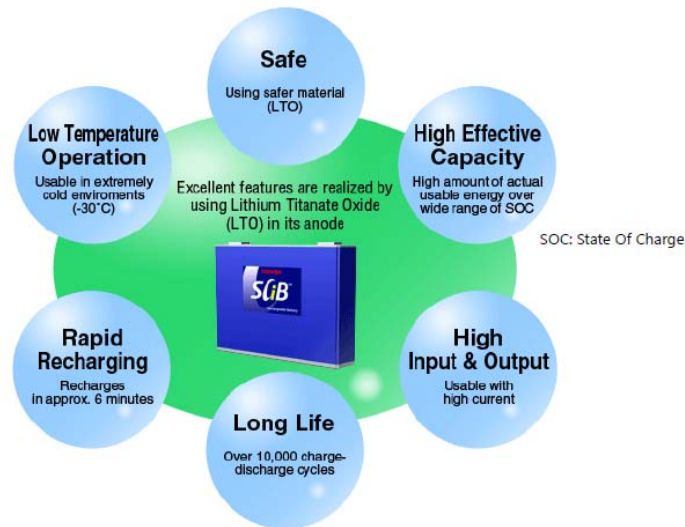


Figure T1 - 13⁹ Attributes of the Lithium Titanate Ion Battery Selected

The battery peaking plant designed has the advantage of being faster to charge than other lithium-ion batteries and provides high currents when needed. Lithium Titanate batteries are also known to be particularly safe, hence its use in electric vehicles. We recognize that Beyond The Grid will have to petition for state regulatory support and building code changes in order to overcome the fear of “lithium” batteries, although we are actually using lithium-ion batteries. See Task 5 for recommendations (recommendation E).

The choice of battery technology and battery plant sizing enables the following features:

- a) Provision of power when both the convention grid and natural gas supply are unavailable
- b) Smooth power transition when the micro grid goes from grid tied to islanded, i.e. standalone configuration

⁸ Note that (a) not all Lithium-ion battery plants are equivalent, capabilities vary by ion-type and that (b) standard lithium batteries (e.g. watch batteries) are not rechargeable. Note also that lithium batteries have a bad reputation for igniting fires, whereas lithium ion batteries are far, far safer.

⁹ MAT-COM-B0360 Toshiba's Rechargeable Battery SCiB R06

- c) Electricity Arbitrage, buying low cost power at night from the grid and selling it at a higher cost back to the grid during the day during peak demands
- d) Grid firming, i.e. preventing voltage sags, and frequency drifts, making the whole grid more robust.

1.4.4 Controls

Controls were studied from two points of view. First, a system controlled and managed by Schneider remotely. This had many advantages especially in the short term. However, in the end, the cost of required redundancy, optical fiber and other issues lead us to choose to run the system locally. Task 2 provides details.

1.4.5 Microgrid Architecture and Flexibility

The innovation in systems architecture that enable low pricing, especially in controls, involves the use of inverters. While the technology is relatively new, it is not unique to one company – several suppliers offer inverters. Furthermore, the technology has been tested at sites developed by Lockheed Martin.

Essential to this architecture is running most of the power from / through batteries. This requires the selection of a battery technology that thrives under continual cycling, as opposed to conventional lead-acid batteries which experience which experience enhanced degradation during prolonged cycling. The battery technology chosen is lithium titanate, for which there are multiple (3+) suppliers. This technology is among the safest lithium ion technology on the market.

Each plant will have an independent control system that will sequence the power output based on the facilities' on-site generation information. The electrical and thermal interconnection methods from the new plant to the existing building will be developed in the next stage of the project. The goal is to use existing access ways as much as possible to simplify installation and minimize the cost.

The three individual plants will allow for future integration of generation technologies as they become available from other programs such as Reforming the Energy Vision (REV). Options to interconnect the three separate plants will be investigated including medium voltage connections. The possibility of using existing utility transformers or new project supplied units will be considered. The data is being gathered from the local utility to address these specific constraints and opportunities. Actual design constraints will be further addressed in the detailed design phase of this project; however, fundamental constraints related to distances, site conditions, and existing infrastructure suitability will be addressed in the feasibility assessment.

Microgrid-owned distribution lines combine the segments during Island Mode as well as during grid-parallel operations.

The proposed generation equipment will be connected to combiner electrical switchgear. Each site's combiner switchgear may be external to the plant and include a step down transformer to match the service voltage as necessary. The combiner switchgear will then connect to the individual building switchgear and operate in parallel or isolated from the utility.

The existing switchgear in each building will be modified to accommodate

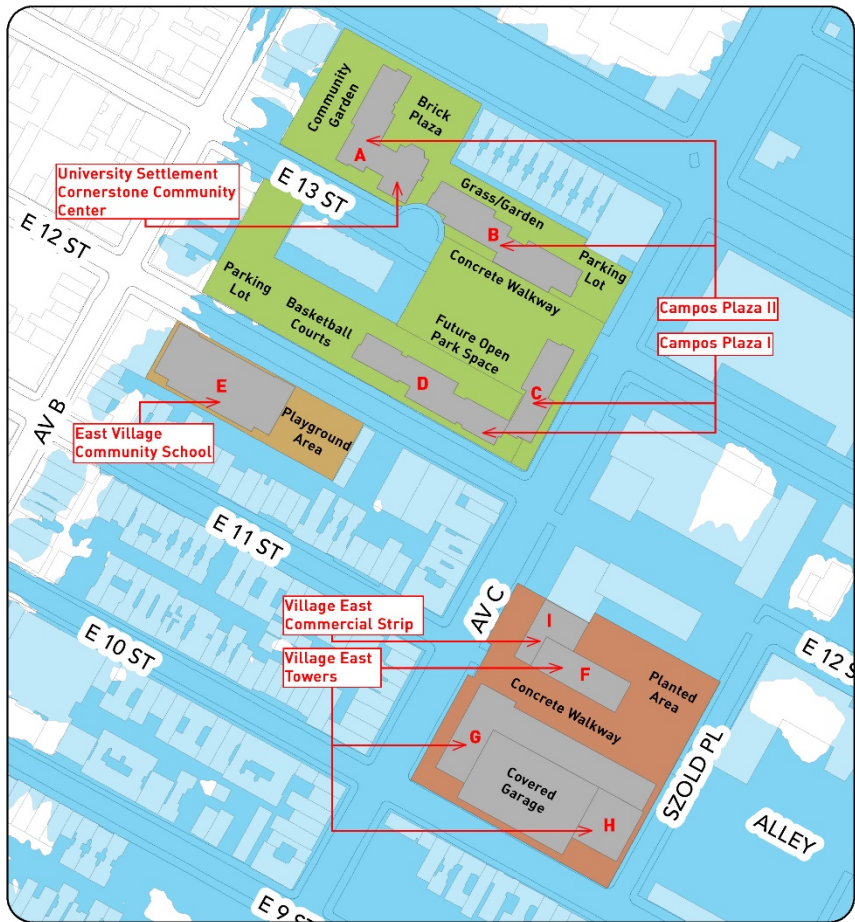


Figure T1-17: The microgrid (NY Prize site 20) would comprise three separate segmentable/ island-able installations corresponding to the three main site partners and covering eight facilities.

a connection to a new intertie circuit breaker. The intertie circuit breaker will be provided with the lock out and tag out provisions to allow for safe maintenance of the new plant and the buildings electrical equipment. The interconnection circuit breaker will include power monitoring and synchronizing controls. The monitoring and controls information will be communicated back to plants control system.

1.5 OTHER CONSIDERATIONS

Both commercial and societal considerations are discussed here. Given that *Beyond The Grid* is mission driven, section 1.5.4 provides a summary of the tangible benefits.

1.5.1 Coordinating with the REV

The goals of Beyond the Grid are aligned with those of New York State Public Service Commission's goals for REV:

- Creating the power grid of the future and enabling customers to better manage and reduce their energy costs
- Promoting system efficiency, reduced carbon emissions, technology innovations, resiliency, renewable/clean energy sources, energy storage, advanced control systems, and competitive energy markets
- Addressing issues like rising electric bills, reliability, jobs, and the needs of low income customers
- Providing an incubator for new technologies such as inverters and lithium titanate batteries.

For a fuller discussion of these points, see Task 3, sections 3.2.4 Meeting NY State REV Objectives, 3.5.2 Analysis of Financial Viability and 3.6 Legal Viability. Leveraging the incubator status is discussed in the next section.

1.5.2 Leveraging Private Capital

Capitalization of the project is discussed in Task 3. Private financing through the use of power purchase agreements (PPAs) is currently being discussed with LES businesses and governmental agencies; long-term PPAs are an integral part of our business case. Given our business model of a not-for-profit entity, we will have the option to evaluate public as well as private financing.

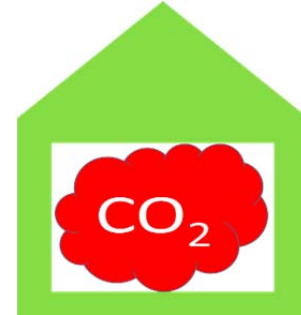
The *Beyond The Grid* microgrid project expects to maximize the use of clean and renewable power for primary local users. Using renewable and clean power technologies will reduce the carbon emissions by the community and will increase the resiliency of the power supply during normal conditions and during catastrophic events. As such, it is anticipated that this project will attract attention from parties that wish to invest in such renewable energy projects, where fuel cost volatility and availability is not a constraining factor. Our attraction for prosumers is discussed in Task 3, section 3.4 Commercial Viability - Creating and Delivering Value.

We aim to become NYSERDA's highest-profile, most innovative incubator of cleantech. Once achieved, that status will give us the opportunity to partner with equipment providers such that

we can achieve expansion with lower capital outlays¹⁰ than a for-profit entity could. We also believe equipment innovation will enhance the job training local residents receive, to the point that we will may have to worry about high staff turnover; a happy problem in this case.

1.5.3 CARBON REDUCTIONS & CARBON MARKETS

Increased efficiency and supplementation of carbon-based fuels with renewables offers the potential to realize significant carbon reductions, and well as cost savings. Additionally, carbon reductions may be a source of future revenue for a potential community microgrid realized on a scale that would qualify it to participate in emerging carbon markets.



Additionally, as a Qualifying Facility/Small Power Production Facility (as defined by Public Utility Regulatory Policies Act of 1978 (PURPA)) the microgrid may engage in carbon-offset trading We also will be exploring potential opportunities available due to the implementation of EPA's Clean Power Plan.

1.5.4 Demonstrating Tangible Community Benefits

Beyond the Grid generates multiple benefits for the diverse, predominantly low-income residents of the Lower East Side, the superset of stakeholders beyond the East Village microgrid participants:

- Reducing energy waste and greenhouse gas emissions;
- Lowering energy costs to help preserve housing affordability;
- Empowering local institutions and residents to lead in climate resilience, mitigation planning and response;
- Creating opportunities for job training (technology, network management and maintenance); as well as transferable office skills.
- Creating safer environments for sheltering in place with grid-independent energy sources that maintain critical building systems
- Establishing a diverse, low-income community as a center for innovative community development without displacement.

¹⁰ Recognizing that electric power generation remains the most capital-intensive industry, lowering the cost of equipment for the build-out will be important. See: <http://connection.ebscohost.com/c/articles/9711205310/electric-utilities-remain-most-capital-intensive-industry>

The microgrid will enhance both basic community benefits and higher-level commercial benefits. This project will allow the community to maintain critical functions in the event of an emergency, including electrical outage. This includes but is not limited to the maintenance of electrical power for fire services, health services, water supply, shelter, and grocery services. This project will support the overall resiliency for the Lower East Side neighborhood.

The production of power in the Two Bridges (aka LES) community will allow revenue generation to fund the capital required to build power generation sources. Hiring and training local labor to build and maintain this project will create new high-paying jobs. The savings from lower cost power can be reinvested in the community to expand opportunities for local residents.



T1-19 For more than half a century, the non-profit organization Two Bridges, has nurtured the unique character of the Lower East Side by developing affordable housing, and advocating for residents and merchants.



TECHNICAL DESIGN COSTS AND CONFIGURATION

2.0 PRELIMINARY TECHNICAL DESIGN COSTS AND CONFIGURATION (TASK 2)

Beyond the Grid is a cross-sector collaboration of architectural designers, engineers, community development professionals and community-based nonprofits with outreach assistance from LES Ready, a coalition of 40+ community groups working to advance disaster recovery and resiliency planning across the Lower East Side.

Beyond The Grid's engineering team comprises the Louis Berger Group, Lockheed Martin and WiFi-NY. Berger has experience finishing projects funded by Federal Housing and Urban Development (HUD) Funds.

The Louis Berger Group (LBG) is an Engineering News-Record top-20-ranked, \$1 billion global professional services corporation that helps clients solve their most complex infrastructure and development challenges. LBG specializes in delivering major infrastructure redevelopment programs in highly populated urban areas. The renewable energy practice has dedicated itself to this project's success. LBG is headquartered in the New York City metro area and has a major office in lower Manhattan.



Lockheed Martin's Microgrid Development Center provides a complete integration environment for simulated and Hardware-in-the-Loop testing of various microgrid architectures and associated microgrid control algorithms. The company has years of experience designing and building microgrids for civilian and military applications.

This microgrid's Manhattan location and the ownership of its member buildings minimizes costs. Specifically, in Manhattan, distribution must be done underground; we do not have the option of overhead lines. Buildings owned by NY-DoE and NYCHA will require that we use union labor. VET's board also expects contractors to use union labor. We have looked into whether the verticality of the project will drive solar installation costs, but fortunately our particular buildings have freight elevator access near bulkheads.

One cost advantage should come with our business model. Our NPO status should allow us to obtain a waiver for sales tax on equipment. Procurement will have need to look out for hidden sales tax. We have already seen quotes where sales tax is placed on both labor or it is hidden in a lump-sum price.

Budgetary price quotes came from companies with years of experience installing equipment in Manhattan and with long-term relationships with the engineering firms on the team. All equipment will be purchased in 2016-2018. For the feasibility study, the *Beyond The Grid* team

estimates accuracy for: Equipment pricing: +/- 15%; Installation pricing: +/- 30%; Maintenance contract rate: +/- 25.

2.1 PROPOSED MICROGRID INFRASTRUCTURE AND OPERATIONS

The proposed microgrid will interconnect buildings electrically through microgrid owned manholes and conduit. Buildings included will not be connected thermally. Where cogeneration is proposed, it will be sized for the individual building needs. The bulk of the microgrid capacity is proposed to be natural gas-fired microturbines in combined heat and power (CHP) configurations. natural gas-based generation will be supplemented by photovoltaic sources. The microgrid will accommodate energy storage using mass battery storage systems to smooth out intermittency of the solar sources and to harmonize frequency and voltage interconnections to the Con Edison grid. Battery storage will be used for blackstart capability with natural gas-fired reciprocating engine-driven backup synchronous generators as failover. These additionally act as “anchor” power sources to provide voltage stability and fast response to load changes when the microgrid operates as an island. If economic analysis indicates a benefit, the synchronous machines could also be used to increase energy exports to the utility system. Costs will be provided in sections 2.3, 2.4 and 2.5.

2.1.1 EQUIPMENT LAYOUT AND ONE-LINE DIAGRAM

Con Edison recommends four connections to diverse Con Edison feeders (to accommodate scheduled outages of 2 feeders at a time. We plan for one connection per site, although if we add other sites we may change these connection placements. Conceptually, Con Edison can accommodate this plan. A one-line diagram showing the proposed microgrid architecture is included in Figure T2-1.

Figure T2-2 shows the physical location of equipment as the members have agreed to it thus far. Team will recommend the best site(s) for both battery storage and microgrid controller after detailed engineering study. The plan of record is to have a single electrical storage location. Submeters will be installed at each facility to measure individual consumption. The microgrid will be bulk-metered by ConEdison at utility interconnection points.

The microgrid will also integrate equipment that is not in place today but is planned for purchase by site partners in 2016: two 650 kW gas-fired backup generators by NYCHA to be placed on the roof of Campos Plaza II; and three 65 kW CHP units by Village East Towers Co-op to be placed at the base of each of the three towers.

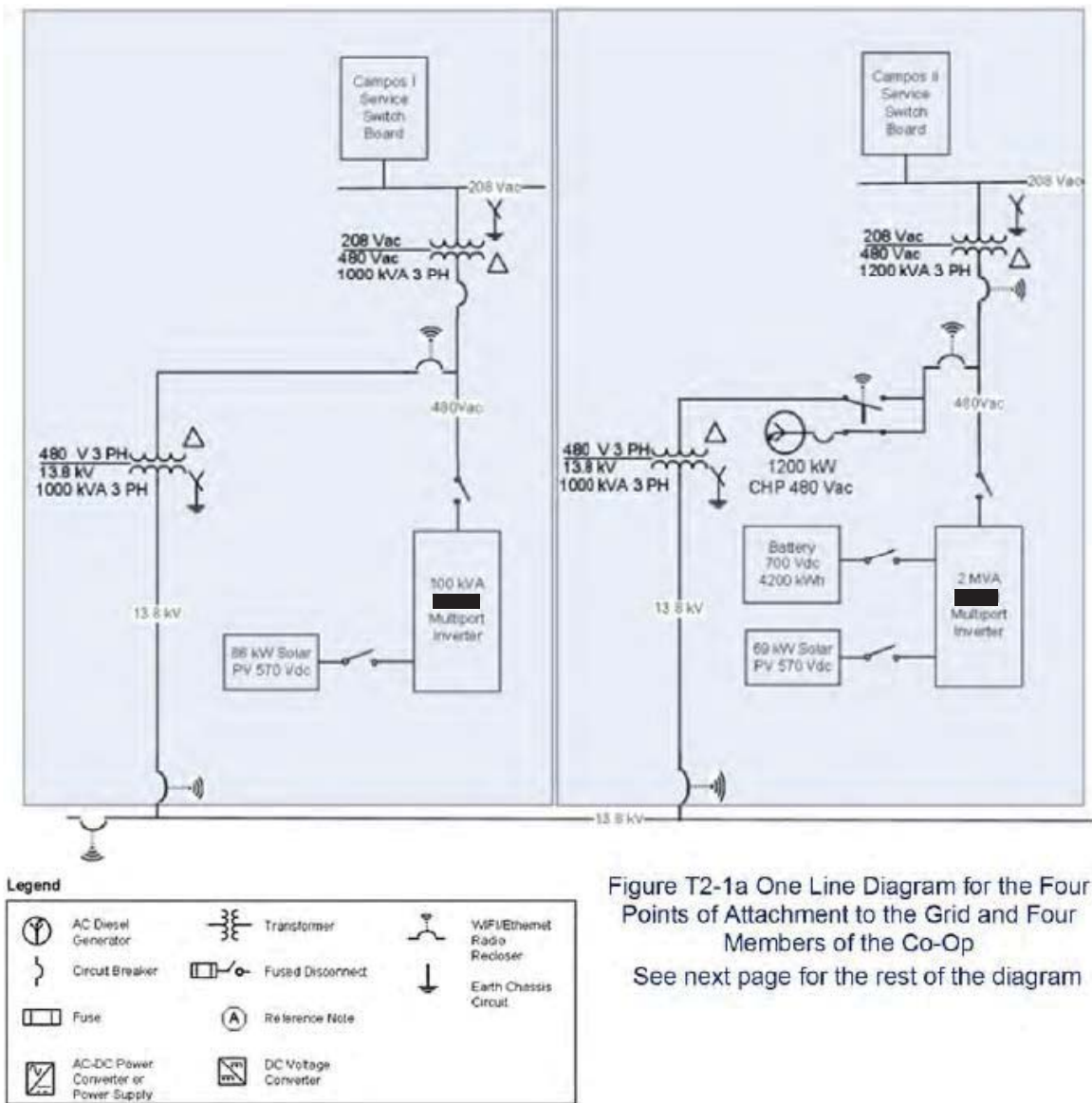


Figure T2-1a One Line Diagram for the Four Points of Attachment to the Grid and Four Members of the Co-Op
 See next page for the rest of the diagram

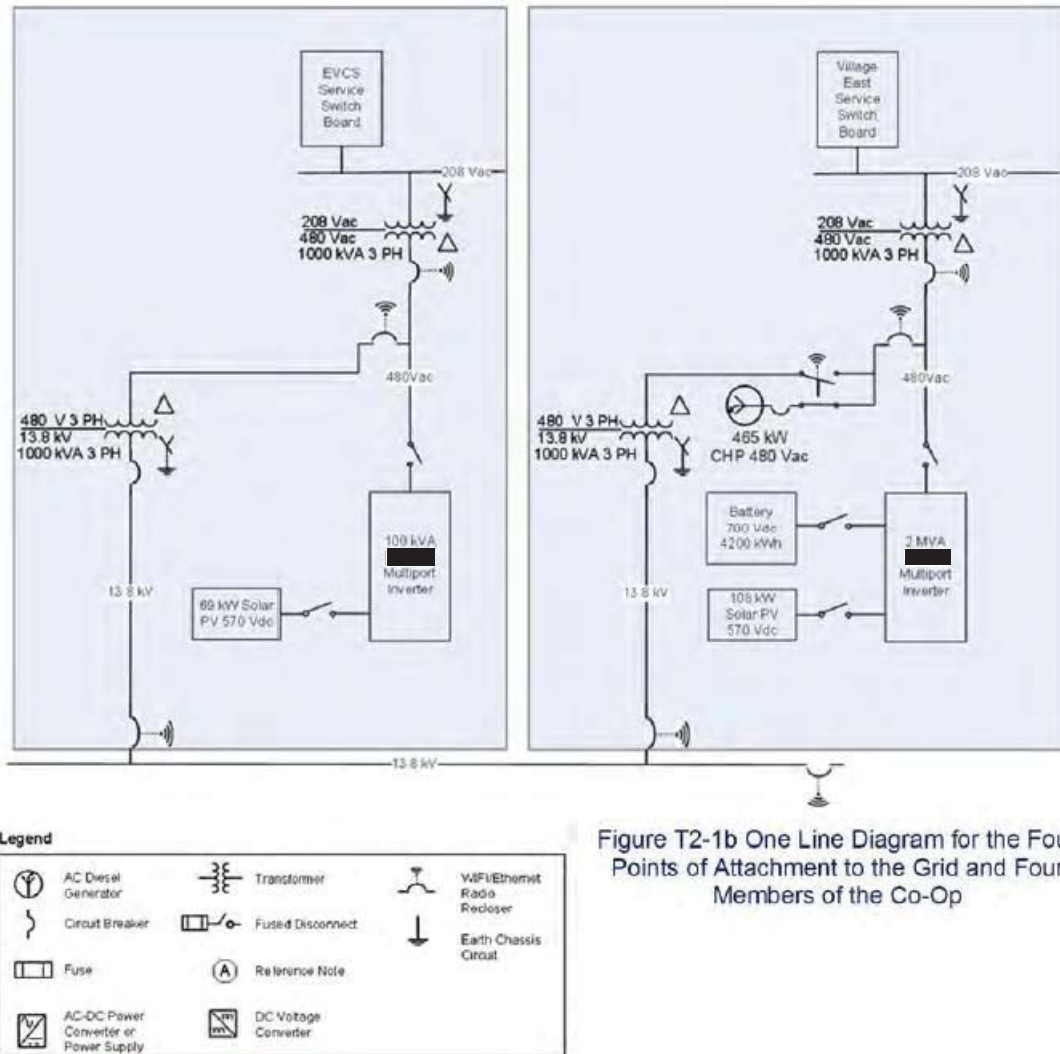


Figure T2-1b One Line Diagram for the Four Points of Attachment to the Grid and Four Members of the Co-Op

Corroded switchgear at each of the building electrical connection points is an unfortunate legacy of Sandy flooding. The Beyond the Grid Team will make replacing this equipment, especially low voltage (480 V) switchboards, a requirement for connecting to the grid. The team believes that the equipment in the Campos Plaza properties was installed in 1983, while equipment in the school building dates back farther.

New equipment to be owned by the microgrid includes the connection of distributed resources, medium voltage (13.8 kV) switchgear and cables to form a microgrid distribution loop. The distribution loop allows the output of the distributed resources to be shared between the various buildings and allows multiple interconnection points with the Con Edison 13.8 kV system owned by the microgrid. New equipment also includes medium voltage feeders, stepdown transformers, and main service breakers to supply the individual buildings as well as controllable breakers to

accomplish load shedding at the individual buildings if required. Overall metering for any individual building would be connected at the new 208 V main service.

Existing equipment shown on the one-line diagram on the next page includes the building disconnects (Figure T2-2). Note that the services to individual buildings will be reconfigured so that service is from the microgrid switchgear rather than the Con Edison low voltage network. This reconfiguration is necessary to allow power export to the Con Edison system without forcing reverse power flow through the Con Edison low voltage distribution network and allows clean separation of power transition during island mode.

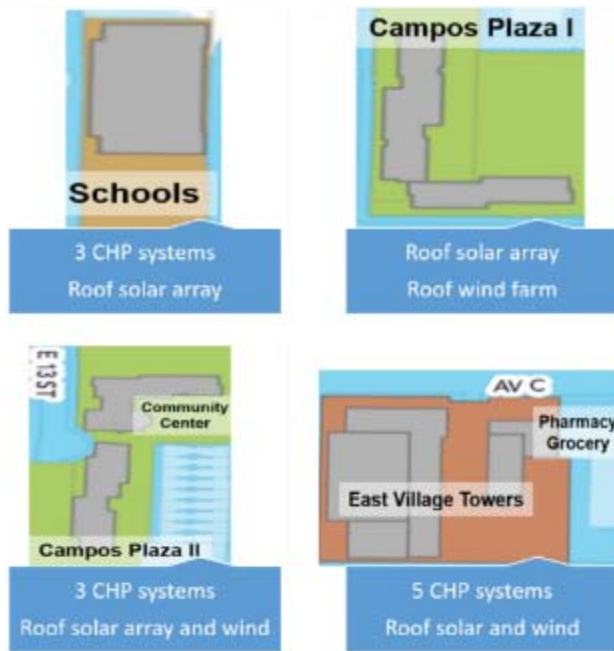


Figure T2-2. Simplified DER and Thermal Equipment Layout with Electrical Interconnections

The proposed architecture allows straightforward microgrid expansion. With this design, additional generation resources could be connected to either the low or medium voltage distribution lines. If the area served by the microgrid were to be increased, the microgrid switchgear loop can be expanded by adding additional micro grid power modules.

2.1.2 OPERATION UNDER NORMAL CONDITIONS AS A QUALIFYING FACILITY

Under normal conditions, the microgrid will operate in parallel with the Con Edison 13.8 kV system, with connections at the 13.8 kV microgrid switchgear. This design will allow bidirectional electricity flow both to and from the ConEd 13.8 kV feeders as per the instructions pre-programmed into the Inverters control systems.

The proposed microgrid is designed to sustain 100% of full power draw through the integration of 8 MWh energy storage in the microgrid's 2.4 MW generating capacity. Per our economic analysis we will export to the Con Edison grid during periods of time when there is low draw of power from microgrid customers. During times of high demand (e.g. summer afternoons when all the window AC units are running) the microgrid will purchase power from Con Edison. Working with LES Ready, tenant organizations and site partners, demand reduction and efficiency measures will be developed to optimize efficient use of microgrid resources and reduce reliance on the main grid.

Requirements to be a Qualified Facility under The Public Utility Regulatory Policies Act of 1978 (PURPA) were analyzed by this team. Generating facilities in this group fall into two categories: qualifying small power production facilities and qualifying cogeneration facilities.

A **small power production facility** is a generating facility of 80 MW or less whose primary energy source is renewable (hydro, wind or solar), biomass, waste, or geothermal resources.

A **cogeneration facility** is a generating facility that sequentially produces electricity and another form of useful thermal energy (such as heat or steam) in a way that is more efficient than the separate production of both forms of energy. There is no size limitation for qualifying cogeneration facilities.

Con Edison, has agreed to buy power from the *Beyond The Grid* microgrid. We focused on participation in Con Edison's buy-back program at Service Class 11 (SC 11) rates. (See Task 3 report for details.) The minimum size required under this rate is 2 MW of installed capacity, our current design calls for 1.997 MW.

When operating in normal grid connected (parallel mode) all DER sources will obtain voltage and frequency reference from the utility electrical power system (EPS).

2.1.3 OPERATION UNDER EMERGENCY CONDITIONS

Upon detection of an abnormal condition (abnormal voltage, abnormal frequency, or loss of the Con Edison system), the microgrid will disconnect from the Con Edison system by automatic opening of the 13.8 kV interconnection circuit breakers. These breakers will be equipped with protection in compliance with guidelines in IEEE Standard 1547 for interconnection of distributed resources and with any specific requirements of Con Edison. The individual inverter-based distributed resources will also be compliant with IEEE 1547 and will disconnect upon abnormal conditions.

The microgrid's Battery Peaking Plant provides smooth power transition when the micro grid goes from grid tied to island-mode. This enables the microgrid to avoid momentary blackout as

well as complex black start procedures. The microgrid controls systems enable black start as a last resort if needed in an extreme emergency.

In islanded or emergency mode, the microgrid will provide up to 4.2MW power (full load, using the battery bank) to the connected members. Once transferred to islanded mode WIFI breakers can automatically shed non-critical loads lowering it to below 1.6MW. This load level optimizes the DER output to sustain the microgrid with the batteries and to handle peaks during long term island-mode operation.

In the case of facilities with automated controls such as the case of The Village East Towers, components enabling the automated subroutine will be installed. Buildings without automatic controls, such as the NYCHA facilities, a floor-by-floor non-critical power shut down may be required.

The addition of automated building controls using standard protocols and methods is recommended to all facilities.

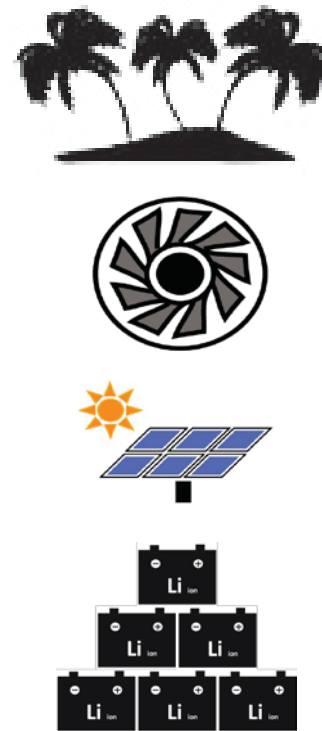


Figure T2-3 Islanded Mode is supported by DER and Battery Peaking Plant

When the fault on the main grid is no longer detected, the microgrid will seamlessly transition out of island-mode. No black start is required. Non-critical loads are turned back on. No power interruption is experienced by microgrid members during grid disconnect/connect events. If there is an outage all DER's will detect the loss of voltage and frequency and isolate from the grid at their connection points in accordance to the governing grid tied operation standards.

During adverse weather events, it is imperative that microgrid equipment and generators continue to be operable. During design, a risk assessment will be performed on each building's critical infrastructure and on location and tie-in points of the various generators. Risks to equipment during storms include: flooding; lightning strikes, high winds; and driving rain, snow, and ice. Mitigation steps will vary depending on the physical site conditions.

2.2 LOAD CHARACTERIZATION

Building loads were modeled using eQUEST software. The eQUEST software is supported as a part of the Energy Design Resources program that is funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison, under the auspices of the California Public Utilities Commission. On the

architectural level we used spreadsheets for the conceptual analysis. These are available to NYSERDA reviewers upon request.

2.2.1 ELECTRICAL AND THERMAL LOADS SERVED BY MICROGRID

Energy usage and costs have been gathered and reviewed for all the facilities included in the *Beyond The Grid* Microgrid. This data is derived from Con Edison provided data, actual bills, building modeling, and information supplied by facilities personnel. This information was then analyzed to determine the following:

- Peak & average electrical demand (kW) for each facility & combined microgrid.
- Annual, monthly & weekly electrical energy use in kWh.
- Annual, monthly & weekly thermal energy use in btu or therms
- Hourly load profiles for all electrical and thermal loads included in the microgrid
- Opportunity windows for planned equipment maintenance that will avoid the need to purchase power from Con Edison.

The peak and average load for the combined loads in the *Beyond The Grid* microgrid are shown in Table T2-1. Monthly and annual totals are included.

Table T2- 1 Power Requirements from Microgrid

<i>Beyond The Grid</i> Microgrid Electrical Energy			
Month	Max kW	Ave kW	kWh
Jan	2,028	985	732,764
Feb	2,136	1,035	695,480
Mar	2,446	1,104	821,125
Apr	2,833	1,200	863,890
May	3,325	1,421	1,057,529
Jun	3,666	1,649	1,187,178
Jul	4,004	1,817	1,351,735
Aug	3,634	1,739	1,293,767
Sep	3,406	1,563	1,125,454
Oct	2,690	1,295	963,441
Nov	2,438	1,143	823,028
Dec	2,353	1,053	783,215
Annual Totals	4,004	1,335	10,965,841

The *Beyond The Grid* Microgrid when working at full capacity will require a total of 10,965,841 kWh/year of electrical energy. Figure T2-4 and T2-5 illustrate load and energy usage for the combined facilities included in the *Beyond The Grid* microgrid. Weekly energy and electrical demand were evaluated using a typical 52 week-year calendar.

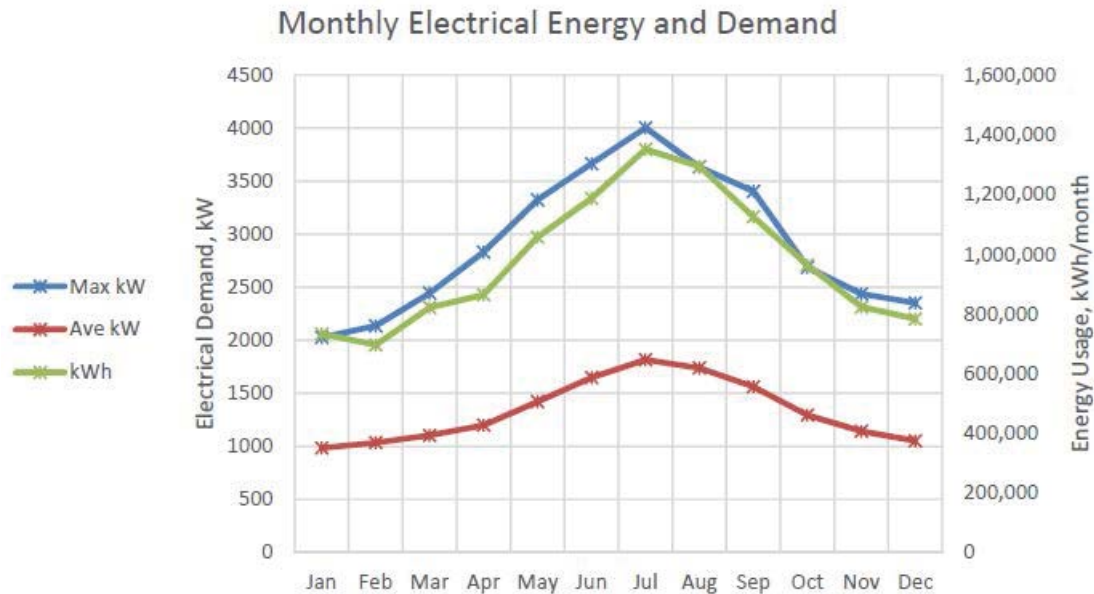


Figure T2-4 : Monthly and Annual Energy Summary

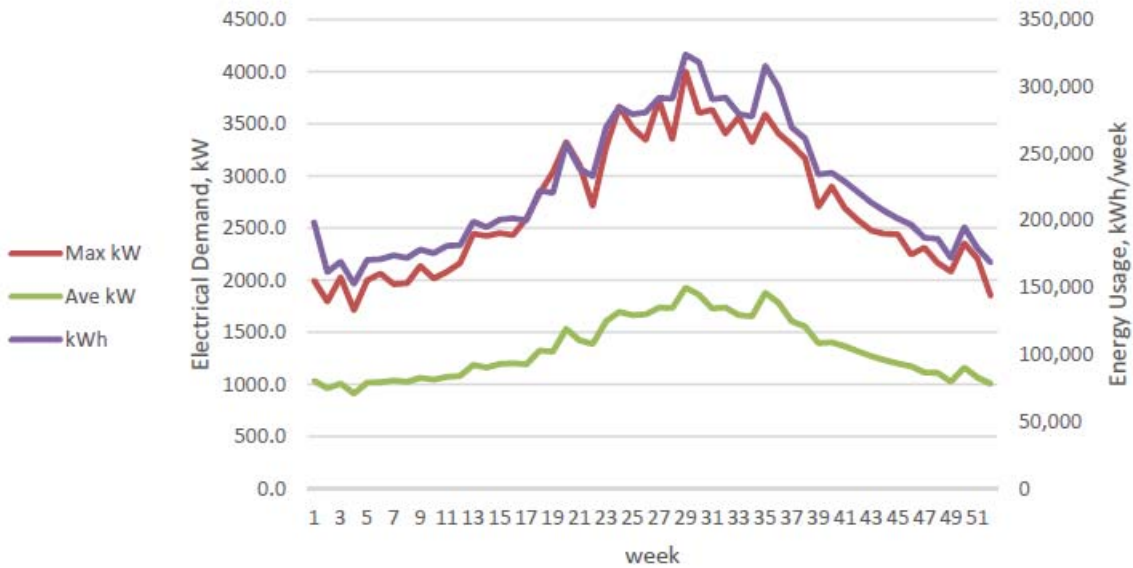


Figure T2-5: Weekly Analysis Results

The school building generates its own steam for space heating on site using a natural gas fired boiler. Natural gas usage by the school building and Heating Degree Days are shown on Figure T2-6.

Steam usage and cost data for all facilities was collected and analyzed, except for the swimming pool and the (unheated) garage located at the Village East Tower complex. The monthly and total annual steam used by the combined *Beyond The Grid* loads is illustrated on Table T2-2.

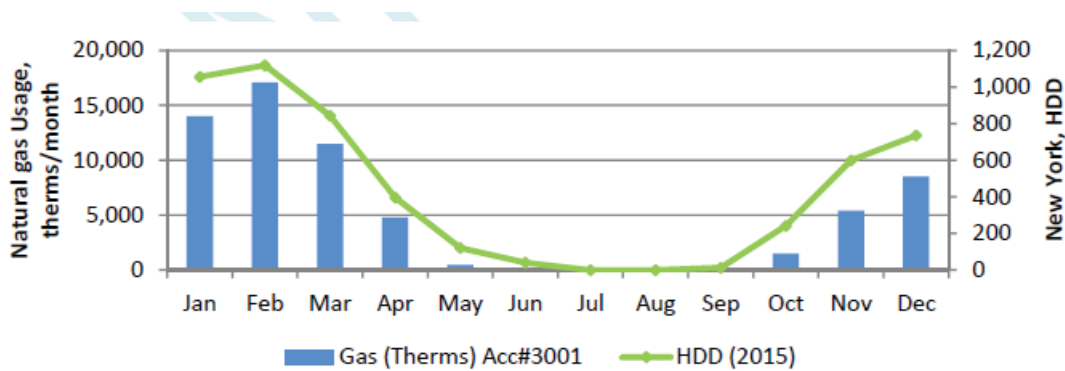


Figure T2 - 6: School Natural Gas Usage

Table T2-2: Aggregate Steam Monthly and Annual Consumption

Steam Consumption & Cost			
Month	HDD HDD: Heating Degree days	Mlb/mo	Total Steam Charges
Jan	1114	9,524	\$279,810
Feb	945	7,328	\$289,799
Mar	852	4,405	\$43,407
Apr	466	3,106	\$89,924
May	135	2,139	\$51,838
Jun	11	3,465	\$68,517
Jul	0	3,412	\$79,708
Aug	1	1,776	\$42,732
Sep	34	2,625	\$56,854
Oct	182	4,659	\$10,839
Nov	600	6,847	\$178,797
Dec	736	8,900	\$232,934
Annual Totals		58,187	\$1,425,159

The average paid is \$2.45/therm.

2.2.2 HOURLY LOAD PROFILES

Electrical and thermal load profiles for all loads served by a microgrid are important to determine the correct size of the on-site generation systems and determine the correct electrical safety equipment and switches. Unfortunately, due to the load size of current facilities included in the *Beyond The Grid* Microgrid there is no interval data being collected by the utility. As an alternative this team used an eQUEST building model to create the electrical and thermal loads profile for all facilities.

Load-Duration-Curves (LDC) were developed and the integral under the curve was checked against usage records. The load duration curves illustrate the relationship between generating capacity requirements and capacity utilization. An LDC is similar to a load curve but the demand data is ordered in descending order of magnitude, rather than chronologically. The LDC for the electrical demand (Figure T2-7) shows that a 2,036 kW on-site generation (or cogeneration) operating 24/7 could produce up to 80% of the energy required by the *Beyond The Grid* Microgrid. With the addition of 8 MWh of mass battery storage the microgrid will be able to power 100% of the energy required.

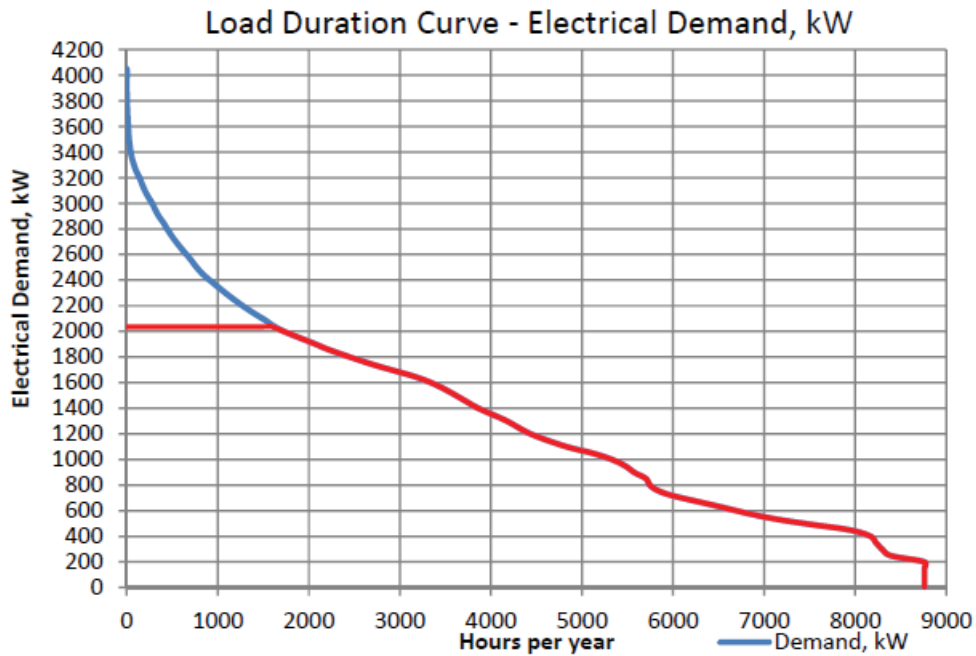


Figure T2-7: LDC – Electrical Demand, kW

Thermal loads are shown as a LDC as well; both cooling and heating loads for the combined microgrid are illustrated on figures T2-8 and T2-9. While it is acknowledged that the microgrid will not be sharing heat, only electricity between the sites, the total loads will be helpful for high level economic analysis.

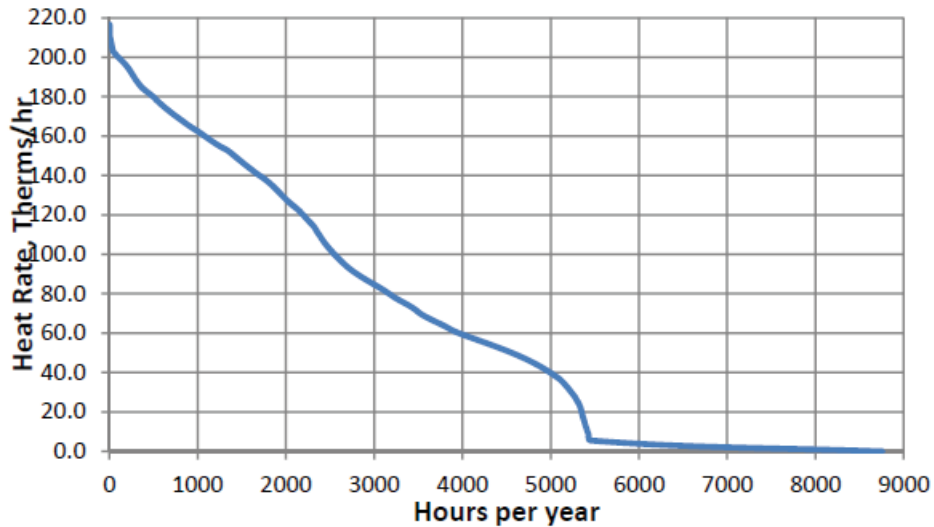


Figure T2-8 LDC – Heat Load, therms/hr

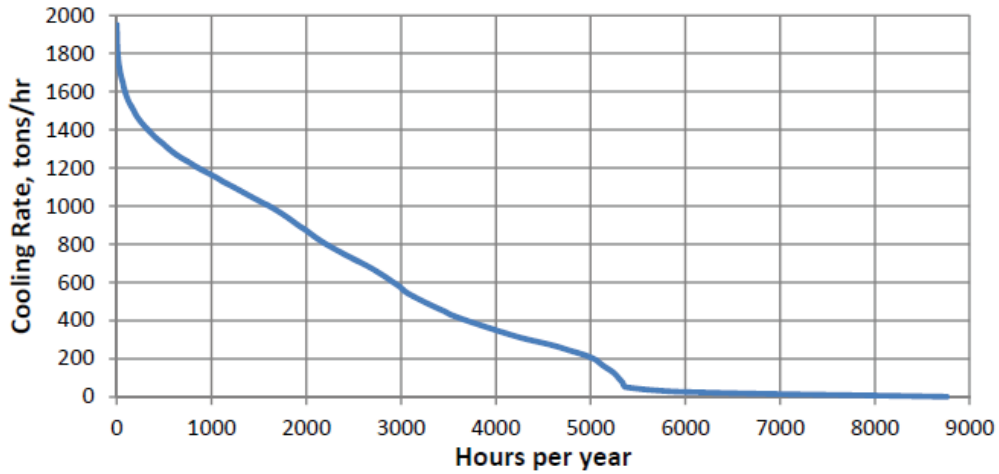


Figure T2-9: LDC – Cool Load, tons/hr

2.2.3 SIZING OF ELECTRICAL LOADS SERVED BY MICROGRID

Utility data was available for some buildings and was used to calibrate the eQUEST model. Electrical loads include lighting, space cooling, ventilation, motors and other miscellaneous loads. Note that one partial facility is also being powered: A police telecommunications repeater receives electricity from Village East Towers.

Table T2-3: Beyond The Grid Electrical Loads

Electricity Bill Owner	Address
New York Housing Authority	635 East 12th Street
New York Housing Authority	205 Avenue C
New York Housing Authority	643 East 13th Street
New York Housing Authority	612 East 14th Street
Department of Education	610 East 12th Street
Village East Towers	411 East 10th Street
Village East Towers	170 Avenue C
Village East Towers	711 East 11th Street
Supermarket & Pharmacy	Ave C
Community Center	East 13th Street

Electricity Use

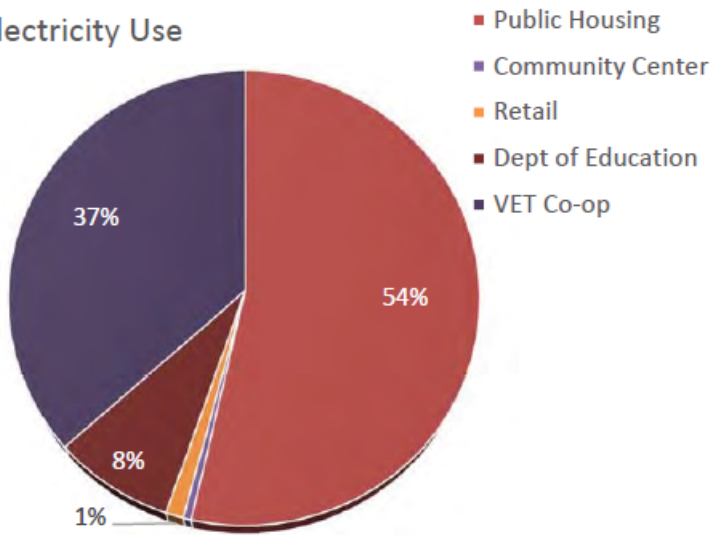


Figure T2-10 Relative Electricity Consumption of Facilities served by the Microgrid grouped by payer and ordered from lowest to highest \$/kWhr rate paid.

Figure T2-10 shows the relative amount of electrical energy microgrid members will consume. The order of the entities electric utility rates is from lowest (NYCHA and L+M) to highest (Village East Towers). The Community Center, which is part of the NYCHA complex is billed separately and hence was analyzed separately.

The spread in the electric rates charged by Con Edison is 5 cents. The business model uses the weighted average so that saving can be equitably distributed.

In islanded mode, the microgrid’s distributed generating assets will provide 100% of electrical demand September through June. In July and August, the microgrid will provide 90% of demand as it is measured today. Plans for building efficiency measures and building control upgrades will bring the equation to equilibrium even at peak summer loads. (This does not consider the battery bank.) Figure T2-11 shows demand by facility.



Figure T2-11 Electrical Loads in Simplified Equipment Layout

2.2.4 THERMAL LOADS SERVED BY MICROGRID

When considering thermal loads, note that not all properties purchase steam from ConEd. Those that do are concerned about the cost. Thermal loads include space heating and domestic hot water. Microgrid customers, excluding the Department of Education, are currently purchasing steam produced at Con Edison’s facility.

Table T2-4: Beyond The Grid Thermal Loads

Steam Bill Owner	Address	Steam Heat Demand, Therms/yr	On-Site Produced Steam, Therms/yr	Microgrid production Therms/yr
NYCHA – Campos Plaza I	635 East 12th Street	76,897		none
	205 Avenue C	102,691		
NYCHA - Campos Plaza II with Community Center	643 East 13th Street	67,885		234,000
	612 East 14th Street	121,086		
	East 13th Street	4,305		
Department of Education	610 East 12th Street	N/A	33,033	186,300
Village East Towers	411 East 10th Street	88,404		186,300
Village East Towers	170 Avenue C	71,928		
Village East Towers	711 East 11th Street	35,210		
Retailers	Ave C	8,435		
Totals		576,840	N/A	N/A

Con Edison provides high-pressure steam (125 psig) to each location. Steam pressure is then reduced at each building and used to serve the space heating and domestic hot water loads. Steam represents a very significant expense for entities within the microgrid. Since heat is not distributed by the microgrid, a therms/year total is not provided.

In summary, installed CHP units will provide a surplus of heat for Campos Plaza II and for East Village Towers, the amount of heat produced is roughly equivalent to the requirement thus minimizing steam purchasing. The difference in price per Mlb paid by Campos II and VET is \$8.61. The business case provides equitable savings to each party. Should CHP be added at EVCS, the business case will reflect overall savings in natural gas consumption since the building generates its own steam.

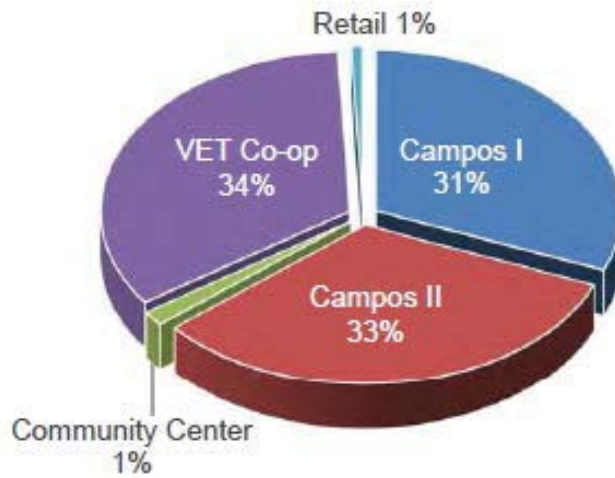


Figure T2-12: Relative Con Edison Steam Consumption by Microgrid Customers.

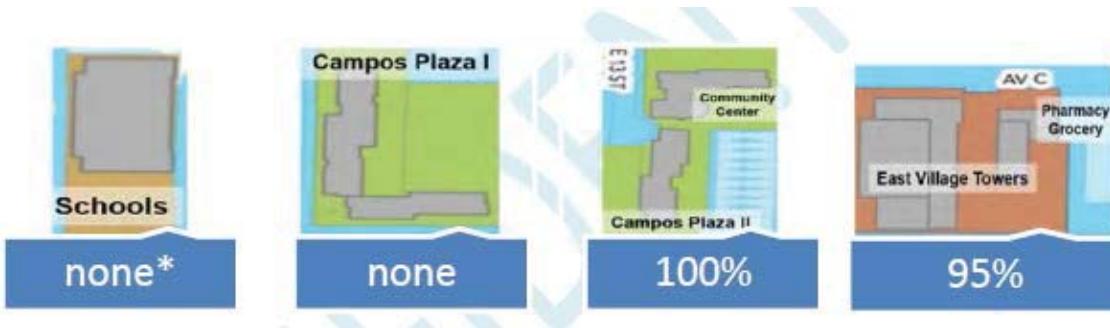


Figure T2-13. Thermal Provision of Microgrid by Facility

*Engineering evaluation may allow us to include CHP at EVCS

2.2.5 REDUNDANCY OPPORTUNITIES

In terms of DER, CHP is at two locations and PV at four locations. Additional FEMA-provided natural gas powered generators at the NYCHA properties will give us provide N+1 capability as well. Furthermore, the size of battery peaking plant gives us considerable breathing room if a node goes down in an unplanned way. We will increase redundancy with expansion of the microgrid (more nodes.)

In terms of telecommunications, redundancy is built in thanks to the participation of WiFiNY. See section 2.6.2 Telecommunications and Community WiFi for details.

Regarding maintenance, because hourly load profiles were not available (see discussion on page T2-10) the team considered the neighborhood character and questioned Con

Edison about characteristics of the grid in this area. The facilities that draw the most electricity and heat are residential. For the most part, residents will depart during the day and energy demands will drop. This means that planned maintenance for units in these locations can be scheduled during the day. At the school building, maintenance can be planned during the summer and at holiday breaks. CHP systems are installed in arrays so that units may be maintained one at a time without causing major disruptions.

2.3 DISTRIBUTED ENERGY RESOURCES CHARACTERIZATION

The Distributed Energy Resources selected for the *Beyond The Grid* microgrid were selected based on following capabilities:

- Maximize on-site power production.
- Startup on demand; assumes no natural gas interruption.
- Provide storage to regulate for non-power producing periods or highs and lows of power production, enable load-shifting to reduce customer rates during peak demand, maximize available power for utility buy-back during peak demand periods, harmonize frequency and voltage for grid interconnection.
- Minimize maintenance.
- Control emission (air pollution and noise) points for consideration of living locations.
- Renewable power is considered a plus to minimize emissions and assure energy supply during any fuel supply disruptions, however unlikely in this case.

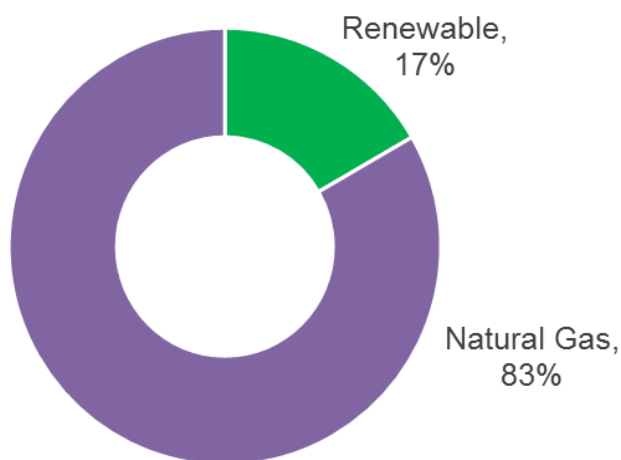


Figure T2-14: Mix of Energy Sources

A total of 2 MW of DER sources were determined; Figure T2-14 illustrates the final generation mix. Seventeen (17%) of the total energy needed will provided by solar. Ideally renewable sources should provide the majority of the needs, however, the current location of the *Beyond The Grid* microgrid makes it challenging to achieve a higher percent.

Efforts are still underway to increase renewables use. See 2.3.1 Type, Rating and Fuel Requirements.

Energy storage is sized to maximize generating output when PV is productive, displace energy harvest to peak use time in the evening and store CHP produced power when utility buy-back rates are low. A complete list of DER and thermal sources is included in Table T2-5.

Natural gas is the only fossil fuel being used. High efficiency CHP units will be owned by the microgrid. Backup generators (also natural gas) will be owned by NYCHA but integrated into the microgrid.

Table T2-5 DER and Thermal Sources

	Generation Capacity (kW)	Power Production Capacity (MWh/yr)	Heat Production (MMBtu/yr)	Heat Production Therms/yr
NYCHA Campos Plaza II and University Settlement Cornerstone Community Center				
Solar PV	69	78	N/A	N/A
Microturbine CHP	1200	4,730	24,300	243,000
L&M for NYCHA Campos Plaza I				
Solar PV	86	100	N/A	N/A
East Village Community School Building				
Solar PV	69	80	N/A	N/A
Village East Towers Co-op and Commercial Strip				
Solar PV	108	125	N/A	N/A
Microturbine CHP	460	3,627	18,630	186,300

2.3.1 TYPE, RATING AND FUEL REQUIREMENTS

The proposed microgrid utilized microturbines as the only source of waste heat; the proposed equipment is a 200kW module provided by Capstone with the following characteristics:

Electrical Performance:
 Electrical Power Output 200kW
 Voltage 400– 480 VAC

Electrical Service	3-Phase, 4 wire
Frequency	50/60 Hz, grid connect operation 10– 60 Hz, stand alone operation
Maximum Output Current	290A RMS @ 400V, grid connect operation 240A RMS @ 480V, grid connect operation 310A RMS, stand alone operation (2)
Electrical Efficiency LHV	33%
Fuel / Engine Characteristics:	
Natural Gas	HHV 30.7– 47.5 MJ/m ³ (825 –1,275 BTU/scf)
Inlet Pressure	517– 552 kPa gauge (75– 80 psig)
Fuel Flow HHV	2,400 MJ/hr (2,280,000 BTU/hr)
Net Heat Rate LHV	10.9 MJ/kWh (10,300 BTU/kWh)
Exhaust Characteristics:	
NO _x Emissions @ 15% O ₂	< 9 ppmvd (18 mg/m ³)
NO _x / Electrical Output	0.14 g/bhp-hr (0.4 lb/MWhe)
Exhaust Gas Flow	1.3 kg/s (2.9 lbm/s)
Exhaust Gas Temperature	280°C (535°F)
Exhaust Energy	1,420 MJ/hr (1,350,000 BTU/hr)

The microturbines total installed capacity is 1,600 kW with a total generation capacity of 13,087,440 kWh/year. Based in a conservative heat value of 10,300 BTU/kWh that is equivalent to 1,348,006 therms consumed.

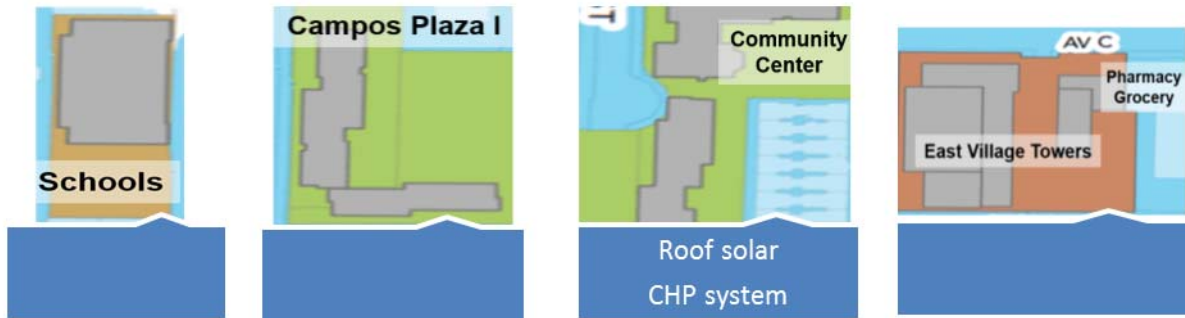
Photovoltaic arrays have been placed to maximize their conversion of natural light to electricity. Noise generation of the inverters running at their maximum is below 40 decibels (equivalent to noise level in a library). Battery storage is used to shift the harvest of sun to evening when electrical demand is the highest in residential properties.

The modules used in the arrays are often specified by the developer, although a customer can be part of that decision. We had been working with Urban Green Energy in part because they provide both solar and wind. Now that we have determined that we will not be using VWTs,¹ *and* that we want to consider concentrating solar and other high yield PV technologies, we may open the PV arrays for RFI/RFP. The solar developer/installer with the largest footprint in NYC is Best Energy Power; unless stated in writing by the customer, Best Energy Power sources their panels from Korean manufacturers: Sharp, Hanwha and Samsung. Quixotic Systems, located in Manhattan since 1999, specializes in projects that meet complex engineering and architectural challenges as well as long experience using advanced photovoltaic technology.

¹ The team believed that it was worth studying wind power, despite its reputation for long (even impossible) pay-back. A location along the East River and 30-stories high could well have been a microclimate that differed significantly from NREL wind-maps.

2.3.2 LOCATION AND SPACE AVAILABLE

Each facility will house a solar array. Rooftops are accessible through bulkheads with fixed staircases. This allows for relatively easy installation and maintenance, including microgrid staff removing snow and ice from solar panels.



F

Figure T2-15: DER in Simplified Equipment Space; see Table T2-5 for utilization

Table T2-6: Site Suitability and Installation Area

Facility	Type	Area (sq ft) Based on NYC solar map	Suitability
NYCHA Campos I	Roof	10,828	Solar
NYCHA Campos II	Parking lot	1,500	CHP on high platform
NYCHA Campos II	Roof	10,764	Solar and backup generators
Community Center	Roof	3,240	CHP
EVCS	Roof	8,557	Solar
EVCS	Basement	3,954	CHP, potentially
Village East Towers	Roofs	13,443	Solar
VET - Main parking garage	Interior space(s)	TBD	CHP and/or microgrid controller and/or battery peaking plant
VET - Small parking garage	Roof	1,920	CHP
VET Commercial strip	Roof	1,200	CHP

Potential site for microturbine placement include the basements of the school building, Campos II, Village East Towers (VET), as well as VET's enclosed garage and swimming pool building. Details are provided in Task 1 section 1.4.2 Availability of Space for Microgrid. A table of the spaces we have selected to use is below.

2.3.3 ADEQUACY TO MEET ELECTRICAL AND THERMAL DEMAND

The proposed microgrid is capable of 100% of peak electrical load by combining the amount of output power generating capacity supplemented with 4 MWh mass batter storage, providing for the entire mix of buildings. The size was determined based on current needs and the economic benefits that best fits the microgrid. As indicated by the LDC, the size of CHP and solar generating assets alone (2 MW) will provide the needs of the microgrid approximately 7100 hrs/year. The balance being supplied by energy stored in the microgrids' batter bank. Demand response strategies will be implemented to reduce the load during emergency events. Current steam and gas infrastructures present a challenge to satisfy the thermal loads of the facilities included, future improvements will be proposed to increase the thermal loads capabilities of the *Beyond The Grid* microgrid.

Energy storage is a critical aspect of the microgrid not only for its uninterruptable power function, but to also maintain voltage/frequency harmonization with the grid, and for economic purposes. Energy storage may be used as grid forming anchoring device during microgrid islanding events.

2.3.4 RESILIENCY DESIGN GOALS

The highest identified risk for disruption of power generation in the project area is associated with flooding from storms (Nor'easters, Subtropical Storms and Hurricanes.) In Task 3, section 3.2.5 Historical Power Outage Data, we provide a table of major disturbances to the electric grid. Winter storms, lightning and forced load shedding are also cited as causes of extended power outages.

The proposed microgrid is designed avoid a repeat of the worst conditions the area has suffered. Catastrophic flooding following Sandy in the areas between VET and the East River lead to cars bobbing up and down in 5-foot, sewage-tainted waters. Electrical substation explosions left the neighborhood in the dark for more than a week. The neighboring steam plant, which is not able to run in island-mode, also fails during major storms leaving thousands of people without heat.

To the extent possible, the design provides local heat from a CHP system. Heat will not be circulated within the microgrid. Electricity will be shared. Electric heat and/or the use of temporary boilers can take care of the (few) areas that will not have CHP. Hence every microgrid member will provide the opportunity for residents to shelter in place. Food and medicine will be available. Purchases can be made through the EBT system.

2.3.5 FUEL SOURCES

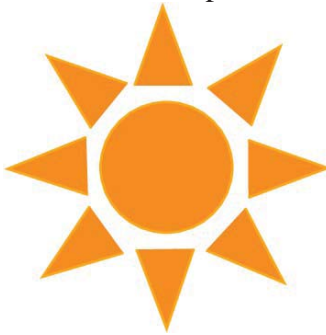
Natural gas purchased from Con Edison will fuel CHP microturbines and back up generation for the *Beyond The Grid* microgrid; no other fossil fuel was considered under this analysis. The natural gas grid has proven to be more reliable than either the electrical grid or steam. We can expect that in islanded mode, the *Beyond The Grid* microgrid can run indefinitely.

The microgrid will increase the requirements for natural gas significantly. Recent upgrades and construction to local gas facilities bode well for us. Nonetheless, the ability of the existing natural gas network to serve the additional needs of the microgrid equipment can only be evaluated by Con Edison. Con Edison will make a determination of the existing capacity to meet the needs of the microgrid after load letters for each affected building are issued by the Engineer of Record to the utility.



Assuming that capacity is available, the logical routing of the new gas services is from the existing gas mains in the street to the existing gas meter rooms that are closest to the CHP. If adequate service is not available in the street, then a new gas service must be extended from an existing gas main to the existing gas meter room.

Con Edison will run the new gas service lines. Since it is likely to be determined that the natural gas is not a critical service, the cost to run the gas service will probably be borne by the customer. Generally, no manholes will be required. There will be a curb valve box at the sidewalk that provides emergency shutdown from outside of the building.



Solar energy, though intermittent, is also reliable in the long run; hence we propose in Stage 2 to run a cost/benefit analysis on the use of concentrated solar panels or similar advanced PV technology to increase the percentage of renewables in the fuel mix. Further discussion of the specification of solar modules (the PV panels with frame that fit into an array) see section 2.3.1 Type, Rating and Fuel Requirements.

Team initially used a standard NREL models to determine expected solar harvest for the calculations used in the Task 2 design. To determine the “bankable PV”, system architect Lockheed Martin re-ran the solar model using PVsyst² since its’ results are commonly used for financial analysis. See Task 3 section 3.5.1 Financial Modeling for details.

² <http://www.pvsyst.com/en/>

2.3.6 Capabilities using Inverters and Advanced Batteries

By providing the total energy demand, the proposed microgrid will satisfy the needs of the building mix for 365 days per year. Peak demand occurs during summer when air conditioning is required. During this time, power drawn from battery storage will defer or reduce the need to import power. The interconnection with the utility grid allows the microgrid to purchase power from Con Edison. The current thermal capabilities of the proposed microgrid for cooling and heating are nominal; future modification to air conditioning and heating systems will be needed to increase the utilization of waste heat produced by the microturbines through the use of absorption chillers.

Table T2-7: Microgrid Capabilities

Capabilities		Comments
Black start	Yes	
Load-following	Yes	
Part-load operation	Yes	
Maintain voltage	Yes	
Maintain frequency	Yes	
Can ride-through voltage and frequency events in islanded mode	Yes	
Interconnection standards compatibility	Yes	Confirmed with Con Edison

2.3.7 ESTIMATED DER COSTS

Budgetary quotes were provided by Lockheed Martin for the battery peaking plant based on previous designs, Capstone distributor RSP for microturbines and Urban Green Energy for the solar arrays. Prevailing wage was estimated for the installation. Our NPO status should allow us to waive sales tax and we have taken advantage of this opportunity.

Table T2-8: Distributed Energy Resources Cost

Capital Component	Installed Cost (\$)
NYCHA II 2x600kW CHP	4,346,358
Village East 265 kW CHP Generators	1,092,705
NYCHA II PV System	265,865
NYCHA I PV System	267,470
EV School PV System	211,370
Village East PV System	332,092
Battery Peaking Plant	3,974,250

2.4 ELECTRICAL AND THERMAL INFRASTRUCTURE CHARACTERIZATION

All of the equipment on the one-line diagram in section 2.1 will be new. (See Figure T2-1). This one-line diagram is conceptual in nature and shows the overall layout of the microgrid power infrastructure.

2.4.1 ELECTRICAL AND THERMAL INFRASTRUCTURE

Low voltage (480 V) switchboards at four locations allow for connection of distributed resources. Each low voltage switchboard connects to medium voltage (13.8 kV) microgrid switchgear via a step-up transformer. The medium voltage switchgear is connected in a loop to allow flexibility in sharing the distributed generating resources among the various buildings. Medium voltage is proposed for the microgrid loop to avoid voltage drop concerns with low voltage, to allow for direct connection to the Con-Edison medium voltage system for energy import and export, and to facilitate installation of underground cables for the distribution loop between the buildings by allowing for more compact cables than would be possible with low voltage.

One circuit breaker at each microgrid switchgear assembly provides connection to the Con-Edison 13.8 kV system. This connection is the path for importing energy if the microgrid generating capacity doesn't meet or is not in service; or for exporting energy when the microgrid generating capacity exceeds the microgrid load. The utility interface breakers would normally be closed and would be opened upon loss of utility service to allow the microgrid to transition to island operation. Suitable metering and protective relaying compliant with IEEE 1547 and any specific Con-Edison requirements will be installed at each utility interface breaker.

Each microgrid switchgear assembly will include one or more circuit breakers to supply the individual buildings through step-down transformers. The buildings are presently supplied from the Con-Edison low voltage (208 V) grid network system. The service disconnects for the buildings will be disconnected from the grid network system and reconnected to the new service conductors from the microgrid switchgear and step-down transformers. With this arrangement, the building services will be supplied by the utility system, the microgrid, or both systems in parallel. Overall metering for any individual building will be connected at the new 208 V main service.

The proposed architecture allows straightforward microgrid expansion. Additional distributed resources could be added to the system via the low or high voltage distribution lines and would be connected to the low voltage distributed resource switchboards. As the area served by the microgrid increases, the microgrid switchgear loop can be expanded by adding additional microgrid modules.

2.4.2 ELECTRICAL DISTRIBUTION RESILIENCY

In Manhattan, electrical distribution is underground which is generally more resilient than overhead lines. One advantage to having to put in our own cabling conduits for distribution is that we will be using brand-new submersible/water-tight materials and components. The microgrid will not be subject to the woes of aging electrical infrastructure. The reliability of the gas supply in the project area is high, as discussed in section

2.3.5 Fuel Sources.

In the proposed microgrid, each building will be connected through a step-up transformer to the microgrid loop. This will fundamentally create a two-feed system for each facility assuring a continuous operation. The proposed microgrid will meet 100% of the total energy demand of the microgrid members full time and during emergencies when. Given the systems architecture we do not anticipate that we will ever have to black start. That said, we have the backup generators to do so.

2.4.3 MANHOLES AND INTERCONNECTIONS TO THE GRID

This section assumes the project has a provision of crossing the public right-of-way, and that Con Edison will charge us what they charge themselves to put in a new system.

As discussed in section 2.1, the proposed microgrid loop provides up to four points for interconnection to the Con-Edison 13.8 kV system at the manholes specified by Con Edison during the next phase. Through the interface breakers, power can flow to or from the microgrid according to the load and availability of distributed resources. Buildings will be interconnected electrically through microgrid owned manholes and conduit.

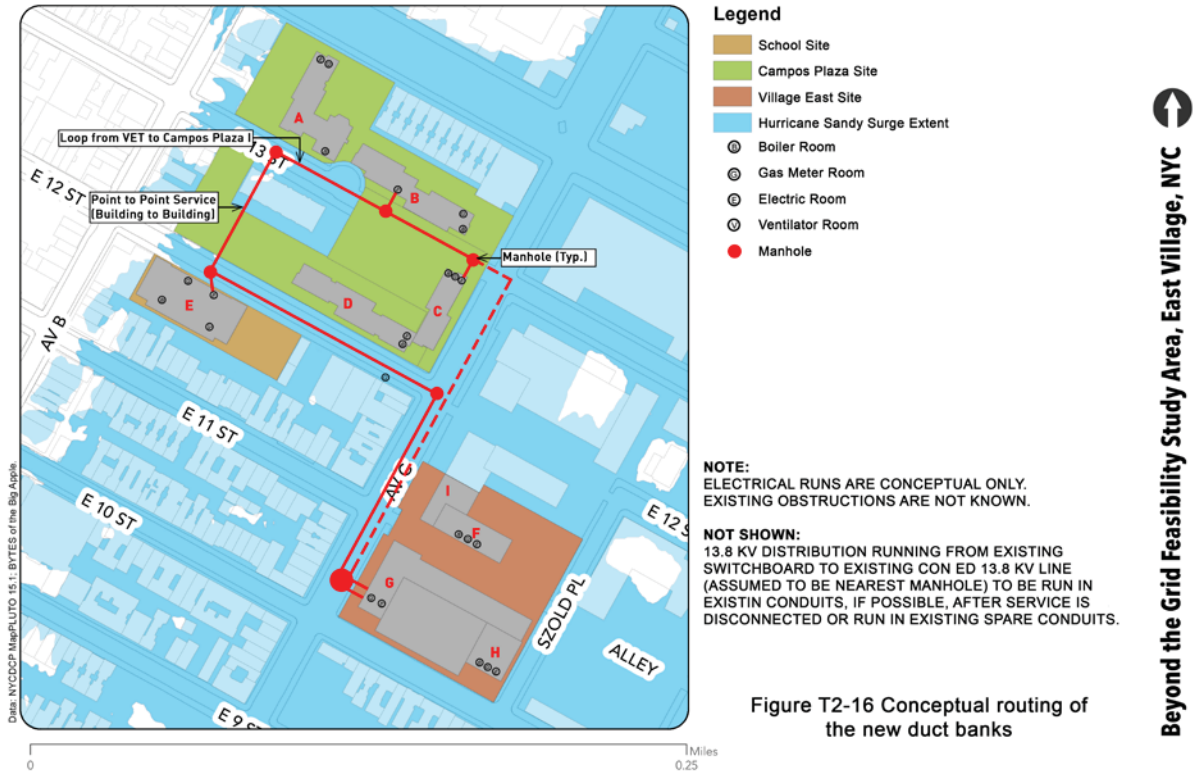
2.4.3.1 Electric Service Distribution

In order for the microgrid to participate in Con Edison's buy-back program, the microgrid must feed power into the 13.8 kV electric grid. To accomplish this, the existing 208 V electrical service switchboard for each of the four sites—Campos Plaza I, Campos Plaza II, Village East Community School (EVCS) and Village East Towers—will be disconnected from the existing 208 V Con Edison service. New 13.8 kV microgrid switchgear in each of the four sites will reconnect with the Con Edison 13.8 kV utility, via new 13.8 kV cables from the new switchgear to the nearest Con Edison manhole. Microgrid owned and installed hardened conduit and distribution lines from the existing switchboard to the Con Edison service will be used to route the new 13.8 kV cable.

Power will be transformed from 13.8 kV at the new switchgear to 208 V at the existing service switchboards to serve the existing 120/208 V building loads. Power from the new CHP plant equipment, rated at 480 V, will also be transformed from 480 V up to 13.8 kV at the new switchgear.

The four new microgrid switchgear assemblies will also be connected building-to-building via a new 13.8 kV underground duct bank that ties each of the switchgear together. The routing of this new duct bank will be from Campos Plaza I to Campos Plaza II to EVCS to Village East Towers. A new 13.8 kV underground duct bank will run below Avenue C from Village East Towers directly to Campos Plaza I to complete the loop.

A conceptual routing of the new duct banks is indicated on Figure T2-16. The routing will need to be coordinated with existing utilities in the street. The exact routing will be analyzed in detail in the next stage. Figure T2-17 indicates preliminary locations of manholes to serve the new 13.8 kV distribution system.

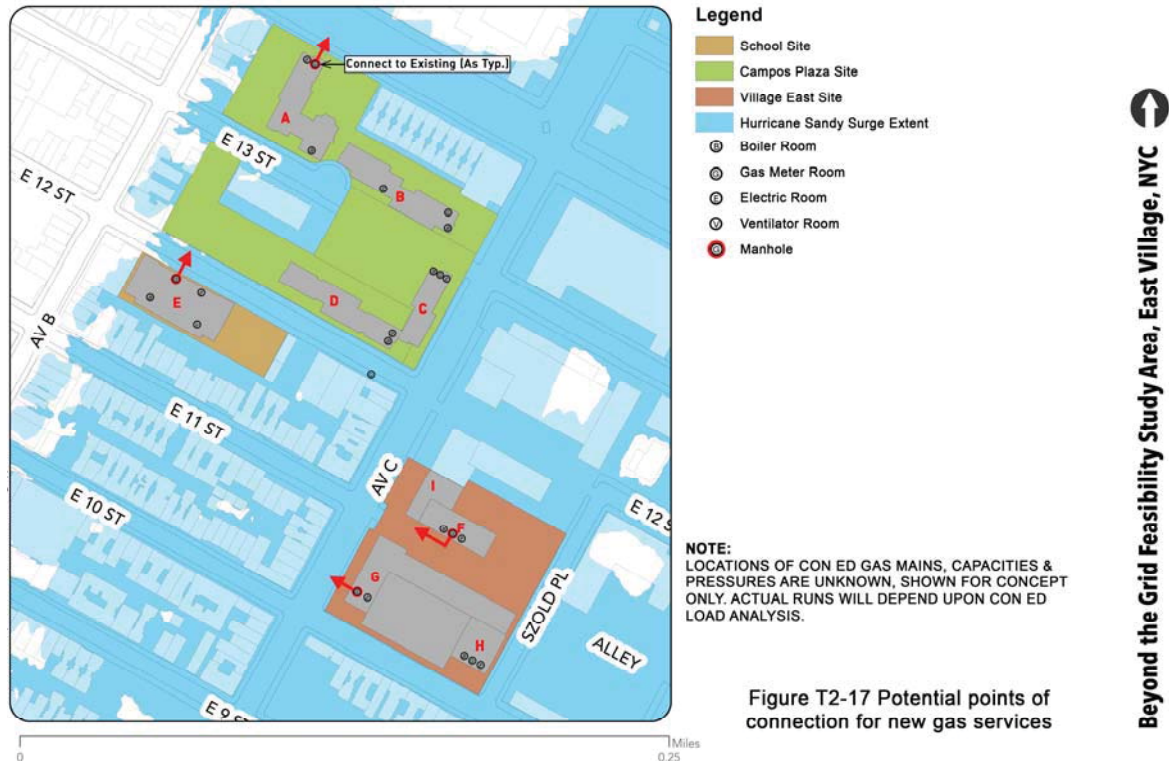


Beyond the Grid Feasibility Study Area, East Village, NYC

The new duct bank will consist of 4 (four) 4-1/2 inch PVC conduits encased in concrete to offer maximum protection. One (1) conduit will be used for 4#4/0 AWG Copper Primary cabling; one (1) conduit will be used for communications cabling and two (2) spare conduits will be provided for use for either power or communications cabling.

2.4.3.2 Manholes and Conduit Runs

Manholes will be standard concrete construction, utility-grade, prefabricated with 36-inch diameter man-hole covers. Beyond the Grid will coordinate with Con Edison to have these installed using Con Edison crews. Potential points of connection for the new gas services are indicated on drawing below.



2.4.4 Estimated Infrastructure Cost

Costs of upgrading building controls will be a condition of the membership agreement based on observations during the site survey that much of the building-owned power equipment has corroded severely since salt water exposure during Sandy.

Microgrid not permitted to utilize existing distribution lines. New manholes and trenching will be required (included in installed cost figure.) New lines will need to be installed, including associated inverters.

The cost of trenching and manhole installation comes from ConEdison’s latest data. We could have to contract ConEd and pay them to perform the work.

Equipment cost estimates are provided Lockheed Martin based on costs of previous designs. Prevailing wage is set by NYC. Louis Berger and Lockheed Martin estimated labor hours. We believe sales tax need not be included given our business model.

Table T2-9: Infrastructure Equipment Cost

Infrastructure Equipment	Installed Costs	Comments
Switchgear	\$1,594,427	4 MW Inverters
Transformers	\$502,459	
HVL Switches	\$696,312	
Low Voltage Breakers	\$984,960	
Batteries for Control Power		Will use batteries on Inverters
MV Cable	\$329,600	
Trenching	\$275,000	ConEdison’s latest cost per linear foot multiplied by the length of the grid-spine
Manhole Average Cost	\$320,000	Telecommunications Manhole Average Cost; Used in reimbursement mechanism; margin of 2x added
Infrastructure Total	\$4,702,757	

2.5 MICROGRID AND BUILDING CONTROLS CHARACTERIZATION

An active network control system that optimizes demand, supply and other network operation functions within the microgrid is the basis for the primary optimization and control scheme. Monitoring and/or control of all system assets. Conditions will be continuous, and primary control will be through a master microgrid controller, as well as distributed control systems. This system will monitor facility demand and optimize supply and other network operation functions within the microgrid. Inter-operability with the primary and variable renewable generation, and Battery Energy Storage System (if applicable) and demand, will be optimized through cloud-based optimization algorithms. Predictive modeling and historical reference through the life of the system will enhance the optimization of the microgrid assets in both grid-connected and island modes. The generation technology used will likely be a combination of synchronous and inverter (UL1741) based technology. The final configurations and mix of control assets will be determined following more detailed analysis of facility energy usage and site-specific interconnection requirements. Input from the local utility regarding substation automation and isolation functions will be required.

Energy conservation measures (ECM) will be addressed during the feasibility assessment. However, given the mix and type of facilities that are intended to form the microgrid at the sites, the anticipated reduction in generation requirements are expected to be limited. Some ECM work has already been undertaken. Formal energy audits may be conducted in order to identify the best ECMs to address. Typical ECMs include lighting retrofits, HVAC controls and equipment upgrades. While energy savings ECMs will focus on energy cost savings for the City, particular

attention will be paid to ECMs which lower demand, since those items will add stability to the microgrid control when in Island Mode in addition to energy cost savings during Normal operation.

2.5.1 CONTROL ARCHITECTURE

A distributed microgrid controller system will be provided to govern the operation of the microgrid. This controller consists of two components: the Microgrid Controller (MC), a reactive real-time controller that is operating on the millisecond and second time scale and Demand Side Operation (DSO) software, a predictive controller that provides optimized DER schedules in 15-minute windows for the day ahead. The MC maintains responsibility for balancing of generation with loads, optimization of generation and storage components and the coordination of islanding/reconnection events. DSO utilizes outside information in the form of weather and load forecasts, energy tariff data such as Time-of-Use rates, Demand Response commands, and user-imposed system constraints to further optimize the microgrid.

The MC will be capable of interfacing with the local controllers provided by the DER vendors. These local DER controllers will be responsible for the most basic level operation of the DER, i.e. maintaining the required voltage and frequency output for system stability. The MC will provide a level of coordination above these local controllers such that the site load is shared between DER and the utility grid (when connected) at an optimal level.

A freestanding master MC enclosure will be provided at the microgrid distribution switchboard. Wall-mounted distributed remote MC enclosures will be located at each DER to enable secure and dedicated control of each resource. Remote MC enclosures will also be located at each microgrid participant building, and the associated medium voltage switchgear for that compound. The majority of the participant buildings do not currently have a building management controller, while others have limited existing building controls. Depending on the feasibility, the microgrid building controller will be integrated with any existing building management controllers.

A modular architecture provides an optimized solution today and can be easily expanded to control additional equipment in the future. The flexibility of the I/O and communications architecture allows it to be easily adapted to a wide range of distributed energy resources and microgrid equipment.

2.5.2 DESCRIPTION OF OPERATION AND FUNCTIONS/ SERVICES PROVIDED

Operation of the microgrid will be done locally by trained technical staff, overseen by a volunteer board and advisors on retainer. Salaries have been informed by Federal department of labor statistics. All manufacturers' requirements for scheduled maintenance intervals for all generation equipment will be written into service contracts. Budgetary numbers were provided by vendors for flat-rate equipment contracts and these are included in the financial model discussed in Task 3.

Services provided are summarized in the table below.

Table T2-10 Summary of Services Provided

Services Provided		Comments
Automatically connecting to and disconnecting from the grid	Yes	
Load shedding schemes	Yes	Manual at VET, but proven to be effective
Black start and load addition	Yes	Using battery peaking plant with generators as backup
Performing economic dispatch and load following	TBD	
Demand response	No	
Storage optimization	TBD	
Maintaining frequency and voltage	Yes	
PV observability and controllability; forecasting	No	
Coordination of protection settings	TBD	
Selling energy and ancillary services	No	
Data logging features	Yes	
Redundant Internet connection	Yes	Through microgrid equipment and WiFi-NY
Redundant telecom and data	Yes	Through microgrid equipment and WiFi-NY

2.5.3 CONTROLS RESILIENCE

Localized microgrid controls improve resilience by eliminating dependency on Internet connection. If utility power is lost in grid connected mode, utility loss will be detected by the IEEE 1547 protective relaying at the isolation point of the circuit. A remotely controlled recloser will isolate the microgrid circuit from the utility. The particular device should be similar to the equipment the utility typically employs. Each has a full complement of protection and communication functions. It monitors voltage on both sides of the switch. The switch would open and the generation resources would be electrically isolated. The operation will be open transition. The synchronous generators would be switched to voltage control mode and simultaneously closed onto the microgrid.

The Microgrid Control System is built from the same standard, rugged, and reliable hardware platform used in thousands of critical applications in the industrial automation and process industries. To ensure resilience against severe weather conditions, control system components will be housed within a member facility and control points will be linked via secure wireless and hardwired links. All control panels will be equipped with their own battery based uninterruptible power supply.

2.5.4 ESTIMATED CONTROLS COST

Cost estimates came from Lockheed Martin and informed by conversations with der Electric and Siemens. Software maintenance of \$15,000/year is not included here; instead it is included in our business model under operations. We believe that our business model will exempt us from sales tax which we could factor into the hardware costs, but was hard to factor out of software and service costs.

Table T2-11 Control Hardware Costs:

Microgrid Controls	Installed Cost	Comment
Software PME etc	\$45,000	Coms Interconnect for Inverters
Software DSO	\$45,000	
Control Panel Installation	\$35,800	Installation only

2.6 INFORMATION TECHNOLOGY / TELECOMMUNICATIONS INFRASTRUCTURE CHARACTERIZATION

At the heart of the microgrid are its controllers, networked together on a secured local network. The controllers monitor the status and performance of the DER and allocate assets dynamically. It also detects irregularities at the main grid interconnections such as voltage and frequency instability or outage, signals the microgrid-to-utility switchgear to disconnect, and for the microgrid's resources to go into island-mode.

The microgrid's networked controllers detect the status of the utility grid connection and transition the microgrid to restore grid parallel operations as conditions permit.

Both hard wired and wireless communication topology and infrastructure will be studied in the next phase of the project development and design to ensure a forward compatible system. We concluded after study that one microgrid frequency synched by high speed fiber Ethernet or WIFI is optimal in this context.

To switch back to grid connected operation, stable voltage and frequency must be detected at the utility side of the isolation switch for at least five minutes (or longer if deemed necessary.) The operation is open transition. The current source devices (inverters) and synchronous generators are switched off simultaneously. After a two second time delay, the utility isolation switch is closed. After a time delay any other isolation switches in the circuit are closed.

2.6.1 COMMUNICATIONS WITHIN THE MICROGRID AND BETWEEN MICROGRID AND UTILITY

The network is designed to localize microgrid controls to maintain communications within the microgrid and directly to the utility in the event of a disruption in internet connectivity, or a fault in any hard-wired interconnections.

All communications between microgrid-owned equipment and Con Edison will follow enhanced security protocols to protect privacy and ensure safe operability of the microgrid.

Each of the four primary sites will be interconnected with a dedicated, secure communications network. The control network will be an optimized mix of secured wireless and wired interconnections using best practices including encrypted VPN and intrusion protection services to prevent security breaches and other disruptions of systems communications. All components of the system are independently powered with dedicated battery backup. The status of each individual node and network segment that interconnects control systems is monitored in real-time.

2.6.2 TELECOMMUNICATIONS AND COMMUNITY WiFi

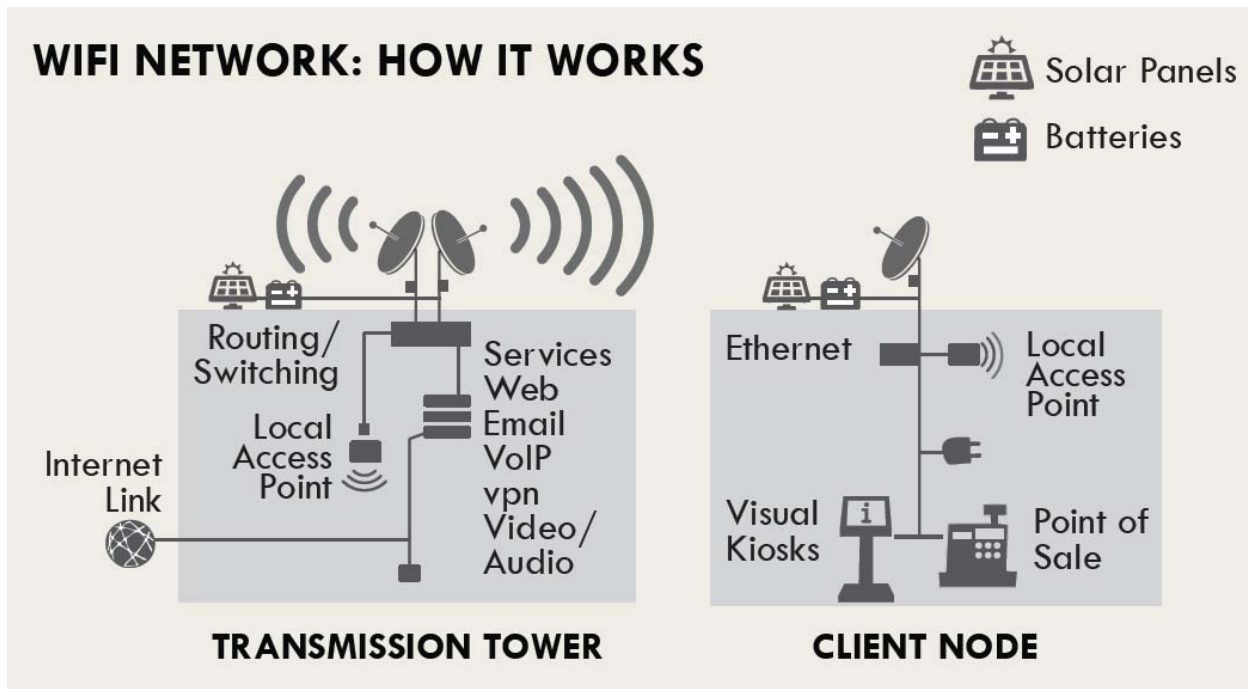
The proposed microgrid will provide power to a community wireless broadband system providing secure Internet connections and telephony. It



is supplied by a 5 GHz tower with four sector antennas and dedicated feeders to remote internet uplinks. As part of disaster management and local resiliency planning, the team has designed in dedicated renewable power with battery backup.

The main transmission hub, located atop Village East Tower's 411 East 10th Street site, has a direct line-of-sight to all of the microgrid site-partners and to Con Edison headquarters at Irving Place, as well as to Con Edison's 15th Street facility. All network components requiring power including switches, access points and feeders, will have their own renewable power subsystems consisting of solar arrays, connected to battery storage. Renewable power and battery storage will provide 100% of the wireless system's power in the event of disruption of DER, to assure communications with microgrid control systems within the microgrid, and as a fail-safe communications link to the utility. In addition, the wireless network provides secure backup Internet connectivity to the microgrid controls.

Figure T2-18 Resilient WiFi Network



The equipment in use has a minimal power draw and is proven to withstand harsh environments while performing reliably. The tower systems consume less than 75 Watts total, and each node consumes only 7 – 10 Watts. Components are inexpensive, robust, have a low failure rate and are easily and rapidly replaced in the event of a failure.

2.7 SUMMARY

The system was designed within the project’s modest budget. Its Manhattan location will require new tunneling, manholes and prevailing wage which drives unavoidable cost. Hence every other part of the project is on an extremely tight budget. Two systems architectural iterations produced a viable business case. The team also has a running list of opportunities to improve the business case through technology changes (e.g. PV), special equipment pricing (leveraging our NPO status), competitive bidding, etc. We believe that our business model will exempt us from sales taxes. Our model also predicts that we will benefit from economies of scale as more buildings join, and we intend to work on this portion of the model as we go forward. The non-profit business model and economies of scale will be discussed further in Task 3.

This microgrid design will deliver a storm-hardened solution for East Village residents and everyone in LES that needs food and medicine in the aftermath of a crisis. The one fuel source the microgrid requires, natural gas, is highly reliable in Manhattan. The design criteria for DER is highly conservative, particularly with respect to placement, given the risk for flooding. That means that, until available basements and other areas discussed in Task 1 are studied further, we are not utilizing them. The design has redundancy with DER nodes and will have further redundancy as the grid expands.

All of the project’s microgrid technologies are proven and fielded, including the battery peaking plant components. That said, *Beyond The Grid* will still be considered an early adopter of innovative technology – both hardware and software. (Refer to section 2.3.6) Our business model places the grid’s boundary at a building’s electrical/heat input, hence *Beyond The Grid* cannot incorporate building control or energy efficiency measures. However, this mission-driven microgrid also educates and strongly encourages the utilization of new technology for building load management, efficiency upgrades, etc.



COMMERCIAL AND FINANCIAL FEASIBILITY

3.0 INTRODUCTION TO COMMERCIAL AND FINANCIAL FEASIBILITY (TASK 3)

Beyond The Grid Community Microgrid provides New York with a significant opportunity to lead by example regarding to innovative, highly flexible energy solutions. Our *Beyond the Grid* team is adapting the rural electric cooperative (or co-op) business model, originally used during the 1930's to ameliorate rural poverty, to meet specific economic and environmental objectives for a highly resource-constrained urban community. The proposed microgrid will occupy the equivalent of two city blocks in the East Village of Manhattan's Lower East Side and directly serve a daytime population of approximately 250 young students, supermarket & pharmacy shoppers and library-goers, as well as the 30% of the residents who are not participants in the labor force (nearly all involuntarily). The nighttime population served will be about 2250, increasing to more than 2500 during crisis events when the community center is converted to a shelter (as it was during Hurricane Sandy.) Learning from the experience of Hurricane Sandy, we know that this is a community that will largely shelter in place during future weather or other crisis events.

3.1 COMMERCIAL VIABILITY – CUSTOMERS

This microgrid focuses on approximately 2250 residential consumers severely impacted by Hurricane Sandy and on the critical services they need. During Hurricane Sandy, in spite of mandatory evacuation orders and lacking other options, the majority of residents in this area sheltered in place. In Figure T3-1 below, the blue areas indicate the extent of the surge and attendant flooding.

During the storm, a large transformer exploded. Power outages caused communication network failures (including telecom and internet) lasting long after the storm had passed. Crucially, the absence of Electronic Benefits Transfer (EBT) system¹ on which many East Village residents rely on to purchase food negatively impacted residents and While the elevators in housing towers were unpowered, elderly and infirm residents were trapped on high floors of Campos Plaza I and II. At least one fatality in the neighborhood was blamed on lack of power: a senior citizen who could not be evacuated by elevator and whose respirator failed.

¹ Retailers must apply for authorization from the US Department of Agriculture to accept SNAP

Because a ConEd generating facility and substation is at the northern edge of the proposed project area, a large portion of the district is defined as an environmental justice community by the New York State Department of Environmental Conservation —a low income population directly impacted by the particulate loads and greenhouse gas emissions from power generation.

The number of individuals actively consuming energy in the project area during daytime hours is approximately double that during evening hours. Residential towers account for the largest aggregate demand, but a supermarket, pharmacy and community center serve a far greater population of nearby residents.

We estimate that the population density of the NYCHA properties



Figure T3-1 Map of Grid Stakeholders; NY Prize Site 20 will serve an environmental justice community

is identical to the city’s average housing density. Hence *Beyond the Grid* will be an ideal model for other Manhattan microgrids.



Figure T3-2 Village East Towers

For our analysis we assumed privately owned units in Village East Towers, a moderate-income cooperative has a population density equal to the average for the privately owned units in their zipcode. Using 2014 statistics and enrollment data from the Department of Education, we estimate the daytime occupancy of the microgrid properties at between 1100 and 1250, depending on time of day and community center programming



A school building, which stands to benefit the most from upgrades in this plan, serves three different groups of elementary age children, including students with acute intellectual needs and accommodation to disorders on the autism spectrum.

Figure T3-3 Three Schools; P94M serves students who are on the autistic spectrum

Lack of food and medicine is particularly acute for families who lack the resources to stockpile reserves; such families are heavily concentrated in NYCHA properties such as prospective microgrid participants in Campos I and II. The community center is expected to be used as temporary shelter and distribution center during future crises as it was during Superstorm Sandy; and in the summer it serves as a “cooling station.” The institutional and business customers on the microgrid will be NYC’s Department of Education (DOE), NYCHA, L+M which manage units for NYCHA, C-Town Supermarket, Avenue C Pharmacy, and University Settlement Cornerstone Community Center.



Figure T3-4 Ave C Pharmacy



Figure T3-5 C-Town Supermarket

Urban planners consider supermarkets and pharmacies to be critical to life, health and safety.

The design of the microgrid will support 100% of peak power of the three main site-partners—NYCHA, DOE and Village East—based on 2015 demand. Full power will be available in islanded mode.

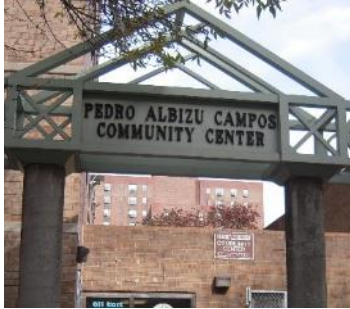


Figure T3-6 Community Center; Cooling center in summer and crisis shelter as needed



Figure T3-7 NYCHA Affordable Housing

Through our design requirements, the *Beyond the Grid* team intends to ensure flexibility and modularity such that the grid can be expanded over time to include more business, employers and housing units adjacent to the four buildings that comprise the microgrid.

Although currently just 4.75 acres (roughly 2 city blocks) in area, the irregular outline of the microgrid and its crossing of two streets means that we expect it can efficiently propagate its benefits through the neighborhood. See Figure T3-1 *Map of Grid Stakeholders*.

Beyond the Grid expects to develop a legal framework using the co-op business model that will afford residents the opportunity to become full shareholders. We will also obtain necessary regulatory approvals and exemptions, including certifying generating facilities as QFs under PURPA. Non-critical load purchasers will initially remain served by ConEd to leverage the project's anticipated high daytime production. The *Beyond the Grid* team has held community meetings at Village East Towers Co-op and NYCHA properties to explain the concept of a sustainable microgrid. Meetings have been well attended, and the Team has received enthusiastic feedback from individuals who want fixed and predictable pricing based on customer choice.

Planned expansion will include: electric vehicle charging stations; power sales to local communications providers; and implementing necessary building energy efficiency improvements.

The *Beyond the Grid* team received initial support from the Energy Coordinator for the Sustainability Initiative at the NYC Department of Education. The P.S. 61 building has the ductwork necessary for central air conditioning. However, currently individual classrooms are cooled with window units, while the auditorium/cafeteria space is cooled just with an air handler. Their Energy Coordinator is open to including an absorption chiller to manage the first floor should their basement elevations qualify it for CHP.

3.2 COMMERCIAL VIABILITY - VALUE PROPOSITION

Residents of both the Village East Towers and Campos Plaza I & II expressed a desire to have fixed and predictable electric payments. The ability to control bills is critical to keeping housing affordable. From a business viewpoint, this creates the same



Figure T3-8 Value Proposition

opportunity that solar installers provide in the suburbs – provide or donate space for renewable energy facilities in exchange for stable and predictable electric bills. The company profits by retaining the difference in generating costs and sales price, while minimizing capital costs through economies of scale.

The Team is learning through discussions that there may need to be two different types of relationships for site partners. Some participants are willing to provide space to house equipment and want to purchase hot

water and power, but are not ready to upgrade their steam boilers and do not want to actively participate in asset management and operations.

Other participants are willing to provide not only some combination of space, capital and operations management, but they are also eager to upgrade systems and purchase the full array of products: electricity, hot water, chilled air (summer) and pre-chilled air for commercial refrigeration; steam (winter); and energy storage.

Additional partners could include: private or public investors (such as USGrid Co.); equipment vendors who provide asset or other financing; microgrid operators (such as Direct Energy), and the Village East Towers Co-operative (whose board is moving to install three microturbines independent of the *Beyond the Grid* project.) Since individuals will be the members of the co-op, they will be a subset of the purchasers of power. Some of the public entities will be power purchasers, and there may be private investors who are microgrid owners but not direct purchasers of power.

3.2.1 BENEFITS TO EAST VILLAGE COMMUNITY AND CON EDISON

Reliable power and economic resilience are the primary benefits to the East Village Community. Predictable power rates that are under ratepayers' control is the primary benefit to direct consumers. Also important are: (1) improved air quality (reduction in particulates for power generated); and (2) opportunities to expand services to additional customers in the area. These benefits are recognized by community groups as essential for improving their quality of life.

We are also fortunate that ConEd embraces distributed energy in general, and microgrids in particular. ConEd has a "utility of the future team" examining technology advancements, changing customer needs, information technology, storm response, clean energy, economic recovery and microgrids. ConEd filed comments in the REV proceeding strongly supporting reforms to further encourage microgrid development.² ConEd's Director of R&D is open to private ownership of microgrids, or co-ownership with the utility³, and from this we will presume ConEd is open to a non-profit cooperative as well. See photograph in Figure T3-9 to follow.

The demand from the Avenue A station peaks at 5-6 PM. In our meetings with ConEd, we have offered the help of our microgrid. ConEd would want to be able to call upon us between 4 - 7pm, a request being worked into our system design. Con Ed wants fast response feed-in, which we can provide.

In the area of the Two Bridges/Beyond the Grid Community microgrid, ConEd has 3 MW of capacity. We will initially develop approximately 2 MW of capacity. Up to 40% of the capacity on average will be available for sale to the ConEd to serve neighboring customers.

² Comments of the City of New York on Microgrids, Reforming the Energy Vision, New York State Public Service Commission, Case 14-M-0101 (May 1, 2015). Joint Utilities' Response to Notice Soliciting Comments on Microgrids, Reforming the Energy Vision, New York State Public Service Commission, Case 14-M-0101 (May 1, 2015).

³ <http://www.smartgridtoday.com/public/Pareto-Energy-works-to-get-big-IOUs-to-adopt-microgrids.cfm>; accessed Jan 10th, 2016.



Figure T3-9 Across Ave C from Campos Plaza is a ConEd substation that was disabled by Sandy; the microgrid (especially as it grows) will be able to assist in the substation's resiliency.

Resilient communications that robustly protect the privacy of their residents are incorporated into the Beyond the Grid plan. As residents of the Lower East Side, just to the south of the microgrid area, two of our team members, Paul Garrin and Kerri Culhane, experienced Hurricane Sandy devastation firsthand. They saw the challenges that lack of communications posed for disaster relief within their own buildings and community-wide. As part of future disaster management and local resiliency, the Team has designed renewable power feeds for WiFi communications as well as access to battery backup.

In a community such as the East Village, the importance of access to WiFi (particularly the affordable WiFi offered by WiFi-NY's 5 GHz tower) should not be underestimated. The knowledge gap facing those who cannot afford smart-phone or computer technology or broadband access has sharp consequences for anyone seeking to enter (or stay in) the workforce. The Two Bridges Neighborhood Council has been working together with WiFi-NY to bridge the digital divide between poor and middle-class by providing modestly priced Internet over community wireless broadband.

3.2.2 SWOT ANALYSIS

The business model for *Beyond the Grid* is based on a rural electrical co-op where individual users of electricity are also shareholders in the business that purchases, owns, runs and maintains the electrical system equipment. Any of the individuals or buildings in the footprint of the microgrid could choose to purchase power from Con Ed or the microgrid, but the advantages of being within the system, both for economic, social and environmental reasons are compelling to the participants because they will have a meaningful stake in the program – especially Village East Towers. One of the greatest strengths of the program is this community commitment. In response, the team envisions training for local residents to become managers and employees of the microgrid co-op.

The population density and vertical living arrangements of the area are also an advantage since the transmission lengths required are incredibly small considering that 2250 – 2500 people can be receiving light, power, heat, hot water and in some cases, conditioned air. Currently residents are paying high rates for power and a very high price for steam. Village East Towers, a cooperative, which does not have individual metering, has an energy bill of about \$1.5M/year for 439 units, including common space and a swimming pool.

Schneider Electric, Louis Berger and Lockheed Martin have established business partnerships with equipment suppliers, many of whom have long-established business in the New York City area. All of the suppliers who have volunteered their time and talent to provide input to the business case offer ongoing service contracts to assure continued in-spec performance of their equipment and a ready number to call in an emergency.

The opportunities follow from the strengths – as we show success, community involvement is likely to spread, allowing for grid expansion and service expansion such as electric vehicle charging stations. The differential between the fixed price of our energy output and the production costs makes an attractive business case. At the time of this writing, NYCHA was not ready to commit to CHP and L+M did not have the space. Therefore, identification of one of the biggest opportunities of this microgrid – the use of waste heat from ConEd steam – has been deferred for future consideration. Another future opportunity is to provide refrigeration for the pharmacy and supermarket, and would maximize thermal load during summer months when heat/hot water demand is lower and utilize thermal load for supermarket which requires little to no heating during winter. Providing electric vehicle charging stations is another revenue stream under consideration.

A distillation of the strengths of *Beyond the Grid*, as well as its weakness, opportunities and threats (SWOT) is provided diagrammatically as below.

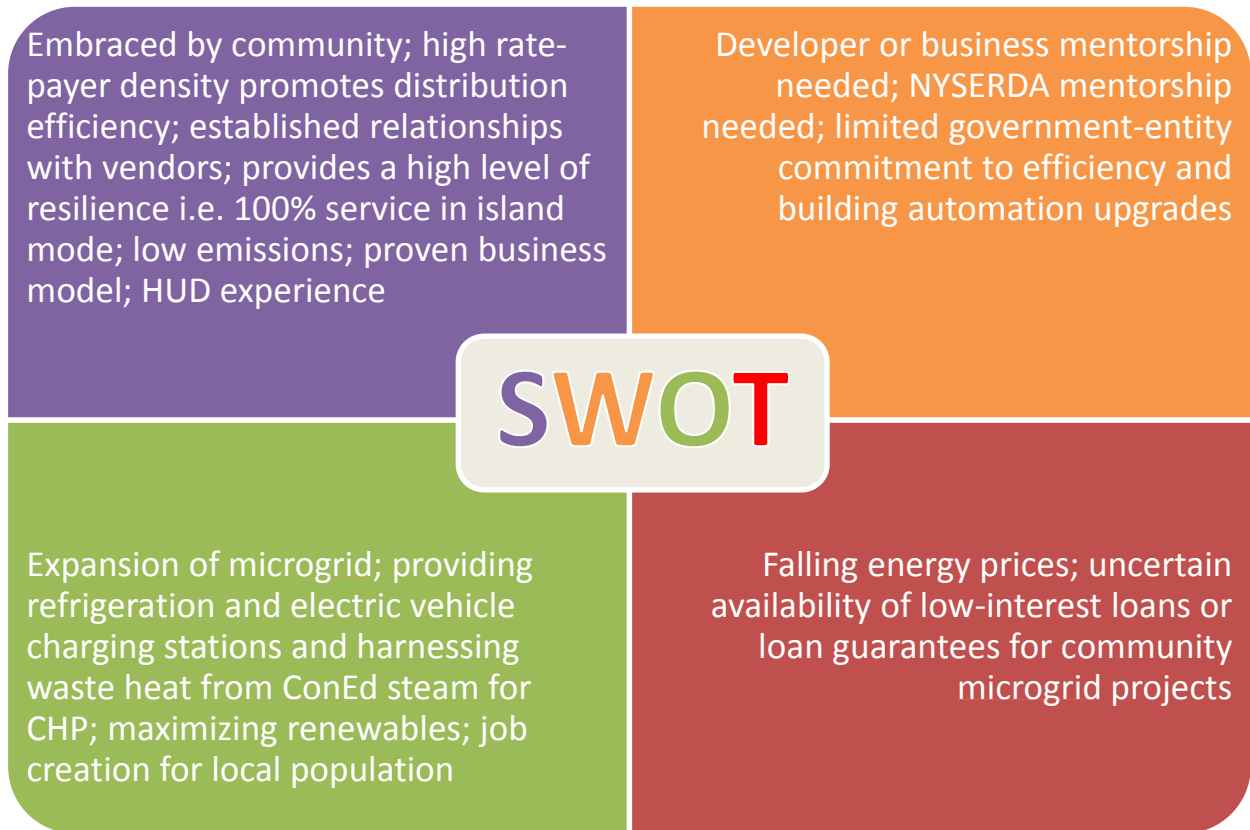


Figure T3-10 *Beyond The Grid* Microgrid **Strength**, **Weakness**, **Opportunity** and **Threat** Matrix

Threats and weaknesses include the risk of falling energy prices and lack of microgrid business experience within the Team at present. Having an initial business case will make it possible for us to recruit the business talent we need. Although it is not critical to our business case, the reticence of government entities (NYCHA and NY DoE) to commit to extensive building efficiency projects could mean that we miss out on programs and incentives. Similarly, it is uncertain what low interest loan programs, charitable contributions, and financing we will be able to obtain.

3.2.3 TECHNICAL DE-RISKING

The characteristics of the equipment siting and project plan are not unique; rather, they reflect a number of best practices. As such, our proposal should be seen by investors as low risk. Also, from the technical point of view, this project will be particularly scalable. The equipment we have selected is modular in nature but could be expanded; meaning as the community’s load increases, equipment can be ordered and installed without additional engineering studies. The

project also has sufficient space and technical expertise to allow trusted suppliers to trial their latest equipment versions.

From a legal standpoint, using a rural electrification co-op legal structure and adapting it as appropriate to the needs of an urban microgrid should make the project replicable. This project will effectively “move the needle” on efficiency and community engagement, and fundamentally augment the security of an otherwise vulnerable community.

3.2.4 MEETING NY STATE REV OBJECTIVES

Among the most pressing issues currently addressed by *Beyond The Grid* is affordable housing which includes stabilizing energy costs. As such, the goals of *Beyond the Grid* are aligned with those of New York State Public Service Commission’s goals for Reforming the Energy Vision (REV), which include:

- **Creating the power grid of the future and enabling customers to better manage and reduce their energy costs** - *Beyond the Grid* offers more predictable, stable energy pricing to individuals, local businesses, and city government entities.
- **Addressing the issues of rising electric bills, reliability, jobs and other needs of low income customers** - *Beyond the Grid* offers customers stable energy pricing and affordable Internet access that helps equalize access to information/communication which is tied to employability and local job growth.
- Promoting system efficiency, reduced carbon emissions, technology innovations, resiliency, renewable/clean energy sources, energy storage, advanced control systems, and competitive energy markets - *Beyond the Grid* is set up to address each of these important considerations, and we expect to have the administrative structure to increase the rate of innovation uptake over time.

3.2.4.1 The East Village’s Unmet Needs

With a high concentration of lower income residents, a geographic vulnerability to extreme weather, and a strong tradition of local activism, the East Village provides a unique opportunity for a microgrid to have a significant impact in addressing the challenges wrought by poverty.

The population to be served by our microgrid is poorer, older and more diverse than city and state averages, as shown below. While the City’s official unemployment rate is 6%, roughly 34% of city residents (most of whom are working-age and largely residents of NYCHA) are not participating in the labor force. (US Census Bureau’s 2014 American Community Survey.)

The median income of the relevant census tract for the microgrid is \$39,479 (+/- \$11,723.) This is significantly lower than the Manhattan-wide median income of \$66,739 (US Census 2010).

Age Demographics

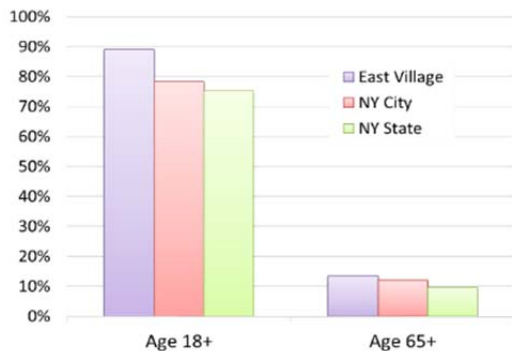


Figure T3-11 Percentage of population of zip code 10009 i.e. the East Village that is (1) adult and (2) retirement age

Poverty

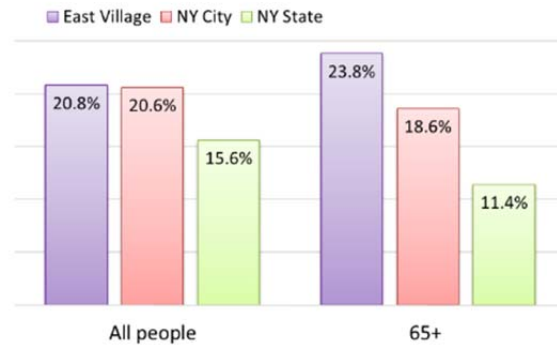


Figure T3-12 Income data based on 2014 American Community Survey expressed as those living below the poverty line for 12 consecutive months

Data for the three schools operating within the school building shown in Figure T3.-13, corroborates the data from the US 2014 American Community Survey. Whites comprise slightly less than half the population; Hispanics of various origins are roughly a quarter of the neighborhood and the remaining fraction is divided between those of Black, Asian, mixed and other race/ethnicity. Two Bridges Neighborhood Council has the credibility and energy to achieve the founding and oversight of the microgrid.

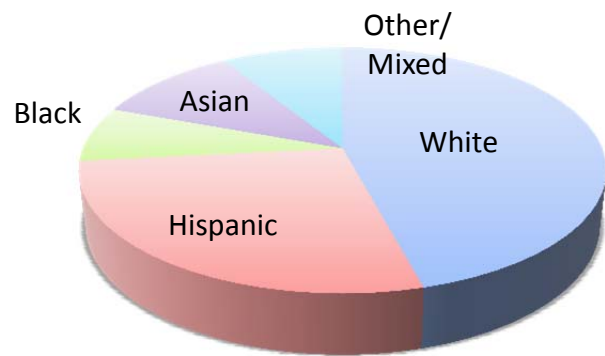


Figure T3-13 Diversity of the Community based on data from US Census Bureau and NYC Dept of Education

Two Bridges has a 50-year history of serving the Lower East Side neighborhoods, including the East Village. The NPO develops affordable housing, promotes the recognition and preservation of the area’s living history and culture, and advocates for residents and merchants through public programs, policy reports, and participation in neighborhood coalitions. By engaging in dialogue about the microgrid with residents, local political leaders and partner organizations, Two Bridges provides critical insight to what can and cannot be achieved.

3.2.4.2 ConEd’s Unmet Needs

The existing distribution grid is inefficient because power needed for the hottest days of the year has to be available year round.⁴ ConEd understands that customers are looking increasingly to disconnect from the utility grid and operate in island mode, and this adds to grid resiliency. Options for cogeneration have improved. The value of islanding was made clear by the experience of Hurricane Sandy.

3.2.5 HISTORICAL POWER OUTAGE DATA

Within the last 20 years, the East Village has experienced 14 major disturbances in the electrical grid according to the U.S. Energy Information Administration. Line 15 (the last line) is not an official major disturbance from the electrical grid point of view; it is a natural gas distribution grid issue. It is included as an example of a disturbance with major local impact. In addition to the major disturbances, the East Village of Manhattan experiences frequent momentary power losses, brownouts, and minor disruptions due to manhole fires, transformer fires, and gas explosions.

As discussed in *Beyond the Grid's* Task 1 and Task 2 sections, most of the buildings in the East Village do not have automated building controls or the ability to optimize load shedding. To the extent that load shedding is done during mandatory conservation periods, it is done by shutting off particular breakers on a panel. The microgrid will not own these panels, hence load shedding will require upgrades on the part of the participants and/or agreements between the microgrid and participants about protocols for load shedding. Table T3-1 provides a summary that is specific to the East Village.⁵

⁴ <http://www.smartgridtoday.com/members/6023print.cfm> April 25, 2014; retrieved January 10th.

⁵ Data obtained from <https://www.eia.gov/electricity/monthly/> and https://www.eia.gov/electricity/data/disturbance/disturb_events_archive.html

T3-1 Major Interruptions to the Electrical Service Affecting the East Village
Listed in Order of Duration

<u>Year</u>	<u>Event Date and Time</u>	<u>Restoration Date and Time</u>	<u>Approximate Duration</u>	<u>Type of Disturbance</u>	<u>Number of ConEdison Customers Affected</u>
2012	10/29/2012 4:01 PM	11/08/2012 7:00 PM	10 days	Severe Weather - Hurricane Sandy	818,000
2006	7/17/2006 6:50 p.m.	July 25 3:06 a.m.	8 days	Severe Weather/Public Appeals Made/Voltage Reduction	25,000
2010	3/13/2010 6:00 p.m.	March 20 9:00 a.m.	7 days	High Winds and Rain	173,000
2011	08/28/2011 5:01 AM	09/03/2011 5:01 AM	6 days	Severe Weather	50,000
2010	2/25/2010 5:00 p.m.	March 02 7:00 p.m.	6 days	Winter Storm	55,000
2011	10/29/2011 4:16 PM	11/02/2011 9:30 PM	4 days	Severe Weather	50,000
2003	8/14/2003 4:11 p.m.	8/15/03 9:03 p.m.	1 day	Unknown	3,125,350
1999	7/6/1999 10:11 p.m.	July 7 5:05 p.m.	1 day	Firm Load Shedding	69,000
2000	5/9/2000 11:39 a.m.	May 9 11:00 p.m.	12 hours	Energy Conservation	N/A
1999	7/6/1999 1:22 p.m.	July 6 10:05 p.m.	9 hours	Voltage Reduction	N/A
2002	7/20/2002 12:40:00 PM	7/20/2003 8:12:00 PM	8 hours	Fire	63,500
2001	6/25/2001 1:25 p.m.	June 25 9:39 p.m.	8 hours	Feeder Shutdowns	N/A
1999	6/8/1999 9:41 a.m.	June 8 5:00 p.m.	8 hours	Weather	N/A
2007	6/27/2007 3:41 p.m.	June 27 4:30 p.m.	1 hour	Lightning	136,700
2015	March 26 3 pm	March 27 AM	Hours – not an official incident	Gas explosion at Second Avenue and East Seventh Street	Localized

3.3 COMMERCIAL VIABILITY - PROJECT TEAM

More than most projects, Beyond The Grid has stakeholders that are integral to its mission. Stakeholders in the project development include members of the Project Sponsors and the Beyond the Grid team (see 3.3.1 below) as well as microgrid customers including:

- NYC’s Department of Education, which includes:
 - East Village Community School (a public elementary school), including Friday evening and summer programs
 - Children’s Workshop School (a progressive public elementary school)
 - The Spectrum School (providing ungraded education through primary and secondary curriculums for students on the autistic spectrum)
 - Emergency shelter
 - Future: cooling station
- NYCHA, managing Campos Plaza II
- L+M, a private company which manages Campos Plaza I for NYCHA
- C-Town Supermarket
- Avenue C Pharmacy
- University Settlement Cornerstone Community Center, which offers extended evening hours and includes:
 - A gym, theater, digital lab, music room, ceramics studio and library
 - After-school and summer day camp for students aged 5-12, including homework assistance, arts and crafts (ceramics, dance, and group art therapy), music, sports, and trips.
 - Evening and Saturday programs for teens 13-17 years, including sports (basketball, softball, volleyball), dance, ceramics, portfolio preparation, music, movie nights, summer youth employment application assistance, and cooking.
 - Evening studios for adults 18 years and up, including athletics (basketball, yoga), and women's peer circle.
 - Evening and Saturday studios for families (parents and children together).
 - Emergency shelter
 - Community cooling station in the summer
- WiFi-NY, offering affordable, resilient Internet and communications.
- A police telecommunications repeater at VET.
- Future: stakeholders to facilitate electric vehicle charging stations, refrigeration, and thermal energy services



Figure T3-14 Opportunity: Provide Refrigeration
 (C-town meat department)



Figure T3-15 Opportunity: Retail between
 Grocery and Pharmacy

For example, the Village East Tower community room is also an emergency cooling center in the summer and the staging area for emergency response in non-flood emergencies. The management and maintenance offices can also benefit, as well the enclosed swimming pool area.

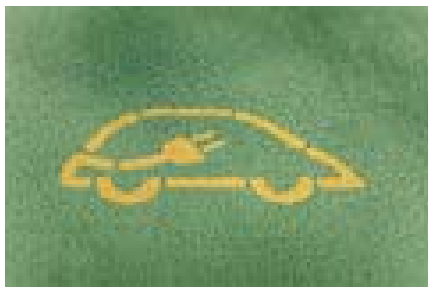


Figure T3-16 Opportunity: Electric Vehicle
 Charging Stations



Figure T3-17 Opportunity: Provide an Additional
 Cooling Station

Campos Plaza I and II provide multi-family apartment housing as part of the NY City Housing Authority’s Section 8 subsidized housing program. Village East Towers are limited-equity, residential cooperative multifamily apartments created under the state’s Mitchell-Lama Housing program. The two largest users of electricity (NYCHA and Village East Towers) together represent 90% of the energy draw are both naturally occurring retirement communities.

Customer commitment is being secured through discussions with the Energy Coordinator for the Sustainability Initiative of the NYC Department of Education, NYCHA authorities, Village East Towers management, and via community meetings where residents can express hopes and concerns. These meetings are led by Paul Garrin, using communication channels such as the

Emergency Preparedness Taskforce of Village East Towers. Follow-up is being coordinated by Two Bridges Neighborhood Council.

Development is expected to be performed by the Beyond the Grid technical team members, and contractors (selected after a competitive bidding process.) The bid package, including engineering drawings and equipment specification, will be developed during the next phase. One exception is the contracting of the manholes which we will need to install across the public right-of-ways; ConEd is potentially willing to install manhole(s), raceways, and cabling as a subcontractor.

3.3.1 PROJECT SPONSORS AND MICROGRID CUSTOMERS

Project team members will be expanded to include suppliers and outside investors. *Beyond the Grid*, along with city government entities and private financiers, will comprise a public/private partnership. Having public entities commit to long term energy contracts will provide a stable source of revenue for the microgrid and enhance our ability to obtain necessary financing for the project.

Con Ed has provided a letter of commitment which was included in the original proposal.

The *Beyond the Grid* team will take the lead in developing and implementing the not-for-profit co-operative structure, with pro bono legal and regulatory expertise from Morrison & Foerster.

LES Ready!, the Lower East Side group dedicated to long term recovery from Hurricane Sandy and mitigation of the impact of future disasters, is also a project sponsor and has provided outreach assistance to reach local residents.

Project financiers and investors, apart from the sponsors providing real estate, have not yet been identified. Fortunately, New York City has a vibrant CleanTech investment community. Team members have been drawn from various clean tech entrepreneurial ventures and have personal relationships with advisors who can direct the team to investors of the right temperament. CleanTech excites many in the NYC metro-area because investors can position themselves to reap upside without having to suffer losses in the development stages of generation technologies such as those included in this project.

Asset management can be performed by the co-op, or contracted out. The co-op model represents the ideal for *Beyond The Grid*, but is not the only option. Asset management for renewables is a relatively mature business. As fewer utilities build their own generating plants, preferring to reduce infrastructure investment and source production, renewable energy management companies have emerged that sell power to utilities, often in the form of power

purchase agreements. These companies manage their own renewable assets and those developed by a third-party.

Using the co-op business model, residents in the Beyond the Grid’s proposed microgrid will have the opportunity to become full shareholders as well as customers of the microgrid and participate to varying degrees.

3.3.2 THE BEYOND THE GRID TEAM

A photo from one of several kick-off meetings is shown below. Note that team leadership is transferring from Kerri Culhane to Dan Ping He.



Figure T3-18 Team Photo. From the left: Bob Fleishman (Morrison Foerster LLP), Dan Ping He (Two Bridges Neighborhood Council), Margaret Matz (Milestone Architects), Paul Garrin (WiFiNY), Kerri Culhane (Two Bridges Neighborhood Council), Alex Nadolishny (Louis Berger Group), Maureen Rabbitt (Louis Berger Group), Chris Corlis (Louis Berger Group), Ray Tillman (Milestone Architects)

Not pictured are Beth Kujan (Louis Berger Group), Dave Gerwing and Paul Wyman (Lockheed Martin), Stephanie Ference, and Paul Varnado (Morrison Foerster LLP), Neil Steinkamp (Stout Risius Ross) and from the Milestone team: Suneet Jagdev, and Jim Standish. Biographical sketches of the principals are provided.



Kerri Culhane, Associate Director, Two Bridges Neighborhood Council

Integrating her interests in social justice,

Kerri Culhane

Role: Program management, community outreach and reporting

environmental sustainability, and the cultural landscape, Kerri leads Two Bridges’ environmental planning and program development. She has over 15 years of project management experience with responsibility for

budgets up to \$11 million. In 2014, Kerri advised the winning *Rebuild by Design Team* as a core planning team lead for the East River Coastal Resiliency Plan, a project using landscape design as a means of passive flood protection. She is currently leading a neighborhood effort to integrate green infrastructure and low-carbon and renewable energy technology throughout the Lower East Side while creating much needed skill building and green jobs training in a community with a 30% non-participation in the workforce. Kerri lives in the Lower East Side.



Alex Nadolishny



The Louis Berger Group

Role: Engineering and Technical Assistance

Alex Nadolishny, LEED AP, Principal Technology Expert, Environmental & Disaster Management Services, Louis Berger Group

The Louis Berger Group has, for 23 years, provided technology roll-out, engineering design, construction management and project delivery services. Alex, working in power generation, waste management and other sectors has successfully completed

many high profile projects for a client list that includes major oil and utility companies (Shell, Chevron, Progress Energy, Keyspan Energy), defense contractors (UTC Pratt&Whitney and Sikorsky Aircraft, KAMAN Aerospace), government agencies such as DoD, FEMA, NASA and US EPA, local government and public agencies including New York City MTA, NYC DEP, NJ DEP. Alex has managed large projects such as the construction of a 500 MW power plant in NY, the rolling out new technologies on the marketplace such as HT Membrane Interface Probe technology as well as equipment rehabilitation projects such as many post-9/11 projects in the NYC Transit system and post- Hurricane Sandy restoration.



Paul Garrin



Role Project co-founder; Wireless systems, networking technologies; outreach and education

Paul Garrin, Founder, WiFi-NY, LLC

Paul is an internationally-awarded media artist and innovator establishing disaster-resilient communications alternatives for mixed income housing residents, small businesses and non-profit organizations. Paul has over 20 years of experience in IP net-

works administration and 12 years of experience building/operating high-speed/low-latency wireless networks.

In his role in *Beyond the Grid*, Paul provides wireless network infrastructure, connectivity and systems security as well as high-level vision for the project and policy objectives. Paul has established relationships with vital community organizations and leaders and acts as educator and liaison to inform and identify the needs and opportunities related to distributed generation, renewable energy, carbon reductions, economics and the creation of community microgrids and affordable broadband communications. Paul is a resident of the East Village.



Robert Fleishman

**MORRISON
 FOERSTER**

Role: Pro bono legal services & policy analysis for regulatory matters; business model scenarios.

Robert Fleishman, Senior Of Counsel, Morrison & Foerster LLP

Bob is in Morrison & Foerster's litigation department in its Washington, D.C. office. Mr. Fleishman has a leading reputation in defending energy and financial industry participants and individuals in energy markets

against charges of market manipulation, particularly before the Federal Energy Regulatory Commission and other regulatory bodies. His deep knowledge of the electric and gas regulatory and enforcement landscape has been recognized by Chambers USA (2010-2015), Best Lawyers in America, Energy (2007-2015), and Legal 500 US (2008-2010; 2012-2015). Mr. Fleishman also received the Center for the Advancement of Energy Markets Service Award (2005).



Neil Steinkamp



Role: Economic and
Financial Advisor

Neil Steinkamp, Managing Director, Stout Risius Ross, Inc.

Neil has extensive experience providing a broad range of business and financial advice to trial lawyers and in-house counsel. He is also co-leader of SRR's Materials practice and head of SRR's pro bono practice. Mr. Steinkamp's experience has covered many industries

and matter types resulting in a comprehensive understanding of the application of damages concepts and other economic analyses.

In his role in *Beyond the Grid*, Neil provides a bridge between the economic analyses of IEc, Lockheed Martin and the Louis Berger Group. He counsels the team on the valuation of risk as well as researching for us how resiliency can be monetized. He is providing introduction to boutique investment and socially conscious lenders.



David Gerwing



Role: Systems Architect

David Gerwing, M.Sc., P.Eng

Dave is Technical Operations Manager at Lockheed Martin Canada. He is part of Lockheed Martin's Microgrid Development Center which provides a fully integrated environment for simulated hardware-in-the-loop and software-in-the-loop design verification. The simulation allows

comparative testing of different microgrid hardware architectures and their associated microgrid control algorithms. This simulation technology helps the company to evaluate cutting edge technology and recommend its deployment where helpful.

Lockheed Martin has extensive experience in design and deployment of microgrids for US military installations. As such, the Lockheed Martin's Microgrid Development Center team can provide insight on a broad range of technologies and systems design.

In his role in *Beyond the Grid*, Dave was responsible for cost reduction of 50% while maintaining the level of service specified.



Margaret Matz



Role: Architectural
consulting

Margaret Matz, President, Milestone Architecture, PLLC

Margaret, a registered architect, has 20 years of experience in designing new, restoration, and sustainable renovation projects for academic institutions, health care institutions, and corporate and retail organizations.

Her work has received many awards, most notably an Annual Record Interiors Feature for the Carmelo Pomodoro showroom, an Annual Interiors Award for the Yumesaki USA showroom, an Abraham Kazan Award for Excellence in Structural Engineering and a Peter Bruder Memorial Fund Prize for Urban Design. She is a LEED Accredited Professional and both an AIA and a US Green Building Council member. She holds a Bachelor of Architecture degree from the Cooper Union for the Advancement of Science and Art. Milestone Architecture PLLC is a women-owned business enterprise (WBE). Margaret lives in the East Village.



Dr. Beth Kujan

Tech Stevedore

Role: Project
Management,
Contributor, Principal
Editor

Elizabeth Kujan, Ph.D., LEED AP

Beth has extensive experience with resiliency in the built environment earning an accreditation with the US Green Building Council. She helped to found and to bring in National Science Foundation and NYSERDA funding for an advanced materials startup company.

In her role in *Beyond the Grid*, Beth provides project management, meeting facilitation, technical writing, visuals, research and analysis. She takes the lead on resiliency analysis, metrics associated with Benefit Cost Analysis and demographics.

Team entities experienced in managing HUD funds: Louis Berger Group, Two Bridges Neighborhood Council. Milestone Architects holds certified WBE status.

3.4 COMMERCIAL VIABILITY - CREATING AND DELIVERING VALUE

The rise of energy “prosumers” who both produce and consume power and place a high value on independent control, has been recognized recently as a trend in a leading study of microgrids.⁶ Beyond the Grid provides a concrete example of the positive factors driving this significant trend.

The idea of the community microgrid in NYC’s East Village, arising from a profound and unprecedented natural disaster, has produced a highly engaged and eager prosumer group centered at Village East Towers.

At a recent community meeting, which was videotaped and attended by a reporter for The Villager, there was great enthusiasm for a co-op that will hold the microgrid assets as a non-profit entity.

It is not surprising that members of a successful residential cooperative would be interested to form and run an energy cooperative. It also bodes well for the future of the project.



Figure T3-19 Paul Garrin speaks at Community Meeting

At present, the NYCHA properties appear to be more interested in purchasing power than in sharing ownership of generation assets. The potential of stable revenue streams from ratepayer members of the co-op, public entities such as NYCHA, and others should enhance the business case to private investors and other funding sources.

In addition, there is a possibility that the project could obtain revenue by participating as an offset project in the area of Building Sector Energy Efficiency. This would involve registering the project in COATS (the CO2 Allowance Tracking System), monitoring the efficiencies of the project, and later offering the offset as a part of the RGGI marketplace through COATS.

3.4.1 EXISTING ASSETS BEING LEVERAGED; NEW ASSETS BEING PLACED

⁶ <https://www.navigantresearch.com/wp-assets/brochures/Navigant-Microgrid-Multi-Client-Final-Report-2015-12-04-Public-Release-Version.pdf>; retrieved Jan., 10, 2016.

Flood resiliency measures are already under consideration by management of the participating properties. This includes flood barriers, upgrades to doors, electrical duct seals, sewer line backflow preventers, sump pumps, and relocation of certain power control equipment above the flood line. The requirements for such upgrades will be provided during architectural design. The cost and detailed design of such measures are not included in the budget figures since the majority of flood hardening measures have separate sources of funding.

Each property is providing new gas-fired backup generators with blackstart capability, funded by FEMA, discussed in the Task 2. At present, the generators would not be helpful to the grid. However, once they are connected to the microgrid, they will provide additional capacity.

Space is the most valuable asset in Manhattan and it is being generously provided for this project by Village East Towers and NYCHA. Backup generators are also being installed by the management of each property and will be incorporated into the microgrid design. At Village East Towers, the most engaged citizens in the program have already committed to purchase three cogeneration microturbines, one for each of their three buildings. That co-op's board intends to have them integrated into the microgrid.

As detailed in the Task 2 report, assets to be placed include microturbines, solar photovoltaic arrays and lithium-ion battery storage. The primary purpose of the battery storage capability is to harmonize voltage and frequency, and arbitrage hourly volatility by making energy produced at times of low demand available during peak demand.

The leadership of the *Beyond the Grid Team*, with the strong support of the Village East Towers community, is strongly committed to achieving as close to carbon neutrality as possible. Future assets envisioned include the use of biogas generated at waste water treatment facilities and through gasification of solid waste collected in trash compactor rooms in the towers.

3.4.2 OPERATIONAL SCHEME

The microgrid is expected to connect to the current power metering systems at each property. The NYCHA properties are individually metered by unit; the Village East Towers cooperative is not individually metered. The three schools share a single meter.

The operating staff of the microgrid is expected to require staff members on shifts, a mechanic and a staff engineer. Ideally, the co-op would like to hire local residents where possible. If that is not possible, the operations would be contracted out. The team considered arranging for a hosted system, whereby the microgrid controller supplier would provide remote control and oversight. This was found to be excessively expensive, and not the norm for microgrids. Further, Capstone CHP units and switchgear are already remotely monitored as part of their maintenance package. The cost of “triple redundancy” was not warranted. Instead, the team

chose to allocate funds to train staff and certain board members during the first year of operations.

The board of the Co-op is anticipated to be comprised of dedicated volunteers led initially by Paul Garrin and advised by Morrison & Foerster, Two Bridges, and Louis Berger Group personnel.

Equipment will be maintained (and serviced in an emergency) by the local supplier/installer of the equipment as part of long-term contracts. Accounting and other business compliance work will be outsourced to ADP, TriNet or another reputable firm specializing in small company administration.

3.5 FINANCIAL VIABILITY

The team has partnered with financial consulting firm Stout Risius Ross (SRR) to test the robustness of the team’s microgrid proposal. The team developed a financial model using some of the same input tabs as the Task 4 analysis⁷ developed by IEc. Louis Berger Group, Schneider Electric, and Lockheed Martin provided CAPEX and OPEX values to the model. Morrison & Foerster and SRR have taken the lead in determining how the model might capture resiliency as well as traditional financials.

3.5.1 FINANCIAL MODELING

Inputs to the financial model are shown in the table T3-1.

Table T3-1. Part 1 Initial Financial Model Inputs

Revenue Inputs & Assumptions	
Members Electric Rate (\$/kWh)	0.155
Annual Growth in Members Electric Rate	3%

⁷ Microgrids for Critical Facility Resiliency in New York State, Report Number 14-36 Final Report prepared by New York State Energy Research and Development Authority (NYSERDA), New York State Department of Public Service (DPS) and New York State Division of Homeland Security and Emergency Services (DHSES), published December 2014 <https://www.nysERDA.ny.gov/-/media/Files/Publications/Research/Electic-Power-Delivery/Microgrids-for-Critical-Facility-NYS.pdf> retrieved March 21, 2016.

Annual Demand by Members (kWhr / year)	10,823,160
Microgrid Capacity	13,565,860
Annual Sales to ConEd (kWhr / year)	2,742,700
Amount from NY Prize Stage 2 contest including cost sharing	1,200,000
Amount from HUD at Stage 3	5,000,000
Initial discount members are getting in electric rates	0.0179
Discount members are getting on steam	0.1055
NYISO Rate for Sales back to ConEd	0.04
Annual Growth in NYISO Rate for Sales back to ConEd	3%
IEC Renewable Energy	0.0048
IEC Renewable Energy Offset Credit Rate	18%
Heat Cogeneration Rate \$/Mlbs	20.0
Annual Growth Rate in Heat Cogeneration Rate	3%
Amount that can be sold to Steam Bill Owners (Therms/Year)	37,958
Estimated Turnkey Installation Cost (\$)	15,473,667
Engineering & Planning Costs	NY Prize 2
Grant from HUD via NYSERDA	5,000,000
NYSERDA Credits - Year 1	1,912,000
NYSERDA Credits - Year 2	985,200
Estimated Annual Operating Costs	
Office manager (half-time)	23,800
Engineer - 1st shift	75,000
Engineer -2nd shift	60,000
Engineer - 3rd shift	69,000
Overhead for labor - % of Labor Costs	25%
Management of Co-Op	0
Rent, insurance, etc	24,000
3rd party accounting/compliance services	3,000
Annual Growth Rate in Annual Operating Costs	3%

Con't next page

Table T3-1. Part 1 Initial Financial Model Inputs

Natural Gas Costs	
Forecasted IEC Fuel Price	7.9098
Annual gas	105,184
Estimated Maintenance Costs	
CHP units	372,752
Microgrid Controls	15,000

Battery Storage	5,000
Battery Peaking Plant	5,000
Annual Growth Rate in Maintenance Costs	3%
Buying power from ConEd	
NYISO Rate Multiplier	1.063
Expected Microgrid Purchases (kwhr/year)	874,660
Annual Growth in NYISO Rate for Sales back to ConEd	3%
Energy Charge	
Rate (\$/kwh)	0.008
Expected Microgrid Purchases (kwhr/year)	874,660
Annual Growth in NYISO Rate for Sales back to ConEd	3%
Demand Delivery Charge	TBD
Reactive power demand charge (per kVAR)	TBD
Rate (per kVAR)	1.41
kVAR	720
Annual Growth in Reactive Power Demand Charge	3%
Extras and adjustments	TBD
Annual Interest Rate - Bridge Loan	5%
Term of the Instrument (years)	20
Annual Interest Rate - Term Loan	3%
Term of the Instrument (years)	20
Discount Rate for NPV Calculation	7%
Calculated NPV \$ 7,005,605	

\$ 7M NPV

Lockheed Martin re-ran the solar model using PVsyst instead of NREL models used by Schneider. PVsyst⁸ is more commonly used for financial analysis. In this case, the results were similar. PVsyst (bankable) solar simulations show 1406 kWh/kW. We will conduct simple first principles calculations of LCOE for CHP Turbines to validate the cash flow for these generation assets; our current projections use simulation data from RSP Systems.

The team intends to model more scenarios between the initial feasibility and final design of the microgrid. Increased economies of scale are possible because current plans include three street crossings required and some blocks not fully served.

Given that talks are underway with properties adjacent to the proposed microgrid, in the future we will consider improvements to the business case by adding customers and/or nodes at Haven Plaza (6 buildings with 371 units' x 2.7 residents/unit on average = 1000 residents), Tanya Towers (1 building with 138 units x 2.7 = 375 residents) and/or Public School 348. An extra 510 ratepayers may help our business case, especially if we can add revenue without adding an extra manhole and instead simply super-sizing the CHP plants

SRR tested the financial model is sensitive to change in demand from its members. A large gain in demand or a 10% loss in demand can make the model change from positive NPV to negative. The team has considered this, and while fluctuation is unpredictable, we consider it a safe assumption that the increase in efficiency which could lower demand will be balanced by increased electronics usage. The buildings are highly unlikely to be expanded (vertical is the only option.) Given that there is a very high density population with occupancy rates at near 100 percent throughout the year, we consider that there is little downside risk of demand falling and possible upside potential.

The total list of sensitivity studies run is:

- Members Electric Rate (\$/kWh)
- Growth in Members Elec Rate
- Rev / Exp Growth Rate Diff.
- Annual Term Loan Int. Rate
- NPV Discount Rate
- Annual Gas demand in MMBTU
- Microgrid Capacity

⁸ <http://www.pvsyst.com/en/>

- Demand from Members

One of the best ways to strengthen the business case is to add rate payers who currently pay retail rates for electricity. However, this is difficult in a neighborhood heavily populated with NYCHA properties. Additional school campuses may provide an opportunity for growth.

The team also intends to investigate cash flow available from potentially using the system as a battery storage resource to arbitrage peak demand hours.

The team also needs to further study the steam rates being paid by each of the entities housing CHP, and to collect data on the winter demand on an hourly basis. We believe, but have rate that VET pays for steam is about \$2.50/therm, and likely NYCHA pays a much lower rate.⁹ A more detailed analysis of revenues available from steam and hot water sales is a top priority in the next phase. We have evaluated the lowest steam rate that maintains a positive NPV and it is roughly \$0.40/therm.

For this report we are assuming that we will merit the NY Prize competition award.

3.5.2 ANALYSIS OF FINANCIAL VIABILITY

Categories of revenue streams and/or savings flowing to the microgrid owner are as follows:

1. ConEd buy back of excess energy (discussed below.)
2. Net metering – we may be able to participate in “virtual net metering” such as community shared solar, if such a program is presented to and approved by the NYPSC through the REV or a different proceeding.
3. Power purchase agreements and sales of power to co-op members - *Beyond The Grid* is pursuing long-term, fixed rate power purchase agreements with the New York City Housing Authority and others and will sell power to co-op members.
4. As to other incentives and the timing of those incentives with respect to the development and deployment of this project, there are several financing sources that may be applicable to the project, either to finance the project as a whole or for one of the three project portions requiring financing: electric generating facilities; energy efficiency upgrades; and distribution systems and interconnection systems with the grid.

⁹ Referencing SC 3 http://www.coned.com/documents/steam/Tariff_LeavesSCs.pdf

- a. New York Green Bank funding could be a significant potential source of financing for the microgrid. Green Bank support may be available for on-site generation from solar, microturbines, and combined heat and power as well as for load reduction and energy efficiency projects. The Green Bank can serve as a lender (senior, mezzanine or subordinated), provide credit enhancements or provide a “warehouse” credit facility as bridge or interim financing during the period where long term financing from private sector sources is obtained. This type of financing requires financial participation by at least one other private sector financial party (debt or equity investment).
- b. Department of Energy loan guarantees - The Department of Energy’s (“DOE”) Loan Programs Office (“LPO”) administers the loan guarantee program authorized by Title XVII of the Energy Policy Act of 2005, as amended, 42 U.S.C. §§16511-16516 (“Title XVII”). Title XVII addresses the capital constraints associated with innovative technologies in order to accelerate the domestic deployment of such innovative energy technology. In August 2015, LPO issued a supplement to its Loan Guarantee Solicitation Announcement relating to Federal Loan Guarantees for Renewable Energy and Energy Efficiency Projects, Solicitation Number: DE-SOL-0007154 (the “Solicitation”) to make clear that Distributed Energy Projects may qualify for the program. DOE may issue loan guarantees to support the financing of an aggregation of such installations and facilities, permitting the borrower to access financing under a single arrangement for the multiple installations of the applicable facilities. DOE will be evaluating if the proposed Distributed Energy Project is based upon a master business plan, necessary to the viability of the Project. The loan guarantees may be available for “[d]ecentralized power or thermal energy generation projects that incorporate new or significantly improved technology at a scale smaller than traditional utility-scale projects that increase efficiency and minimize losses associated with transmission and distribution by being located at the point of consumption,” including renewable energy combined with storage and cogeneration and/or combined heat and power. Given the scale of the microgrid project, we would need to determine, as a threshold matter, the costs to apply for the DOE loan guarantee application for a Distributed Energy Project.
- c. Clean Renewable Energy Bonds (CREBs) – This is a form of tax credit bond which provide qualified issuers and qualified borrowers the ability to borrow at 0% interest – interest is paid by the U.S. government in the form of federal tax credits instead of interest paid by the issuer (note – the tax credits are still considered taxable income to the bondholder). They must be issued by a “qualified issuer” and the project must be owned by a “qualified borrower” (the definition for both includes cooperative electric companies described in 501(c)(12)); 95% or more of the bond issuance proceeds must be used for capital expenditures for a “qualified project” (the definition includes solar generation facilities.)

- d. Energy Efficiency Upgrades - NYSERDA Participation Loan. NYSERDA partners with lenders across New York State to help small businesses and not-for-profits access low-interest financing for energy efficiency improvements. NYSERDA will provide 50% of the loan principal, up to \$50,000, at 2.0% interest, and another lender of the borrower's choice will provide the rest of the loan at market rate. Lenders can now offer energy efficiency financing at a below market rate to small businesses and not-for-profits statewide.
- e. NYSERDA Funding - We believe the proposed microgrid will qualify for CHP credits and these are incorporated into the financial model both in year 1 and as a credit in year 2. The team is grateful for the feasibility study funding and intends to merit additional NY Prize funds.
- f. Empire State Development Corporation Economic Development Purposes Fund - Provides loans and grants for economic development assistance for businesses in New York State including infrastructure investment and economic growth investment.
- Infrastructure Investment: Designed to attract or expand business fostering further investment via developing or expanding basic systems and facilities, including energy generation and distribution. Infrastructure Investment projects that provide job commitments are viewed favorably.
 - Economic Growth Investment: Designed to foster economic growth through cultural activity, higher education activity, regional revolving loan and grant programs, other local or regional initiatives, agribusiness initiatives, marketing activities, training or education programs, or technical assistance that may not have direct job creation goals. May cover expenses such as acquisition of equipment, new construction, planning and feasibility studies and working capital.

As to the categories and relative magnitudes of the capital and operating costs that will be incurred by the microgrid owner, and whether they will be fixed or variable, to supplement the electricity generated on site the project will take energy from the grid subject to ConEd's Standby Service (Service Classification No. 14-RA). Standby Service provides a rate structure applicable to multiple dwelling customers for redistribution, including a contract demand charge and usage rates structured by time of day and season.¹² In addition, any actual interconnection costs will be required to be paid to ConEd in advance.

Microgrid technologies offer significant promise for value creation but require careful balancing of functional capability with benefit monetization opportunity and operating risk. It is important that this microgrid project will be implemented in a market with wholesale energy trading, abundant low-cost fuel (natural gas), and a regulatory environment that is expected to facilitate utility ownership of microgrids or utility and third-party partnerships with large, consistent and islandable loads. Microgrids are promising platforms for piloting grid modernization

technologies, and although additional technical features may increase microgrid value they also increase complexity, risk, cost, and the need for extensive testing.

Financial viability has been shown both by SRR financial modeling and Lockheed Martin’s financial analysis. The combination of both models is provided in the table below.

Table T3-2 provides a summary of the business case spreadsheet.
 NPV is positive

	2017	2018	2019	2020	~	2035
Total Revenue	\$2,547,909	\$2,624,362	\$2,703,130	\$2,784,723	~	\$4,339,013
Total Operating Costs	\$1,616,691	\$1,614,142	\$1,649,006	\$1,684,569	~	\$2,362,078
% of Total Revenue	63%	62%	61%	60%		54%
Estimated Operating Income	\$931,218	\$1,010,221	\$1,054,124	\$1,100,154	~	\$1,976,935
% of Total Revenue	37%	38%	39%	40%		46%
Debt Repayment						
Principal Repayment (net of credits)	\$365,644	\$383,926	\$498,722	\$295,674		\$460,650
Interest Expense	\$604,518	\$586,236	\$471,439	\$238,346		\$73,370
Net Cash Flow	\$ (38,943)	\$40,059	\$83,963	\$566,134	~	\$1,442,915
Present Value Factor	0.9667	0.9035	0.8444	0.7891	~	0.2860
Present Value of Net Cash Flow	\$ (37,648)	\$36,193	\$70,897	\$446,762	~	\$412,706
Total Net Present Value	\$7,005,605					

That this microgrid is located in New York City is important as there is concentrated demand which is “vertical” (unique to cities) and very low transmission losses. Our system will be high efficiency and the average daytime population will be roughly half of nighttime population.

3.5.3 FINANCING OPTIONS

Financing options include low-interest loans, commercial bonds, and vendor financing.¹⁰

Banks and progressive philanthropies are being studied as sources for low interest loans. The Department of Energy Loan Guarantee Program has bolstered investment in clean energy projects by guaranteeing loans made by investors. This program is especially targeted toward utility-scale development; as utility construction is highly capital intensive. Additionally, the

¹⁰ If a Property Assessed Clean Energy (PACE) program is initiated in Manhattan, this would offer a financial benefit to certain co-op members. PACE is not an option for this project at the time of writing. For more information: energy.gov/eere/slsc/property-assessed-clean-energy-programs

American Recovery and Reinvestment Act of 2009 provided a business energy investment tax credit (ITC) for utilities and solar farm developers. The ITC provides a tax credit equal to 30.0% of construction costs to utilities, which has stimulated demand for utility-scale solar farms. We will explore investments by charitable organizations.

Although the payback for commercial bonds may be problematic, future expansion of the microgrid may be useful in obtaining such bonds. Social equity investors such as Encourage Capital and Goldman Sachs Social Impact Fund run by IFF.¹¹ Finally, our close relationships with companies such as Urban Green Energy, Princeton Power, and Capstone may be useful in obtain financing.

3.5.4 ENERGY ARBITRAGE AND SALES BACK TO THE GRID

The general concept is to take low cost energy and offset more expensive energy. We plan to minimize demand charges (which can account for more than 50% of an electricity bill) and shift loads from peak to off peak rates using battery storage for energy generated during off-peak times.

Net deliveries of electricity into the local distribution system will be compensated under ConEd's Buy-Back Service (Service Classification No. 11). ConEd pays the monthly average of the real-time locational based marginal prices (LBMP) set by NYISO for New York City (Zone J), plus a 6.6% premium because deliveries will be into ConEd's "secondary distribution" system [Confirm interconnection will be at 120V-480V range]. If there are hours in which deliveries to the grid exceed 1MW, an increased rate benefit applies, as do obligations to prospectively schedule generation with ConEd. ConEd will also pay for the capacity it purchases monthly, based on the price of installed capacity for NYISO Zone J.

Future short-term expansion of our project will model expansion of the microgrid to include these adjacent properties likely requires nominal additional investment. We expect this will reinforce the business case.

3.6 LEGAL VIABILITY

Conceptually, Beyond the Grid's business model (a non-profit electrical cooperative) is inspired by America's thousands of rural electric cooperatives created in response to

¹¹ <http://www.iff.org/> IFF is a mission-driven lender, real estate consultant and developer that helps communities thrive by creating opportunities for low-income communities and people with disabilities.

President Franklin D. Roosevelt's Rural Electrification Act of 1936.

As in the rural model, Beyond The Grid's microgrid serves its member/ratepayers, and participates in power exports to the distribution network.

In practicality, the key project ownership structure will be incorporation as a membership cooperative corporation under the New York Cooperative Corporations Law.



Certain requirements for corporate governance and reporting must be met. In order to comply with those requirements, the membership of the organization would be comprised of individual ratepayers and community organization leaders. *Beyond The Grid* has already entered into agreements with, and received letters-of-project-support from, each owner of the buildings proposed to be part of the microgrid, ensuring access to the proposed sites.

The project will seek federal tax exempt status under Internal Revenue Code (IRC) section 501(c)(12), which permits exemptions for “mutual or electric cooperative companies” or like organizations which return excess revenues to the membership on a pro-rata basis. The project will comply with income, distribution, record keeping, and governance requirements to maintain federal tax exempt status.

As a provider of electric service to submetered residential and commercial customers, the project must comply with state consumer protection and privacy laws. The Home Energy Fair Practices Act provides residential customers with significant protections with respect to collection of past due utility charges and termination of electric service. PSC regulations cap submetered electric charges at the rate that the utility would have otherwise charged for the same service and provide that submetered customers can use the PSC's customer complaint procedures to resolve disagreements over charges for electric service. The project will implement business practices which balance the need for aggregated and individual consumer usage data with privacy concerns and potential new privacy regulations, the scope of which is not yet certain since the issue is currently being considered by the PSC.

The generation proposed as part of the project should qualify as a “co-generation facility” under state law (NYPSL § 2) and as QFs under PURPA and regulations implemented by the Federal Energy Regulatory Commission (18 C.F.R. § Part 292). The project will therefore have the right to sell energy and capacity to ConEd at rates equivalent to ConEd's avoided costs, and will be exempt from various state and federal regulatory burdens applicable to electric utilities and electric corporations.

As part of the REV, the PSC is encouraging the development of microgrids, and has specifically solicited and received comprehensive public feedback on the appropriate regulatory framework to facilitate and incentivize microgrid development.

The *Beyond The Grid* project would unquestionably advance the PSC’s stated policy goals and attributes guiding REV’s microgrid initiative. For example, the project will expand controllable and efficient generating capacity in a congested area while empowering customers with resilient and renewable energy sources.



#REV4NY

Comments in the REV proceeding from a variety of stakeholders overwhelmingly see microgrids as part of New York’s future, and the *Beyond The Grid* project fits squarely within that vision.

It is uncertain at this time whether the PSC will order comprehensive reforms to create a new state regulatory framework for community microgrids or minor clarifications to affirm how community microgrids fit into existing regulations and exemptions. In any event, no unique characteristics of the *Beyond The Grid* project present any particular regulatory hurdles beyond the general industry-wide uncertainty about precisely how the PSC will regulate microgrids under REV.

It is possible that REV will result in tangible benefits for the project, such as reduced interconnection costs, more favorable Standby Service rates,¹² and clear access to public rights-of-way for distribution conduits internal to the microgrid. REV should also provide clear guidance for the project’s operation and how it can ensure compliance with existing state and local laws and regulations (including those governing energy service companies, community choice aggregators, public utilities, and use of public space.)

Beyond The Grid does not anticipate any localized regulatory hurdles to the project since the City of New York filed comments in the REV proceeding strongly supporting reforms to further encourage microgrid development. ConEd is also supportive of community microgrids provided that it would retain ownership and control of the electric distribution and interconnection facilities and serve as the Distributed System Platform Provider (a class of entities proposed under REV.)

¹² For a discussion of *Beyond the Grid*’s specific plans regarding standby rate minimization, see Task 2 section 2.2.4 Thermal Load Served By Microgrid.

We are amenable to an arrangement where ConEd would play such central roles, particularly given the close proximity of the East Village microgrid to a major ConEd substation. We hope that a change in the building code or a waiver would allow the project to use state of the art equipment, especially for energy storage.

Air permitting could also be an issue for the project. We will need to keep track of the issues that arise from DER being bundled with the rest of the microgrid to be other than a “minor source.”

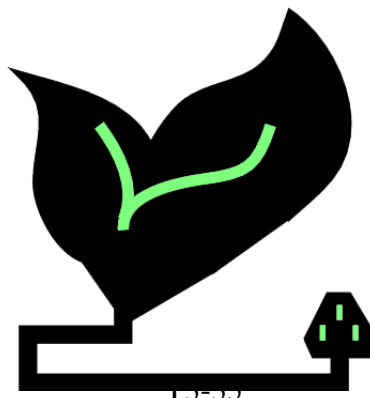
Access to public rights-of-way could be an issue for the project because *Beyond The Grid* will need to connect its various buildings with wires crossing below public streets and connect to ConEd. Absent any regulatory reforms to facilitate microgrid access to public rights-of-way for distribution wires, *Beyond The Grid* will need to either turn over ownership and control of its public wires to ConEd or obtain a franchise or consent from the New York City Department of Transportation to cross public rights-of-way.

3.7 TASK 3 SUMMARY

This feasibility study shows a solid community value proposition, a solid social proposition (more on this is Task 4) and eager stakeholders. *Beyond The Grid* will “move the needle” on community engagement and well as resiliency thereby fundamentally augmenting the security of an otherwise vulnerable community.

The SWOT analysis points to a need for more advisers for the team and the participation of a developer, at the same time the upside potential of this expandable grid is, theoretically, as large as Manhattan itself. Talks are currently underway to expand the proposal to neighboring buildings.

The team is experienced, capable and has a deep bench of talent. Furthermore, the business case is viable, as described in section 3.5 Financial Viability. The legal case study shows that the proposed Urban Energy Cooperative business model is both viable and compelling.



BENEFIT COST ANALYSIS

BENEFIT-COST ANALYSIS SUMMARY REPORT

Site 20 – Two Bridges (Manhattan)

PROJECT OVERVIEW

As part of NYSERDA’s NY Prize community microgrid competition, a project team led by Two Bridges Neighborhood Council has proposed development of a microgrid that would enhance the resiliency of electric service for residents in lower Manhattan. The Two Bridges/Beyond the Grid Community Microgrid would serve a mix of residential, educational, and commercial sites along Avenue C between East 10th Street and East 14th Street in the East Village. This area is prone to extended outages and was heavily affected by flooding with electric and steam heat outages following Superstorm Sandy.¹ The microgrid would have multiple owners of power generation units and serve the following facilities:

- Campos Plaza I and II, four buildings offering nearly 500 affordable housing units managed by NYCHA and L+M Development Partners.
- A community center associated with Campos Plaza;
- The East Village Towers (buildings F through I), 439 privately owned, moderate-income, cooperative housing units;
- A building housing three alternative public schools, including The East Village Community School with 289 elementary students; the Children’s Workshop School with 255 elementary students; and the Spectrum School which teaches students who are on the autism spectrum and at an elementary educational level.²
- A commercial strip housing a supermarket, pharmacy, and other businesses.

The microgrid would incorporate an array of natural gas combined heat and power (CHP) units, complemented by solar and battery storage capabilities. A total of 11 CHP units would be distributed as follows:

- Six 200 kW CHP units would be located at Campos II; and
- Five CHP units would be located at East Village Towers, including one 200 kW unit and four 65 kW units.

¹ Data from EIA.gov lists 14 major power disturbances between 1999 and 2012 totaling 45 days without power; based on review of data provided at https://www.eia.gov/electricity/data/disturbance/disturb_events_archive.html.

² NYC Department of Education, 2014-15 School Quality Snapshot/ES, East Village Community School, accessed at http://schools.nyc.gov/OA/SchoolReports/2014-15/School_Quality_Snapshot_2015_EMS_M315.pdf.

Solar PV resources with a total nameplate capacity of 0.332 MW would be distributed to the Campos Plaza, Village East Tower, and East Village Community School facilities. Battery storage (location to be determined) would allow storage of intermittent solar generation. The operating scenario submitted by the project’s consultants indicates that the CHP and solar resources would produce approximately 13,400 MWh of electricity per year, roughly 1.14 times the amount required to meet the average annual demand of the participating facilities. Finally, two 0.65 MW natural gas backup generators located at Campos Plaza would provide supplementary power during major power outages. To assist with completion of the project’s NY Prize Stage 1 feasibility study, IEC conducted a screening-level analysis of the project’s potential costs and benefits. This report describes the results of that analysis, which is based on the methodology outlined below.

METHODOLOGY AND ASSUMPTIONS

In discussing the economic viability of microgrids, a common understanding of the basic concepts of benefit-cost analysis is essential. Chief among these are the following:

- *Costs* represent the value of resources consumed (or benefits forgone) in the production of a good or service.
- *Benefits* are impacts that have value to a firm, a household, or society in general.
- *Net benefits* are the difference between a project’s benefits and costs.
- Both costs and benefits must be measured relative to a common *baseline* - for a microgrid, the “without project” scenario - that describes the conditions that would prevail absent a project’s development. The BCA considers only those costs and benefits that are *incremental* to the baseline.

This analysis relies on an Excel-based spreadsheet model developed for NYSERDA to analyze the costs and benefits of developing microgrids in New York State. The model evaluates the economic viability of a microgrid based on the user’s specification of project costs, the project’s design and operating characteristics, and the facilities and services the project is designed to support. The model analyzes a discrete operating scenario specified by the user; it does not identify an optimal project design or operating strategy.

The BCA model is structured to analyze a project’s costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.³ It also calculates an annualized estimate of costs and benefits based on the anticipated

³ The seven percent discount rate is consistent with the U.S. Office of Management and Budget’s current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission’s (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent

engineering lifespan of the system’s equipment. Once a project’s cumulative benefits and costs have been adjusted to present values, the model calculates both the project’s net benefits and the ratio of project benefits to project costs. The model also calculates the project’s internal rate of return, which indicates the discount rate at which the project’s costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

With respect to public expenditures, the model’s purpose is to ensure that decisions to invest resources in a particular project are cost-effective; i.e., that the benefits of the investment to society will exceed its costs. Accordingly, the model examines impacts from the perspective of society as a whole and does not identify the distribution of costs and benefits among individual stakeholders (e.g., customers, utilities). When facing a choice among investments in multiple projects, the “societal cost test” guides the decision toward the investment that produces the greatest net benefit.

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.⁴

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project’s costs would exceed its benefits. In order for the project’s benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 5.2 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

discount rate, to value CO₂ emissions. As the PSC notes, “The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects.” The model also uses EPA’s temporal projections of social damage values for SO₂, NO_x, and PM_{2.5}, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

⁴ The New York State Department of Public Service (DPS) requires utilities delivering electricity in New York State to collect and regularly submit information regarding electric service interruptions. The reporting system specifies 10 cause categories: major storms; tree contacts; overloads; operating errors; equipment failures; accidents; prearranged interruptions; customers equipment; lightning; and unknown (there are an additional seven cause codes used exclusively for Consolidated Edison’s underground network system). Reliability metrics can be calculated in two ways: including all outages, which indicates the actual experience of a utility’s customers; and excluding outages caused by major storms, which is more indicative of the frequency and duration of outages within the utility’s control. In estimating the reliability benefits of a microgrid, the BCA employs metrics that exclude outages caused by major storms. The BCA classifies outages caused by major storms or other events beyond a utility’s control as “major power outages,” and evaluates the benefits of avoiding such outages separately.

Table 1. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 5.2 DAYS/YEAR
Net Benefits - Present Value	-\$15,500,000	\$272,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-12.9%	5.8%

Scenario 1

Figure 1 and Table 2 present the detailed results of the Scenario 1 analysis.

Figure 1. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

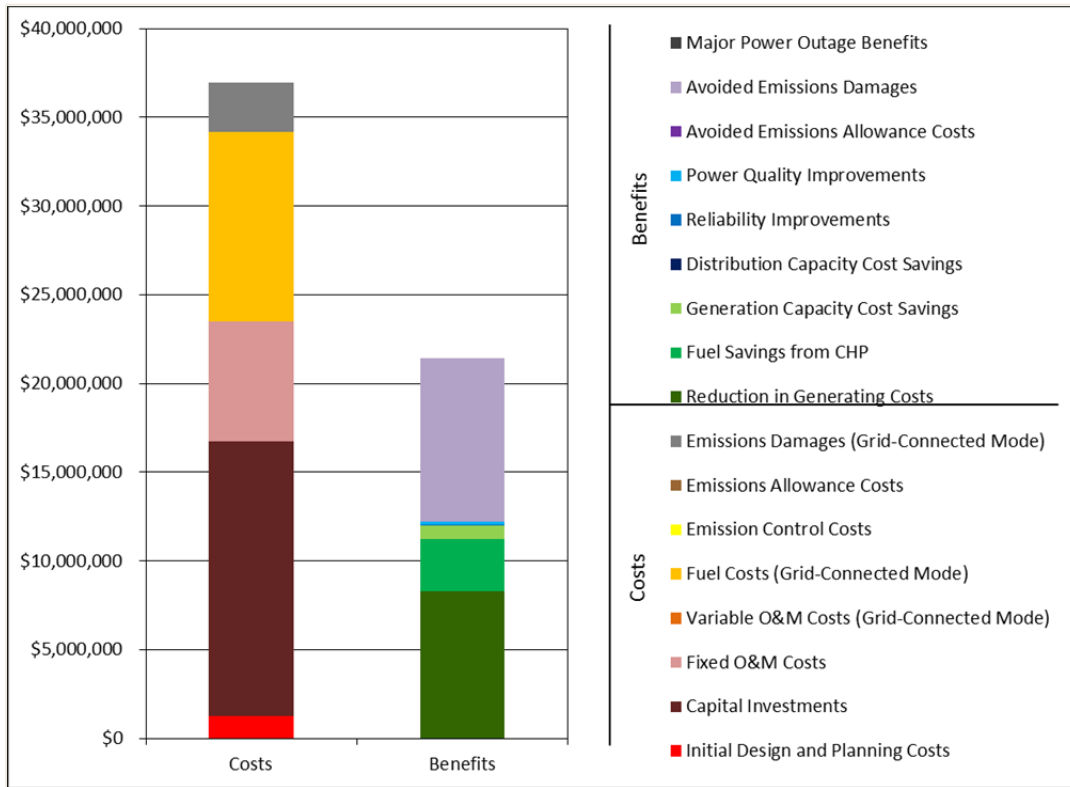


Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
Costs		
Initial Design and Planning	\$1,260,000	\$112,000
Capital Investments	\$15,500,000	\$1,320,000
Fixed O&M	\$6,740,000	\$595,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$10,700,000	\$945,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$2,770,000	\$181,000
Total Costs	\$37,000,000	
Benefits		
Reduction in Generating Costs	\$8,290,000	\$731,000
Fuel Savings from CHP	\$2,940,000	\$259,000
Generation Capacity Cost Savings	\$776,000	\$68,400
Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$50,600	\$4,470
Power Quality Improvements	\$134,000	\$11,800
Avoided Emissions Allowance Costs	\$4,550	\$402
Avoided Emissions Damages	\$9,230,000	\$602,000
Major Power Outage Benefits	\$0	\$0
Total Benefits	\$21,400,000	
Net Benefits	-\$15,500,000	
Benefit/Cost Ratio	0.6	
Internal Rate of Return	-12.9%	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately \$1.3 million. The present value of the project's capital costs is estimated at approximately \$15.5 million, including costs associated with the new CHP units; PV systems; battery storage unit; and modifications to the distribution network. The present value of the microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at \$6.7 million, based on an annual cost of \$595,000.

Variable Costs

The BCA analysis also considers the project's variable costs, i.e., costs that are likely to vary with the amount of energy the microgrid produces. A significant variable cost associated with the proposed project is the cost of natural gas to fuel the CHP units. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.⁵ Based on these figures, the present value of the project's fuel costs over a 20-year operating period is estimated to be approximately \$10.7 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that the system would not be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's CHP units are estimated at approximately \$181,000 annually. The majority of these damages are attributable to the emission of CO₂. Over a 20-year operating period, the present value of emissions damages is estimated at approximately \$2.8 million.

The project team anticipates no other variable costs for the microgrid.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately \$8.3 million. Cost savings would also result from improvements in fuel efficiency provided by the new CHP system. The BCA estimates the present value of fuel savings over the 20-year operating period to be approximately \$2.9 million. The reduction in demand for electricity from bulk energy suppliers and for heating fuel would also curtail emissions of CO₂, SO₂, NO_x, and particulate matter from these sources, yielding emissions allowance cost savings with a present value of approximately \$4,500 and avoided emissions damages with a present value of approximately \$9.2 million.⁶

⁵ The model adjusts the State Energy Plan's natural gas and diesel price projections using fuel-specific multipliers calculated based on the average commercial natural gas price in New York State in October 2015 (the most recent month for which data were available) and the average West Texas Intermediate price of crude oil in 2015, as reported by the Energy Information Administration. The model applies the same price multiplier in each year of the analysis.

⁶ Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model values emissions of CO₂ using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency (EPA). [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.] Because emissions of SO₂ and NO_x from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid’s energy generation or distribution capacity.⁷ The project team estimates the capacity available for the provision of peak load support to be approximately 0.466 MW per year, based on estimates of output from the new CHP systems, photovoltaic arrays, and battery during system peak.⁸ Based on these figures, the BCA estimates the present value of the project’s generating capacity benefits to be approximately \$776,000 over a 20-year operating period.

The project’s consultants do not anticipate that the microgrid will enable utilities to avoid the cost of expanding or improving the local distribution network.⁹ However, the project would entail a substantial investment in new distribution infrastructure. Specifically, the project team indicates that the microgrid would “not be permitted to utilize existing distribution lines. New manholes and trenching will be required...New lines will need to be installed, including associated Inverters.” These investments may yield benefits beyond what is accounted for in this analysis, e.g., easy expansion of the microgrid service to nearby properties.

The project team has indicated that the proposed microgrid would be designed to provide reactive power support to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO’s requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the markets for ancillary services are highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing such services.

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers’ susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately \$4,470 per year, with a present value of \$50,600 over a 20-year operating period. This estimate was developed using the U.S. Department of Energy’s Interruption Cost Estimate

⁷ Impacts on transmission capacity are implicitly incorporated into the model’s estimates of avoided generation costs and generation capacity cost savings. As estimated by NYISO, generation costs and generating capacity costs vary by location to reflect costs imposed by location-specific transmission constraints.

⁸ The project team originally credited the full nameplate capacity of the solar resources in providing peak load support. The analysis assumes that these resources would be available 15 percent of the time; this assumption is consistent with the project team’s estimate of solar availability over the course of the year.

⁹ Impacts to transmission capacity are implicitly incorporated into the model’s estimates of avoided generation costs and generation capacity cost savings. As estimated by NYISO, generation costs and generating capacity costs vary by location to reflect costs imposed by location-specific transmission constraints.

(ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:¹⁰

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.¹¹

The estimate takes into account the number of residential and small or large commercial or industrial customers the project would serve; the distribution of commercial or industrial customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the current absence of backup generation among the customers.

It is important to note that the analysis of reliability benefits assumes that development of a microgrid would insulate the facilities the project would serve from outages of the type captured in SAIFI and CAIDI values. The distribution network within the microgrid is unlikely to be wholly invulnerable to such interruptions in service. All else equal, this assumption will lead the BCA to overstate the reliability benefits the project would provide.

On the other hand, the project consultants indicate that the analysis may understate the value of improved reliability. The microgrid will help insulate the vulnerable populations from minor outages, brownouts and surges. For instance, the Spectrum School will benefit from more consistent availability of air conditioning. Currently the school relies on old window units; with heat service from the new CHP units, the school would have the option to upgrade to central air-conditioning and ensure learning conditions that better serve the special needs of the students.

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. Specifically, the project team foresees two power quality events per year at all facilities. The model estimates the present value of this benefit to be approximately \$134,000 over a 20-year operating period.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.6; i.e., the estimate of project benefits is approximately 60 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

¹⁰ www.icecalculator.com.

¹¹ The analysis is based on reported 2014 SAIFI and CAIDI values for ConEdison.

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.^{12,13}

The proposed microgrid's location presents challenges to the use of backup power. Manhattan power lines are underground, and power outages are correlated with flooding events. As a result, use of backup generators in below-grade utility areas of the facilities is typically precluded for several days until flood waters recede. No backup generators currently exist at the participating facilities, and while rental generators might be used for a long-term outage, their feasibility is uncertain. Therefore, the project team recommends that the analysis of major power outages assume no backup generation at the facilities, all of which would lose 100 percent of their service capability.

The demographic features of the residential facilities also affect outage costs. The project's consultants describe both Campos Plaza and Village East Towers as "naturally occurring retirement communities," meaning that many residents are senior citizens (despite the fact that the buildings are not formally designated for seniors). The senior population is heavily dependent upon elevators for passage in and out of the buildings (the residential towers vary from 10 to 25 stories). Outage costs at the facilities include \$1,500 to evacuate vulnerable residents (e.g., those on respirators) and \$5,000 per day to house these at-risk residents. Furthermore, the proportion of elderly, at-risk residents is growing, so these costs may increase in future years.

To value power losses for the residential facilities, the analysis assumes that residents left without power incur social welfare losses. The project's consultants estimate that a total of 2,218 individuals live in the Campos Plaza and Village East buildings.

Specific information on the consequences of an outage for the commercial facilities is not available. In the absence of more detailed information, the analysis values a loss of service based

¹² The methodology used to estimate the value of lost services was developed by the Federal Emergency Management Agency (FEMA) for use in administering its Hazard Mitigation Grant Program. See: FEMA Benefit-Cost Analysis Re-Engineering (BCAR): Development of Standard Economic Values, Version 4.0. May 2011.

¹³ As with the analysis of reliability benefits, the analysis of major power outage benefits assumes that development of a microgrid would insulate the facilities the project would serve from all outages. The distribution network within the microgrid is unlikely to be wholly invulnerable to service interruptions. All else equal, this will lead the BCA to overstate the benefits the project would provide.

on estimates of the cost of a power interruption provided by the Department of Energy’s ICE Calculator. Table 3 summarizes the value of service estimates provided by the ICE Calculator.

Table 3. Value of Maintaining Service, Scenario 2

FACILITY	FACILITY SECTOR	ECONOMIC	VALUE PER DAY
Campos Community Center	Small Commercial industries	- All other	\$14,635
Commercial Strip	Large Commercial industries	- All other	\$160,552
East Village Community School	Large Commercial industries	- All other	\$91,307

Based on these values and the other assumptions outlined above, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the facilities of interest is approximately \$270,000 per day. The net impact of the uncertainties is unclear. On the one hand, the benefits are the product of assuming no backup generation and a full loss of services at all facilities. While this has been true historically, we may expect improvements to be made independent of this microgrid. In this sense, the approach may overstate the economic consequences of a major power outage, especially if the outage does not coincide with flooding (meaning that use of rented backup generation is feasible).

On the other hand, the cost of evacuating and housing the building residents will likely increase over time as the population ages. In addition, Village East Towers houses a police telecommunications repeater, which increases the coverage and clarity of police and other emergency communications. Loss of power at Village East eliminates this service and may have implications for the reliability and promptness of emergency services. These considerations are not explicitly addressed, suggesting that the analysis may understate the benefits of a microgrid.

Summary

Figure 2 and Table 4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 5.2 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 5.2 Days/Year; 7 Percent Discount Rate)

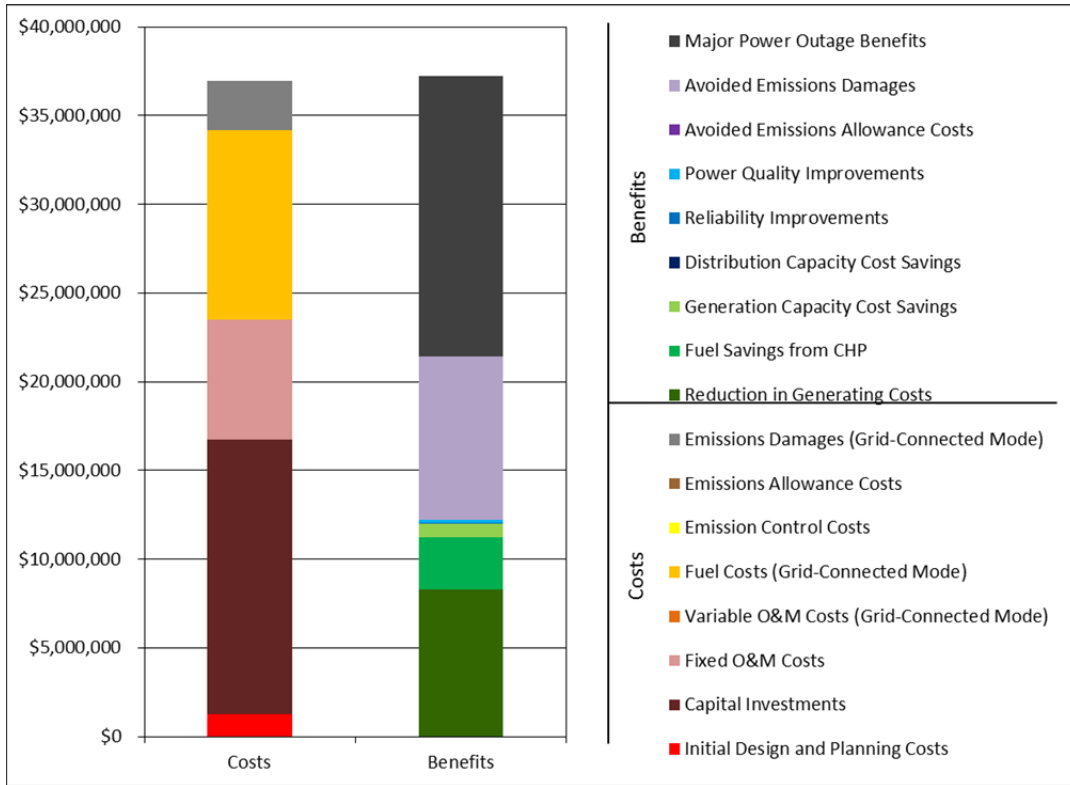


Table 4. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 5.2 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
Costs		
Initial Design and Planning	\$1,260,000	\$112,000
Capital Investments	\$15,500,000	\$1,320,000
Fixed O&M	\$6,740,000	\$595,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$10,700,000	\$945,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$2,770,000	\$181,000
Total Costs	\$37,000,000	
Benefits		
Reduction in Generating Costs	\$8,290,000	\$731,000
Fuel Savings from CHP	\$2,940,000	\$259,000
Generation Capacity Cost Savings	\$776,000	\$68,400
Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$50,600	\$4,470
Power Quality Improvements	\$134,000	\$11,800
Avoided Emissions Allowance Costs	\$4,550	\$402
Avoided Emissions Damages	\$9,230,000	\$602,000
Major Power Outage Benefits	\$15,800,000	\$1,400,000
Total Benefits	\$37,200,000	
Net Benefits	\$272,000	
Benefit/Cost Ratio	1.0	
Internal Rate of Return	5.8%	

TASK 4 ADDENDUM BY BEYOND THE GRID

4.3 CONCLUSION

Beyond the Grid's NYSERDA NY Prize stage 1 feasibility study focuses on a pilot area in Superstorm Sandy impacted East Village in downtown Manhattan. The site is located adjacent to the generating plant whose salt-water-flooded transformers exploded, cutting power and heat from 39th street to the Seaport. (See photo T5-1) Housed among the thousands of neighboring residents are vulnerable populations in high-rise homes, a public school building and critical facilities including a community center, a supermarket and a pharmacy.

Though Sandy was the most severe of area's recorded grid outages (10 days), it is by no means the only severe outage. Since 1999, eight (8) incidents have led to power loss for a day or more. The total number of federally-tracked major disruptions is 14. Task 3, section 3.2.5 provides details. Not surprisingly, local residents also complain of minor disruptions as well. Hence the community support for the grid.

Calculating the average number of days/year of outages over time, the team found that the historical data is quite close to the BCA average, even without taking into account the urban-based circumstances listed in Task 5. See Figure T4-3 below.

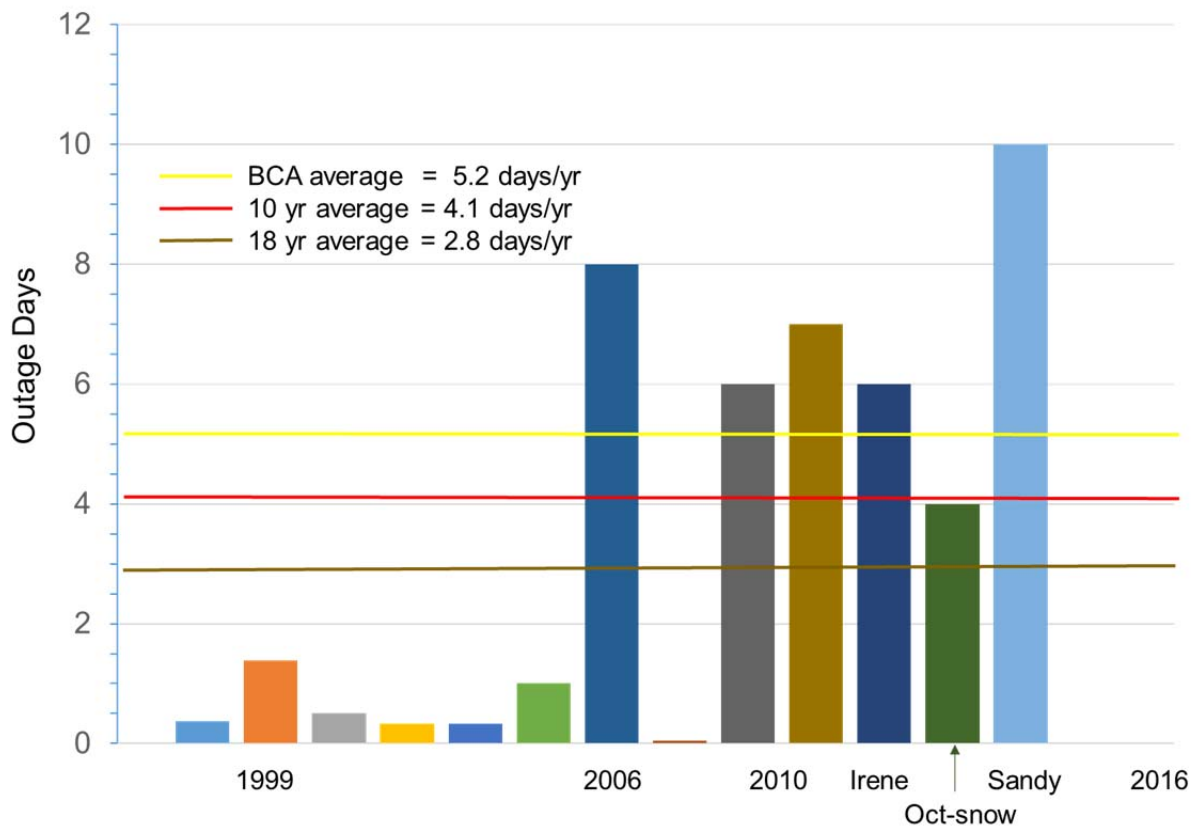


Figure T4-3 Outages (in days) in the East Village
 During the time that federal records have been kept

More concerning to the team and the local residents, is the trend occurring over time: more storms with longer duration of outages. The area is fortunate that only minor disturbances have occurred from 2013 – 2016. However, no one thinks we have seen the last of major weather incidents effecting the grid.

We are fortunate to have the technology and means to finance, build, and operate an exemplary community microgrid. The design outlined in this report can produce a microgrid capable of selling electricity, hot water, chilled air (summer), pre-chilled air for commercial refrigeration, steam (winter) and energy storage. Gas-fired microturbines and solar arrays will produce just over 2 MW of electricity while also charging 4 MW-hours of battery storage. As documented in Task 2, the microgrid can serve 100% peak load of residents and facilities in both grid-connected and islanded mode. It can be built at a cost of about \$15 million dollars with a net present value (NPV) of \$7M.

Beyond the Grid's business model (a non-profit electrical cooperative) is inspired by the eighty (80) years of success of the non-profit rural electrical cooperative. Beyond the Grid strives to establish the model for the Urban Electrical Cooperative, along with becoming largest incubator of cleantech in the state. Our expandable, replicable business model allows us to become NYSERDA's gem.

Our technical design incorporates the integration of proven technologies, methods, and best practices that will produce reliability, scalability, efficiency, and high availability. It starts with its own 208V power loop within submersible armored conduits running under the streets that link together and the buildings served and generating/storage sources they house. A second 13.8 kV loop connects at 4 points to Con Edison lines through automated switchgear and bi-directional bulk metering. Solar and gas-fired microturbines will be Qualifying Facility under the PURPA Act thus allowing the microgrid to buy and sell to Con Edison.

Admittedly a rural electrical cooperative, on which our model is based, is able to receive low interest loans from the US Department of Agriculture; we cannot. Fortunately, our research has discovered many similar financing mechanisms and we intend to become the first of many urban electrical cooperatives. We believe that once New York can show that the model works, it will become a model for other cities.

The barriers to developing the microgrid are all surmountable. For example: Microgrid-owned electricity transmission lines must cross the public right of way. We will need REV to make this possible. Tasks 2 and 3 consider this issue from various perspectives.

The microgrid, by providing 100% of peak load to its members substantially reduces demand on existing utility-owned transmission lines. Its ability to operate in island mode for extended periods obviates social costs associated with typical power outages during emergencies, including emergency services, health costs, insurance losses, loss of life, loss of business.

Benefits provided by an operating microgrid in the *Beyond the Grid* study area are not fully captured in the benefit cost analysis. City-specific impacts not factored-in are listed in Task 5. A cut to the chase: having lights, working elevators, heat, hot/cold water, communications, along with supermarket and pharmacy (both accepting EBT) during times that otherwise would be a blackout provides stability, safety, and ensures quality of life. Without the microgrid episodic climactic events will cause crises with casualties, losses and high costs. The East Village is determined not to repeat the past.

We look forward to continued involvement with the NY Prize program.

Signed,

Beyond the Grid Team

