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Report – Task 5

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Task 5 Draft Report – Staten Island East Shore Microgrid

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Executive Summary

This Report was prepared under Stage I of the NY Prize program. NY Prize is a part of a statewide endeavor to modernize New York State's electric grid, spurring innovation and community partnerships with utilities, local governments, and the private sector. Its mission is to enable the technological, operational, and business models that will help communities reduce costs, promote clean energy, and build reliability and resiliency into the grid. This report summarizes the Stage I feasibility analysis of the proposed Staten Island East Shore Community/Healthcare Microgrid (MG), a project that would create a 'Community Grid' centered on the Staten Island University Hospital (SIUH) – North Campus as the key node of a microgrid network. This project is referred to herein, in abbreviated form, as the "East Shore Microgrid". It would link to other community facilities, including critical facilities (as defined by FEMA and NY Prize) and facilities that serve vulnerable populations. The study, sponsored by the Staten Island University Hospital (part of the Northwell health system), has been performed by an experienced group of companies, including Anbaric Microgrid, Louis Berger and Sega. Anbaric is an experienced developer of energy infrastructure projects and brings a manufacturer-agnostic and third-party investment viewpoint to the analysis. Louis Berger and Sega are experienced planning and engineering organizations that are well suited to performing the conceptual configuration, cost estimating and performance analysis of the microgrid components (sources, loads and connecting infrastructure and controls).

The SIUH North Campus, although located in a high risk zone, remained operational during Superstorm Sandy, due to its elevation. Additionally, it is furnished with an independent power facility consisting of a Combined Heat and Power (CHP) plant with a dual fuel (diesel/natural gas) power backup system. As part of a FEMA funding program, which limits scope to "replacement-in-kind", the facility is projected to implement major resiliency upgrades including construction of replacement emergency generator facilities at higher elevations and energy efficiency measures. The proposed microgrid project would expand the anticipated power supply (which are primarily focused only on life-safety preservation emergency power) with additional capacity (including renewables) and configuration upgrades to create a microgrid that can operate additional services for an extended period and serve nearby critical facilities and community.

The East Shore Microgrid would fit within an overall approach to a South Shore microgrid network developed on a conceptual basis and selected by the local community and stakeholders as a "Proposed Project" as part of the post-Sandy Community Reconstruction Plan under the New York Rising Program for Staten Island. Additionally, the area is designated as a "microgrid opportunity area" as defined by Con Edison, which indicates a strong interest by the utility for such a development because it would help solve challenges on an aged distribution grid.

The team has developed an equipment layout diagram and a one-line diagram of the proposed MG, including location of the distributed energy resources (DER), thermal generation resources (TER) and utility interconnection points. This diagram is included as Appendix B, drawing SLD-01.

The peak MG demand is approximately 14.1 MW , subject to further review of coincident loads that may be identified during design. This MG concept assumes that all essential and non-essential loads, including loads during peak demand periods, will be served by new DER's and solar units regardless of islanded or normal grid-connected mode.

The MG average demand has been estimated at approximately 7.7 MW, with minimum loads occurring in winter months with an estimated aggregated total of approximately 5.5 MW. The annual average energy consumption is estimated at approximately 70 million kWh.

ConEd's existing distribution infrastructure in the MG area will require that a combination of both non-critical and critical loads be served, as adequate switching and infrastructure topography is not available to be precisely selective on load shedding . Based on information provided by ConEd for the Seaside Substation, the non-critical load is expected to be approximately 3.5 MW average and 6 MW peak, comprising just below half of the projected peak load of the microgrid.

In case of islanded operation, the MG would be sized to serve all electrical demand of connected facilities. Demand reduction measures may be considered to disconnect non-essential loads in the event that equipment could not reliably serve all loads . It should be noted, however, that the hospital would both be served by the microgrid as a critical facility and it would also retain its required emergency generators which would provide critical and life safety power as a further redundancy.

The proposed Microgrid provides four main value propositions. First and foremost, it would provide resiliency to the southeast shore area of Staten Island by supplying power locally through distributed resources directly to the electrical distribution system in that area. This area is particularly vulnerable to frequent power interruption and extended outages due to extreme weather conditions (including storm flooding activity as was evidenced during the Superstorm Sandy flooding). In contrast to other parts of the Con Edison network, this area is served by radial feeders from Con Edison, with limited network redundancy, as feeder disruption cannot be compensated for by supply from other feeders and substations on the network. As such, improvements in electrical supply and load shedding capability would create benefits for the community as a whole. This includes continued operation of a wide range of critical facilities and other users, including hospitals, wastewater treatment facilities, multifamily housing, including those for vulnerable populations, police stations, traffic signals, as well as a significant portion of the area's commercial corridor, including gas stations, pharmacies and small businesses.

The second value proposition would be the generation of baseload power and thermal energy to the South Beach Psychiatric Center and to the Staten Island University Hospital. The use of state-of-the-art efficient engine-generator sets would allow for cost-effective and lower emission energy and heat relative to current configurations.

The anticipated near-term CHP thermal load is relatively low, however, thus the CHP component of this Microgrid is not as significant as the proposed simple-cycle generation for peak power support and resiliency. As such, a third value proposition derived from the Microgrid would be generation capacity available for peak load support. During peak power periods, where wholesale purchases of electricity are high, Con Edison could dispatch energy from these resources to provide grid load relief (assuming peak load constraints exist) and to provide potentially lower cost power to its customers.

The fourth identified value proposition is the ability to better integrate renewable energy resources into the local distribution feeders by balancing them with dispatchable resources. Several opportunities exist for solar power, including potential future expansion and /or reconfiguration of the campuses of both SIUH and SBPC (including parking) as well as nearby facilities such as the Staten Island Ocean Breeze Track & Field Athletic Complex, a new nearby City facility connected to the MG that has extensive roof opportunities for solar.

While the project offers strong social benefits, the current avenues for revenues pose challenges to its realization. The main issue affecting financial viability is the recovery of capital investment for the capacity resources developed. It is envisioned that the appropriate avenues for this remuneration would be through the local utility (Con Edison) for the improvements made to a vulnerable part of their grid and the NYISO for capacity supplied to its market in Zone J.

1 Project Description

Staten Island (and in particular the East and South shores) are characterized by the following vulnerabilities:

- Island condition: Limited internal and external infrastructure connectivity: roads, transit, power, telecom
- Highly dependent on vehicular transportation

Superstorm Sandy, which had a devastating impact on Staten Island, resulted in a wide range of emergency conditions, often long-lasting, including the following:

- Power: widespread, extended outage
- Telecom: widespread, extended outage
- Roadway network: outage (roads flooded initially and traffic signals not working for extended periods), including evacuation routes
- Business corridors and centers: outage, lasting post-flooding
- Critical facilities (hospitals, fire stations, police stations, schools, elderly housing): Out of service or compromised due to flooding, lack of access or power disruption.

This project proposes to create a resilient microgrid comprised of nodes and links that provides backup capacity for critical infrastructure systems and functions during and after emergency conditions. The proposed microgrid also increases reliability, efficiency, sustainability and economy of such systems during regular conditions.

This project would create a microgrid network centered on the SIUH North Campus, as the key node of a microgrid and possibly a future network of microgrids. Widespread power outages following Superstorm Sandy dismantled the communications network, among other impacts, and elucidated the need for a reliable, independent power supply network as well as a dependable method for communications and transportation during disaster response.

As described in the NYRCR Action Plan for Staten Island, this project is one of several Proposed Projects for CDBG-DR Funding. Such funding could be used to construct above-ground utility lines among critical and community facilities, including those that serve socially vulnerable populations, while power generation could be established by third parties.

The microgrid would link to other community facilities. This study is evaluating the potential to include: the South Beach Psychiatric Center, the NYC DEP Mason Avenue and South Beach Pump Stations, Public Schools 52, 46 and 11, the NYC Department of Parks and Recreation's Elevated Track and Field Facility, NYCHA's South Beach and Berry Houses / Senior Centers, FDNY Engine Company 159, the Hylan Boulevard Retail Corridor and the traffic signals along this key evacuation route, the Jefferson Avenue SIR station, the Parks Department's District 2 B maintenance center, , and Camel Richmond Healthcare and Rehabilitation Center. Other potential facilities can be connected, either through alternate routing of wires or future phases.

The SIUH North Campus, although located in a high risk zone, remained operational during Superstorm Sandy, due to its elevation and independent power supply, consisting of Combined Heat and Power (CHP) with a dual fuel (diesel/natural gas) power backup system. The facility is projected to implement major resiliency upgrades, under a separate program, including construction of replacement CHP capacity at higher elevations and energy efficiency measures. This proposed microgrid project would build upon the anticipated power and telecom resiliency upgrades, as well as potential additional capacity (including renewables, energy efficiency, and conservation) and configuration upgrades to create a microgrid that can serve nearby critical facilities. As part of future expansion it could also connect to other microgrids as they are completed (Staten Island Railway).

As part of the evaluation of microgrid distributed energy production and demand reduction resources, the project team has investigated the inclusion of various technologies, including:

- Cogeneration
- Solar Power
- Battery Storage
- Demand Response
- Integration of Building Management Systems
- Microgrid Controls
- Interconnection and Paralleling of Emergency Generators
- Power Electronics and Switchgear
- Sectionalizing of Utility Grid
- Substation Upgrades
- Dedicated Distribution Lines
- Software Platform for Economic and Reliability Dispatch Optimization

1.1 Microgrid Capabilities (Task 1)

A microgrid is an electricity distribution system comprised of distributed energy generation resources that are used to support critical loads within a defined area. A key feature of microgrids is ‘islanding’, the ability to separate from a central electricity grid if that power supply is interrupted. This feature can maintain power to critical facilities during extreme weather conditions or system emergencies, bringing power to individual customers when necessary.

Microgrids have become an increasingly adopted as a solution to the growing impacts of storms and transmission outages on electrical utility systems. By providing additional resiliency to the electricity grid, microgrids can benefit the local economy by reducing losses due to power outages and attract new businesses interested in clean, cost-effective and reliable energy system.

1.1.1 Minimum Required Capabilities (Task 1.1)

The proposed East Shore Microgrid is characterized by the following attributes, which meet the minimum required capabilities identified by NYSERDA in Task 1 Development of Microgrid Capabilities, Sub Task 1.1 Minimum Required Capabilities.

a. Critical Facilities: (Serves at least one but preferably more, physically separated critical facilities located on one (1) or more properties.)

The proposed microgrid is anchored by a critical facility; Staten Island University Hospital (SIUH). In addition, six critical facilities (as defined by NY Prize or FEMA) have been identified as part of our base microgrid and five critical facilities have been identified as potential future microgrid participants. All of these facilities are primarily located within a 0.5 mile straight-line radius of SIUH. These include schools, police departments, facilities of refuge, and fire stations (as identified by the NY Prize RFP). These critical facilities along with other potential microgrid participants have been identified in Table 1 and Figure 1 following.

Facility	Address	NY Prize Critical Facility (1)	Critical or Locally Significant (NY Rising)	Vulnerable Populations	Juridiction
Base Microgrid Participants					
Staten Island University Hospital North	**475 Seaview Avenue**	Yes	Critical (FEMA)	Yes	**SIUH**
South Beach Psychiatric Center	777 Seaview Avenue	Yes	Critical (FEMA)	Yes	DASNY
PS 52	450 Buel Avenue	Yes	Locally Significant	Yes	DCAS
Mason Avenue Pumping Station	494 Mason Avenue	Yes	Critical (FEMA)	No	NYC DEP
South Beach Pump Station	300 Father Capodano Blvd.	Yes	Critical (FEMA)	No	NYC DEP
Engine 159, Satellite 5 (FDNY)	1592 Richmond Road	Yes	Critical (FEMA)	No	FDNY
NYCHA Berry Houses / Community Center	1700 Richmond Road	No	Critical (FEMA)	Yes	NYCHA
Future Potential Microgrid Participants (Critical)					
NYCHA South Beach Houses / Community Center	150 Parkinson Avenue	No	Critical (FEMA)	Yes	NYCHA
PS 46	41 Reid Avenue	Yes	Locally Significant	Yes	DCAS
PS 11	50 Jefferson Street	Yes	Locally Significant	Yes	DCAS?
Mark Street Pump Station	29 Mark Street	Yes	Critical (FEMA)	No	NYC DEP
122 Precinct (NYPD)	2320 Hylan Blvd	Yes	Critical (FEMA)	No	NYPD
Future Potential Microgrid Participants (Non-Critical)					
Hylan Boulevard Retail Corridor (Seaview to --)		No	Locally Significant	No	Private
Traffic Signals on Evacuation Routes (Seaview to --)	12 Signals on Hylan Blvd	No	High Priority for NYC DOT	No	NYC DOT
Track & Field Facility (Parks)	625 Father Capodano Blvd.	No	High Priority for NY Parks	No	NYC Parks
Staten Island Railroad - Dongan Hills	Dongan Hills	No	Locally Significant	No	NYCT / MTA
Staten Island Railroad - Jefferson Avenue	Dongan Hills	No	Locally Significant	No	NYCT / MTA
District 2B Offices (Parks)	950 Father Capodano Blvd.	No	High Priority for NY Parks	No	NYC Parks

(1) NY Prize Critical facilities are identified in the NY Prize RFP as: Wastewater Treatment Plants, Hospitals, Universities, Facility of Refuge or Shelters, Schools (K-12), Police Departments, Libraries, Hospitals, Fire Stations

Table 1 – Potential Microgrid Participant Data

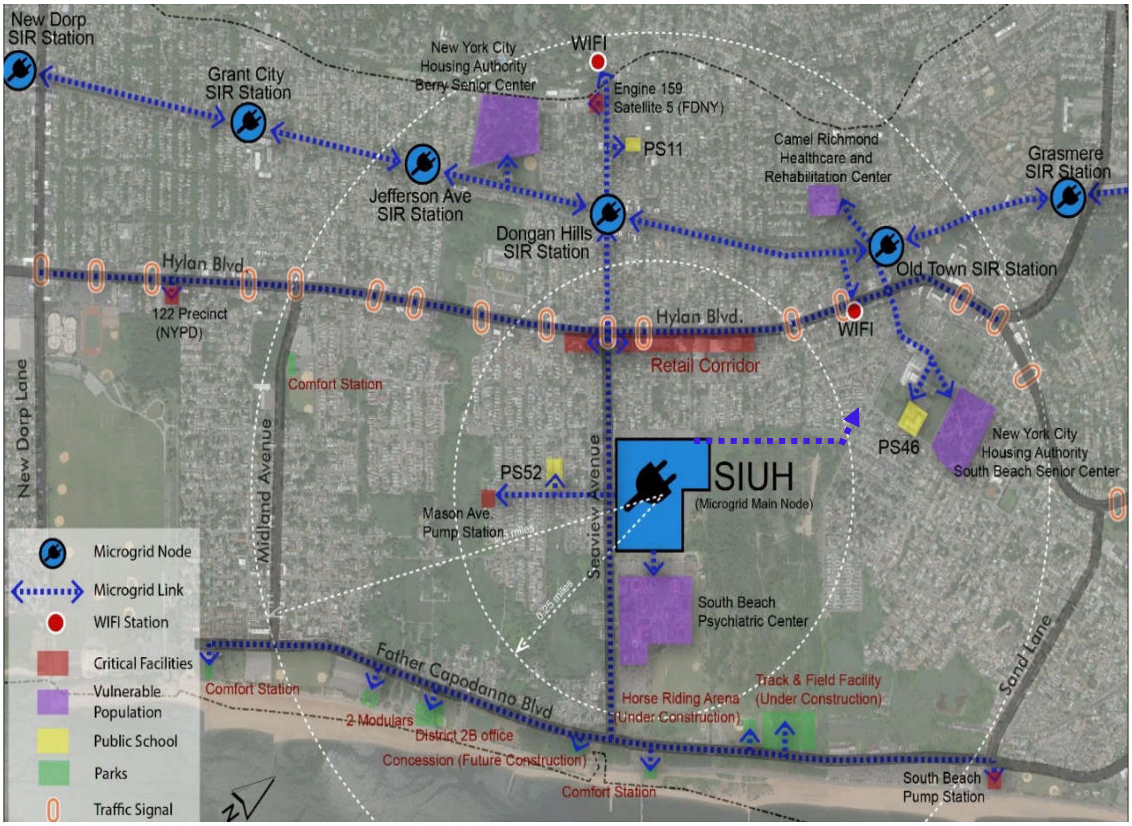


Figure 1 – Potential Microgrid Participant Layout

b. <u>Generation Sources:</u> *(The primary generation source capacity cannot be totally diesel-fueled generators.)*

The primary generation source capacity will utilize natural gas fuel and is anticipated to be locatedat the SIUH North Campus. Solar generation will also be used to supplement this gas-fired capacity. In addition, backup fuels will be investigated. The SIUH North Campus currently operates an independent power supply, consisting of a natural gas based Combined Heat and Power (CHP) with a dual fuel (diesel/natural gas) power backup system. SIUH and the South Beach Psychiatric Center also have a variety of standby and emergency generators that utilize diesel fuel. Generation and fuel diversity are key to improving the resiliency of the microgrid and reduce the risks of fuel supply shortages. As such, new generation and energy storage have been considered at various microgrid locations.

SIUH is currently implementing major resiliency upgrades, under a separate program, including relocation of backup generator facilities at higher elevations and energy efficiency measures. This proposed microgrid project would be implemented in consideration of these resiliency upgrades.

While Staten Island has lower solar radiation potential than many other parts of the country, the microgrid will utilize solar photovoltaic cells to supplement baseload electrical generation. Clean and modular generations sources, including fuel cells and microturbines, have been reviewed and will be considered for future microgrid phases. Opportunities for other generation sources will be considered. New innovative solutions will be considered, but within the context of their proven track records for reliability.

c. On-site Power: *(A combination of generation resources must provide on-site power in both grid-connected and islanded mode.)*

   Combined, the proposed generation resources would be able to provide on-site power in both grid-connected and islanded mode, and form an intentional island. As indicated above, various generation resources will be utilized at various strategic locations on the microgrid. SIUH currently operates in grid connected mode with 40% of SIUH power needs provided autonomously, and 60% provided though grid connectivity. In islanded mode SIUH can operate entirely on power generated by its own SIUH facilities. A similar operational model is plannedfor this new microgrid as a whole.

Control systems for switching between grid-connected and islanded mode will be developed so that, in the event of a power loss, the proposed microgrid is able to automatically separate from the grid and reestablish a grid connection after normal power is restored. It is envisioned that a system such as those offered by S&C and Schneider could be utilized for this task.

d. Islanded Mode: (Must be able to form an intentional island.)

   The East Shore Microgrid will have the ability to island and separate from the ConEd grid. Existing feeders have been identified on ConEd's 33 kV and 4 kV systems that can be used for electrical distribution to the microgrid in an islanded mode. New switches would allow for this separation. The microgrid operator will be able to coordinate with ConEd through integrated controls and protocols to ensure proper switching of the local grid to support islanding of the microgrid.

e. Power Flexibility: (Must be able to automatically separate from grid on loss of utility source and restore to grid after normal power is restored.)

Control of the proposed microgrid will be handled through microgrid controllers. The ability to automatically separate from the grid on loss of utility and restore after power is restored, is a feature offered by several microgrid controllers currently on the market. These controllers would be incorporated into the electrical distribution infrastructure at SIUH or other facilities, depending the final layout.

f. Maintenance: (Must comply with manufacturer's requirements for scheduled maintenance intervals for all generation; plan on intermittent renewable resources that will be utilized toward overall generation capacity only if paired with proper generation and/or energy storage that will allow 24 hrs per day and seven days per week utilization of the power produced by these resources.)

   The proposed resources will be designed for firm capacity support; intermittent resources would be used to shave peak loads and improve overall system variable costs where possible. Either dedicated microgrid staff or ConEd (through a services agreement) will maintain the distribution lines and components. The microgrid operator would maintain the generation resources. It is yet to be determined who would be the owner/operator of these sources.

g. Consistent Operation: *(Generation must be able to follow the load while maintaining the voltage and frequency when running parallel connected to grid. It also needs to follow system load and maintain system voltage within ANSI c84-1 standards when islanded.)*

Through the microgrid controllers selected, generation will be able to follow the load. The microgrid controllers will use real time load data to forecast the future load requirements. Depending on the specific controller selected, frequency control can be accomplished either within the microgrid controller capabilities, or left to the local controllers of the generation assets. The Voltage will be regulated within the controllers per the ANSI C84-1 standards.

h. Control and Communication: *(Include a means for two-way communication and control between the community microgrid owner/operator and the local distribution utility through automated, seamless integration. Include processes to secure control/communication systems from cyber-intrusions/disruptions and protect the privacy of sensitive data.)*

   A means of automated, integrated two-way communication and control between the proposed microgrid owner/operator and the local distribution utility is currently under development.

Processes used to secure the control/communications systems from cyber intrusions and disruptions shall be an inherent property of the microgrid controllers. The microgrid controllers shall also include privacy controls to protect information. The microgrid controllers procured shall be compliant with NERC CIP standards.

i. Diverse Customers: (Provide power to critical facilities and a diverse group of customers connected directly to the microgrid—diversity should apply to customer type (e.g. residential, small commercial, industrial, institutional, etc.) and overall demand and load profile.)

   The proposed microgrid will provide power to a diverse group of customers with a range of load conditions. The following list of proposed participants have been identified and include base and potential future microgrid participants.

Commercial	Hylan Boulevard Retail Corridor (Partial now with potential future build-out)
Residential	NYCHA Berry Housing Misc. 4 kV customers on 4 kV feeders 304, 306, and 307 *NYCHA South Beach Housing (Future)*
Community Services / Infrastructure	Staten Island University Hospital – North Campus South Beach Psychiatric Center NYC DEP Mason Avenue Pump Station NYC DEP South Beach Pump Station FDNY Engine Company 159 Public Schools 52 ***Future:*** *Public Schools 46 and 11* *NYC Dept. of Parks and Rec Track Facility* *Key Traffic Signals (Evacuation Routes)* *Camel Richmond Healthcare and Rehabilitation Center* *Jefferson Avenue SIR station* *Parks Department's District 2 B maintenance center*

j. Fuel Supply: *(Must include an uninterruptible fuel supply or minimum of one week of fuel supply on-site.)*

Uninterruptible gas supply availability and contracts are being investigated. Onsite diesel fuel storage will be assumed for emergency purposes. Backup fuel options and fuel tanks will be investigated as possible to allow for continued operations during gas outages. Energy storage including battery storage (and possibly thermal energy storage) may be used to reduce the peak demand for emergency scenarios with an interrupted fuel supply.

k. Resilient to Disruption: (Demonstrate that critical facilities and generation are resilient to the forces of nature that are typical to and pose the highest risk to the location/facilities in the community grid. Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time.)

Staten Island University Hospital North Campus and South Beach Psychiatric Center are planning and implementing major resiliency upgrades, under a separate program. This includes improvements to their electrical systems in consideration of site elevations. During Sandy, the flood waters surrounded the plant hospital property but the central plant remained operational. The backup generation at the South Beach Psychiatric Facility, among others, were flooded.

For this microgrid, FEMA flood plain maps and Sandy Tide Maps were reviewed to identify microgrid facility flooding vulnerabilities and identify areas of potential improved resiliency through use of hardened facilities (flood walls, higher elevations, etc). Additional resiliency improvements will be considered to improve the electrical distribution system (underground power lines, additional distribution equipment, etc.) The use of existing electrical distribution infrastructure limits the microgrid's distribution to a radial system. As possible, a looped distribution system will be considered for future microgrid phases to reduce single points of failure.

l. Black-start capability: *(Provide black-start capability.)*

Existing and potential new reciprocating engines will have black start capabilities. The existing reciprocating engines at SIUH and South Beach Psychiatric Center both have black start capabilities. Onsite fuel storage in combination with energy storage will be used in these emergency conditions.

1.1.2 Preferable Microgrid Capabilities (Task 1.2)

The proposed microgrid will also consider the following capabilities, which are identified by NYSERDA in Task 1 Development of Microgrid Capabilities, Sub Task 1.2 Preferable Microgrid Capabilities. They include features that integrate and demonstrate innovative technologies in electric system design and operations, and innovative measures that strengthen the surrounding power grid and increases the amount of actionable information available to customers.

a. Active Network Control: *(Include an active network control system that optimizes demand, supply and other network operation functions within the microgrid.)*

An integrated microgrid control system will be considered that would optimally dispatch microgrid components to ensure that demand would be met with the optimum mix of resources, including power from the central electricity grid.

As discussed in other sections, microgrid logic controllers currently available have the capability for load following and load shedding. These capabilities allow the controllers to optimize both supply and demand.

Through set points in the controllers, it is possible to integrate renewable DERs and energy storage with dispatchable DERs to optimize the supply and minimize the operational costs. As the load demands are monitored, the controllers may switch on and off specific loads to feed the most critical loads first, thus optimizing the demand of the microgrid.

Specific network microgrid logic controllers may also be obtained to monitor and control the specific network functions. These specific logic controllers are able to provide status information on the microgrid to utility connection switch. They also control the power flow to and from the utility grid and usually use power meters on each side of the connection.

b. Energy Efficiency: *(Include energy efficiency and other demand response options to minimize new microgrid generation requirements.)*

The microgrid logic controllers are equipped with multiple features to optimize energy efficiency. Through the logic controllers, the proposed microgrid will be able to maximize the use of renewable energy by selectively dispatching energy to meet the load demand. The controllers may also input real-time weather data to forecast renewable energy availability. It may also be possible to minimize distribution losses and maximize energy efficiency through Volt/VAR controls. Multiple options will be investigated and utilized to minimize new generation requirements.

b. Operations and Maintenance: *(Address installation, operations and maintenance, and communications for the electric system to which interconnection is planned.)*

See above.

c. Innovative Services: *(Coordinate with the Reforming the Energy Vision (REV) work to provide a platform for the delivery of innovative services to the end use customers.)*

Reforming the Energy Vision (REV) is an initiative by the state of New York to increase the availability of clean, resilient and affordable electric energy to the residents of New York. The initiative aims to increase opportunities for local power generation, enhanced reliability and energy savings. The proposed microgrid centered at the Staten Island University Hospital (SIUH) can meet all of these goals.

As discussed under task 1.1.2, the project team is investigating the inclusion of several technologies, including but not limited to:

- Combined Heat and Power
- Solar Power
- Battery Storage
- Demand Response
- Integration of Building Management Systems

- Microgrid Controls

These technologies, implemented at the SIUH campus and surrounding community facilities, will provide clean, locally generated power. With the proper utilization of the microgrid logic controllers and selection of DERs, energy savings may be achieved through efficient distribution of the generation.

d. Cost/Benefit Analysis: *(Take account of a comprehensive cost/benefit analysis that includes, but is not limited to, the community, utility and developer's perspective.)*

   A cost/benefit analysis is being performed as part of this effort to determine the appropriate selection of microgrid components.

e. Private Investment: *(Leverage private capital to the maximum extent possible as measured by total private investment in the project and the ratio of public to private dollars invested in the project.)*

   Anbaric Microgrid is working with SIUH on this proposal with the intent of ultimately arriving at a partnership and private investment opportunity.

f. Renewable Energy: *(Involve clean power supply sources that minimize environmental impacts, including local renewable resources, as measured by total percentage of community load covered by carbon-free energy generation.)*

   See above.

g. Community Benefit: *(Demonstrate tangible community benefits.)*

   The microgrid project is a community supported project. The benefits include:

   - ***Economic Benefits***: This project could create an estimated 65 full-time equivalent jobs. The installation of microgrids and other energy saving devices is expected to reduce the overall strain on the regional electrical network. In addition to storm-related power outages, this project is expected to have potential economic benefits such as reducing the impact of blackouts and brownouts, due to demand outpacing capacity. It would also enable critical facilities to function, potentially including two NYC DEP stormwater pumping stations, which in turn could reduce the costs of property damages associated with stormwater flooding. Through inclusion of a demand response program, which pays the electricity consumer to stand ready as a last line of defense to these rare but dangerous electric reliability crisis situations, an additional income stream is available to these customers. This type of project also aligns with the City's electrical power component of PlaNYC and OneNYC.

- ***Health and Social Benefits:*** The proposed project impacts the area centered on the North Campus of SIUH with a population of approximately 20,245. Health and Social Services assets secured by this project include the SIUH North Campus and South Beach Psychiatric Center, as well as Public School 52. Specific facilities that serve vulnerable populations would also be secured, including the NYCHA Berry housing. Resilience for vulnerable populations is also indirectly enhanced as critical facilities remain accessible post-disaster or disruption.

- ***Environmental Benefits:*** The project is expected to yield environmental benefits through the incorporation of renewable and efficient CHP generation and building energy management programs. Avoidance of disruption in wastewater treatment facilities may result in reduction of the risk of environmental impacts.

h. Customer Interaction: (Incorporate innovation that strengthens the surrounding power grid and increases the amount of actionable information available to customers—providing a platform for customers to be able to interact with the grid in ways that maximize its value.)

The microgrid would serve as a command and control platform by which customer-sited resources included demand reduction and generation could be coordinated and appropriately dispatched to meet emergency and normal operating mode needs.

2 Preliminary Technical Design Costs and Configuration

2.1 Proposed MG Infrastructure and Operations

The team has developed a simplified equipment layout diagram and a simplified one-line diagram of the proposed MG, including location of the distributed energy resources (DER) and utility interconnection points. This diagram is included as Appendix B, drawing SLD-01.

Normal Operations

To maximize the benefit to all MG participants, the MG will operate to provide power and thermal energy during normal conditions. This will reduce ConEd's load on the system by offsetting it through generation in DERs. DERs in a CHP configuration will provide thermal utilities to SIUH for periods of thermal demand. For these cases, the intent is to size the DER such that thermal generation at the full DER load will be consumed for greater than 50% of the year. For periods of low thermal load, the DER's may operate with a bypass stack for electrical generation only to allow for operational flexibility. This is particularly important for peak ambient temperature days when the electrical demand is high with a low thermal demand. Existing thermal generation resources will be used to backup CHP thermal generation, to produce thermal utilities during periods of bypass stack use, or to load follow.

MG generated electricity will supply the Seaside Substation and the SIUH substation. The Seaside Substation distributes 33 kV power to SBPC while providing 4 kV power to other microgrid participants. Reciprocating internal combustion engines ("RICE"), with waste heat recovery for CHP, as well as solar photovoltaic panels will be used for electrical generation. Battery storage systems may be used to store power for use at strategic times and to provide some additional short-term backup.

The MG will be monitored from a central point of control that utilizes a MG Control System (MCS) to remotely control, balance, and load all DER's. This MCS will be used to monitor and control production by generation equipment as well as deployment/storage for battery storage systems.

During normal conditions, the MG would be connected to the ConEd system to provide voltage support, satisfy electrical demand during periods when the grid may be experiencing a shortfall of generation or to support growth of the community. The MG would operate on the ConEd infrastructure. MG electrical generators would sell into the ConEd system.

Natural gas will be the primary fuel for generation assets, with backup available by using diesel and fuel oil. Battery storage may also provide backup for electrical demand for periods where fuel is not available. If fuel supply is lost, the system MCS in combination with operating procedures at each MG node will allow for transferring to a backup fuel source.

Emergency Operations

This project would include the addition of transfer switches in strategic locations such that, if ConEd loses power to their feeders, the transfer switches will open to isolate the MG from the rest of ConEd's system. Particularly, switches would be installed on the ConEd 33R15 feeder to isolate SIUH from the 33R15 supply, while still allowing a physical connection to the Seaside Substation at SBPC. A second switch would be installed on the 33R13 feeder, to isolate SIUH from the other ConEd loads on that supply also. A third switch would be installed at the Seaside Substation to isolate the ConEd 33R40 feeder from the MG. Transfer switches will isolate the MG, including its critical loads from the broader distribution network during this period only. In this case, all load balancing will occur through the MCS in cooperation with the operation of generation at MG participant locations.

Facilities that serve critical life safety loads will continue to maintain dedicated emergency generators to meet that need. These generators will not be connected to the MG and will be maintained and tested as normal.

2.2 Load Characterization

Electrical Loads

During the normal grid-connected mode, the peak electrical demand will be dictated by the sum of the individual peak loads of all MG participants. While these peaks are not expected to be coincident, the sum of all peaks will be used for planning. The peak load for all participants seems to coincide with the peak summer ambient conditions.

The peak MG demand is approximately 14.1 MW, subject to further review of coincident loads during design. This MG concept assumes that all essential and non-essential loads, including peak demand periods, will be served by new DER's and solar units regardless of islanded or normal grid-connected mode.

The MG average has been approximated as 7.7 MW, with minimum loads occurring in winter months with an approximate aggregated total of 5.5 MW. The annual average energy consumption is approximately 70 million kWh.

ConEd's distribution infrastructure in the MG area will require that a combination of non-critical and critical loads be served as adequate switching and infrastructure topography is not available to be precisely selective on load shedding. Based on information provided by ConEd for the Seaside Substation, the non-critical load is expected to be approximately 3.5 MW average and 6 MW peak.

In case of islanded operation, the MG would be sized to serve all electrical demand. Demand reduction measures may be considered to disconnect non-essential loads in the case that equipment could not reliably serve all loads.

Exhibit 2.2.1 following presents a "simulated" load duration curve that approximates the MG electrical demand over a sample year.

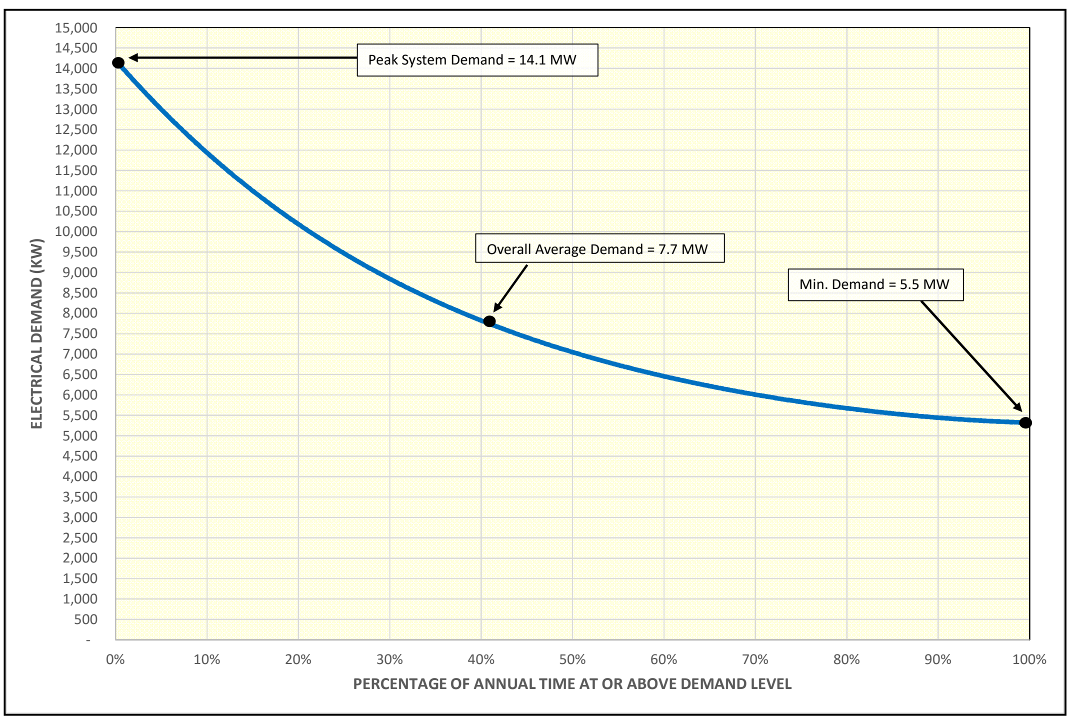


EXHIBIT 2.2.1 – SIMULATED MG ANNUAL ELECTRICAL LOAD-DURATION CURVE

Thermal Loads

Exhibit 2.2.2 following highlights the thermal distribution system attributes and approximated consumption for MG participants with central thermal generation systems.

Facility	Central Thermal System	Central Chilled Water System
Staten Island University Hospital (SIUH)	Hot Water Generation and Distribution System Annual Avg = 10 mmBtu/hr Peak = 21 mmBtu/hr Min = 3 mmBtu/hr	Electric Chillers
South Beach Psychiatric Center (SBPC)	Low Temperature Hot Water Generation and Distribution Annual Avg = 3.3 mmBtu/hr Peak = 10.7 mmBtu/hr Min < 1 mmBtu/hr	Electric Chillers
NYCHA Berry	Nominal 10 psig steam generation and distribution with condensate return Annual Avg = 9.8 mmBtu/hr Peak = 24 mmBtu/hr Min < 3 mmBtu/hr	None

EXHIBIT 2.2.2 – MG PARTICIPANT THERMAL GENERATION SYSTEMS SUMMARY

- Provide hourly load profile of the loads included in the MG and identify the source of the data. If hourly loads are not available, best alternative information shall be provided.

Electric and thermal load duration curves were approximated for each of the major MG participants. Hourly metering data was generally not available and monthly totals were used to extrapolate approximations for these curves.

SIUH

Monthly gas and electricity total consumption data was used to extrapolate LD curves based on 2014 data. Exhibit 2.2.3 presents the approximated annual electrical load duration curve. Exhibit 2.2.4 presents the approximated annual thermal load duration curve for the hot water system.

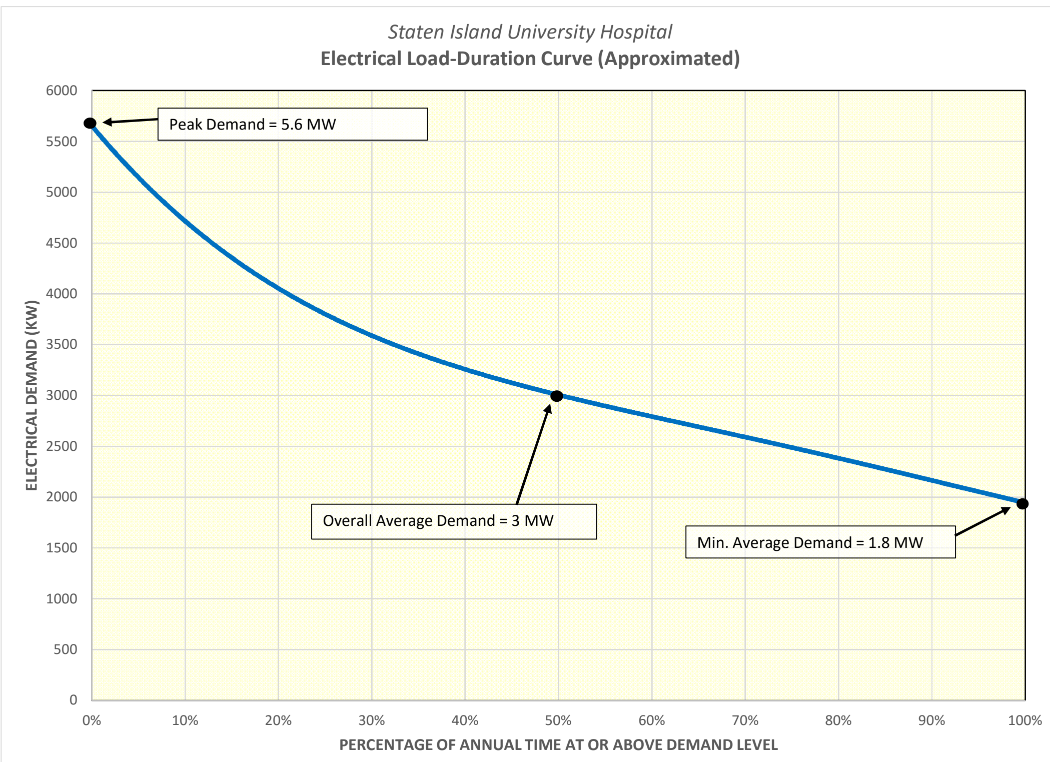


EXHIBIT 2.2.3 – APPROXIMATED SIUH ELECTRICAL LOAD-DURATION CURVE

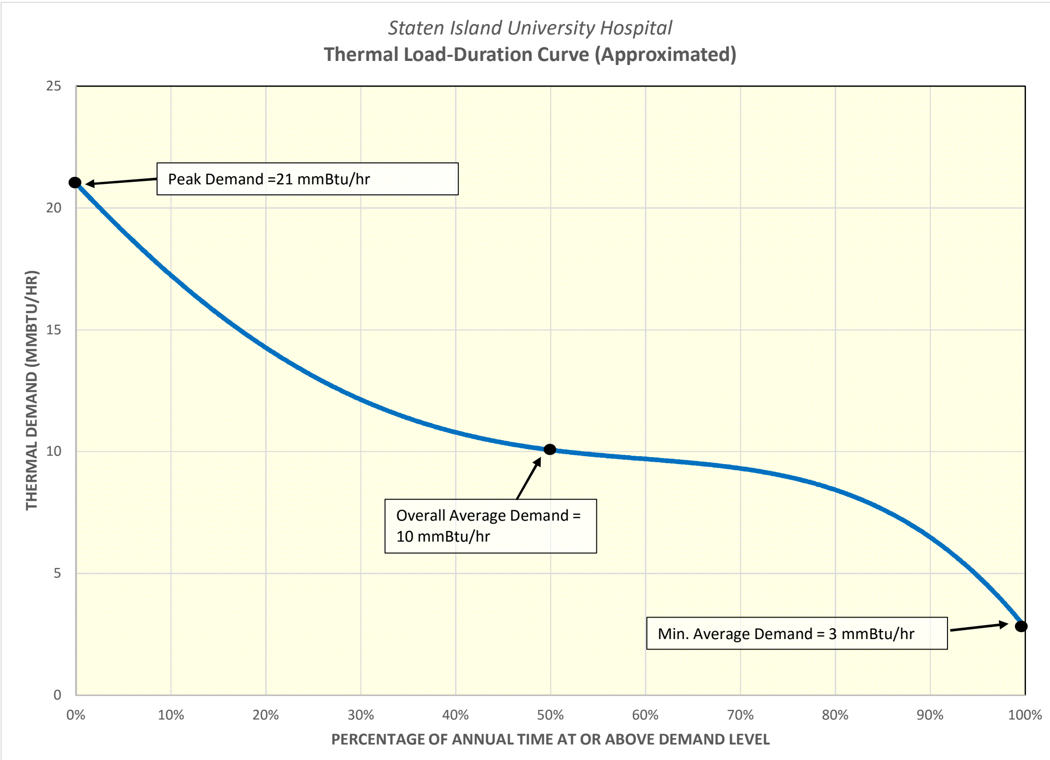


EXHIBIT 2.2.4 – APPROXIMATED SIUH THERMAL (HOT WATER) LOAD-DURATION CURVE

SBPC

Hourly load data was provided for electrical demand by SBPC between 2012 and 2015. Monthly gas data was provided and used to extrapolate the thermal LD curve. Exhibit 2.2.5 presents the approximated annual electrical load duration curve. Exhibit 2.2.6 presents the approximated annual thermal load duration curve for the hot water system.

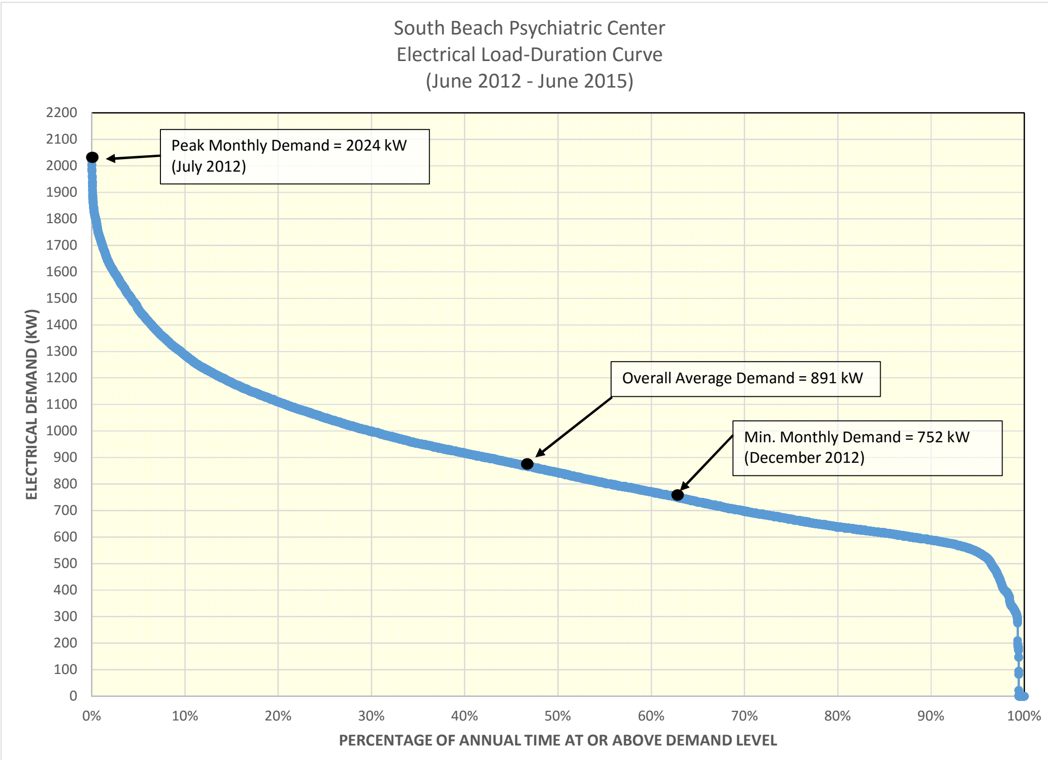


EXHIBIT 2.2.5 – SBPC ELECTRICAL LOAD-DURATION CURVE

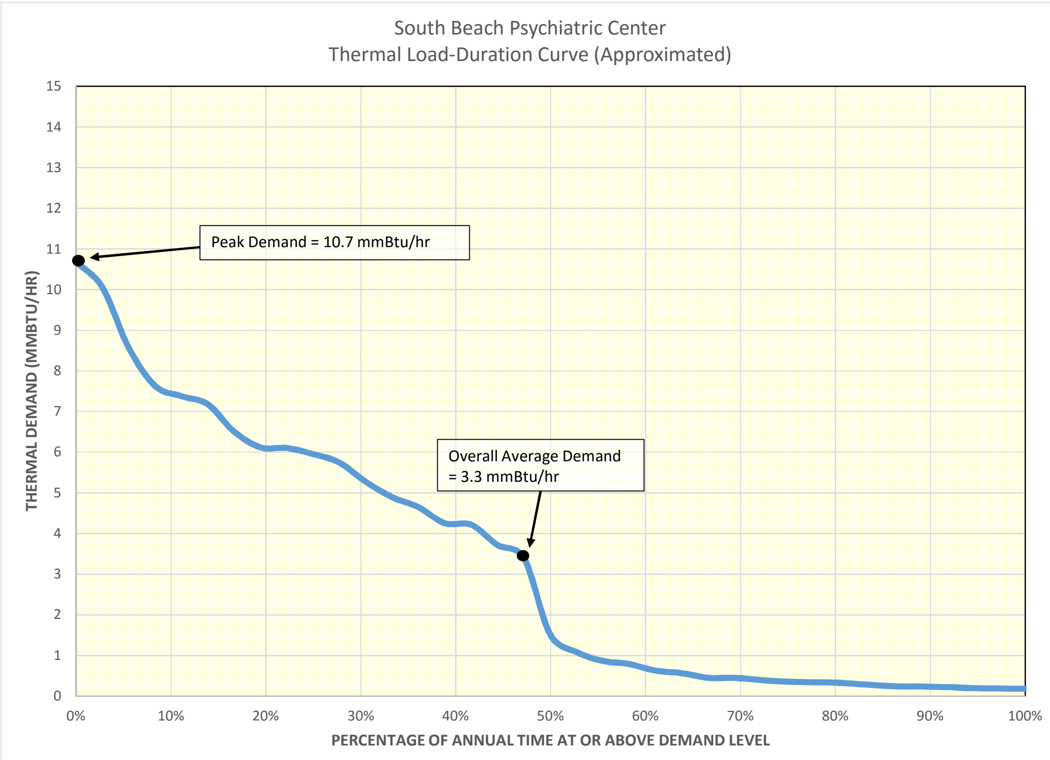


EXHIBIT 2.2.6 – APPROXIMATED SBPC THERMAL (HOT WATER) LOAD-DURATION CURVE

The approach described above is somewhat simplistic and conservative. In actuality, the SBPC facility may benefit from the installation of an absorption chiller which could take waste heat from the microgrid generator and utilize it to make chilled water, displacing the need to run electric centrifugal chillers. This would involve the installation of an absorption chiller in available space at the central utilities room and the installation of necessary controls and interconnecting piping.

NYCHA Berry

Monthly gas and electric bill data from 2012 to 2015 were provided and used to extrapolate the LD curves following. Exhibit 2.2.9 presents the approximated annual electrical load duration curve. Exhibit 2.2.10 presents the approximated annual thermal load duration curve for the low pressure steam system.

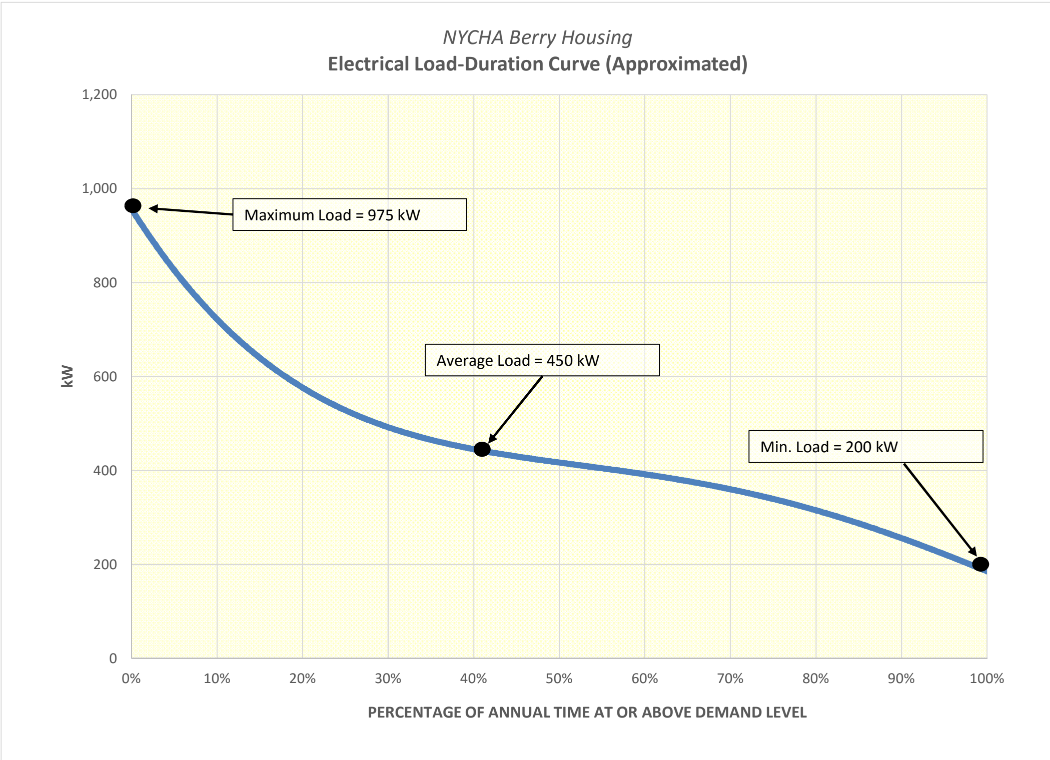


EXHIBIT 2.2.9 – NYCHA BERRY ELECTRICAL LOAD-DURATION CURVE

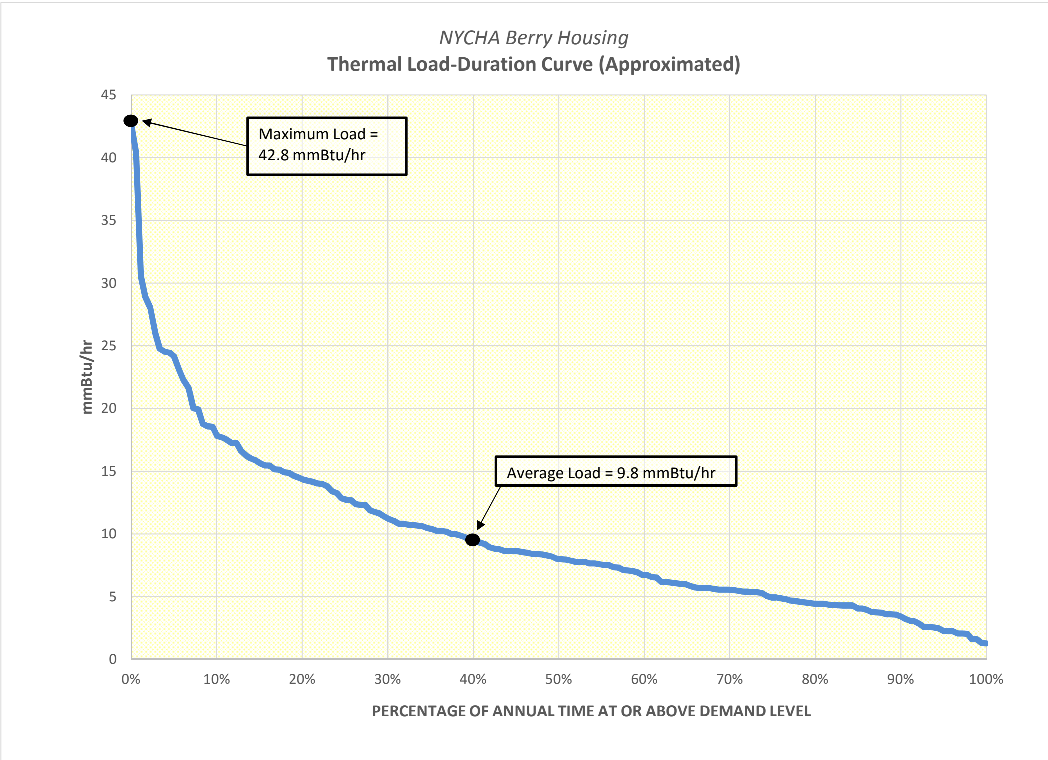


EXHIBIT 2.2.10 – APPROXIMATED NYCHA BERRY THERMAL LOAD-DURATION CURVE

- Provide a written description of the sizing of the loads to be served by the MG including a description of any redundancy opportunities (ex: n-1) to account for equipment downtime.

The MG will be designed to allow a minimum N+1 redundancy to meet critical electrical loads only. Demand reduction measures and/or extra generating capacity will be employed to ensure that redundancy measures are met. This MG concept assumes that resources are available to cover both essential and non-essential loads.

Extending the N-1 criteria to the electrical infrastructure poses a unique challenge. To minimize capital cost, the planned infrastructure for the MG is to use the existing ConEd overhead, radial system. As such, redundancy currently does not exist with the existing distribution system.

One way to add resiliency would be to create a looped overhead system. Through our investigation of the project site, there is currently not physical room on the distribution poles for additional feeders to create a looped system between all microgrid participants. Taller poles would be required, in addition to new overhead circuits. While providing distribution redundancy, a looped overhead solution would not address the resiliency needs to forces of nature.

The possibility of undergrounding the overhead system has been investigated by other parties and found to be a costly endeavor. Studies have been prepared for Staten Island specifically. Some of the challenges commonly encountered when planning underground circuits include: lack of available right-of-way, existing underground obstructions such as water, gas, and electric utilities, high water table and disruption to local businesses as traffic is diverted during construction. All of these factors impact the cost of constructing underground circuits. However, an underground circuit between SIUH and SBPC may be a viable option to increase resiliency due to their proximity and shared property line.

2.3 Distributed Energy Resources Characterization

Exhibit 2.3.1 following highlights the DER/TGR's for the MG facilities. New DER/TGR's were selected based on the ability to serve the annual demand of the MG as highlighted later within this review. Selections were also made based on CHP potential and the thermal generation characteristics at each facility.

Facility	Existing/Planned DER/TGR	New MG DER/TGR
SIUH	2,500 kW Reciprocating Engine (Gas primary, diesel) with Heat Recovery Emergency Only: 5,000 kW Reciprocating Engines (diesel) Three (3) Fire Tube Boilers (gas) Electric Chillers	Three (3) Nominal 4,400 kW Fuel Reciprocating Engines (one unit in CHP mode)
SBPC	Standby Only: 2,000 kW RICE (diesel) Emergency Only: Three (3) RICE - 350 kW, 400 kW, and 800 kW (No. 2 fuel oil)	200 kW Solar PV Battery Storage System

	Numerous hot water boilers and heaters at locations across campus	
NYCHA Berry	Three (3) Steam Boilers, each rated approx. 234-BHP - Gas/oil No Electrical Generation No Central Chiller Plant	50 kW Solar PV Battery Storage System
Other MG Facilities	None	50 kW Solar PV Battery Storage System
Note: This table highlights all electrical generation resources at each facility as well as central thermal plants. Building or room specific thermal generation resources have not been included.		

EXHIBIT 2.3.1 – DER AND TGR SUMMARY FOR MG FACILITIES

SIUH and SBPC are the most likely locations to install new DER's, with exception to deployment of solar units and battery storage units at key MG participants.

SIUH

The campus is relatively congested, particularly in consideration of an ongoing project to improve resiliency of the campus central generation systems by installing a new central plant building. Exhibit 2.3.2 following highlights the space and layout considerations of new DER/TGR units at SIUH. New equipment would likely be installed outside of this building in proximity to the electric utility feeds located on the northwest edge of the site, as indicated.

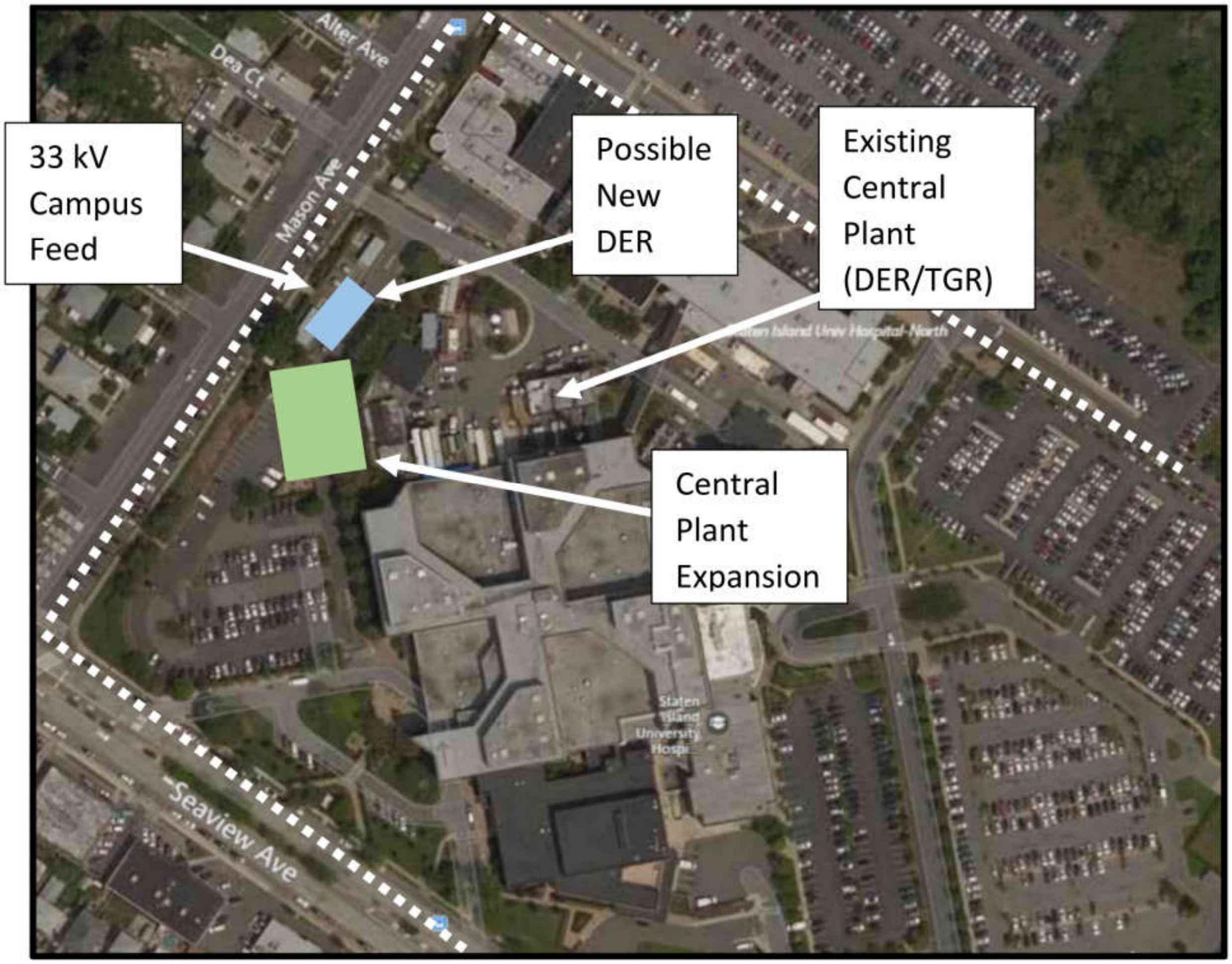


EXHIBIT 2.3.2 - SIUH LAYOUT (aerial photo courtesy of Bing Maps)

SBPC

Buildings 8, 9, and 17 currently share a common hot water distribution system. A new care center (Building 18) will be constructed in coming years and tied to the hot water distribution system. All other campus buildings have local TGR's. Exhibit 2.3.3 following highlights the layout of the campus and identifies space near the current 33 kV electrical feeds for new DER's. This campus is a potential candidate for MCS controls.

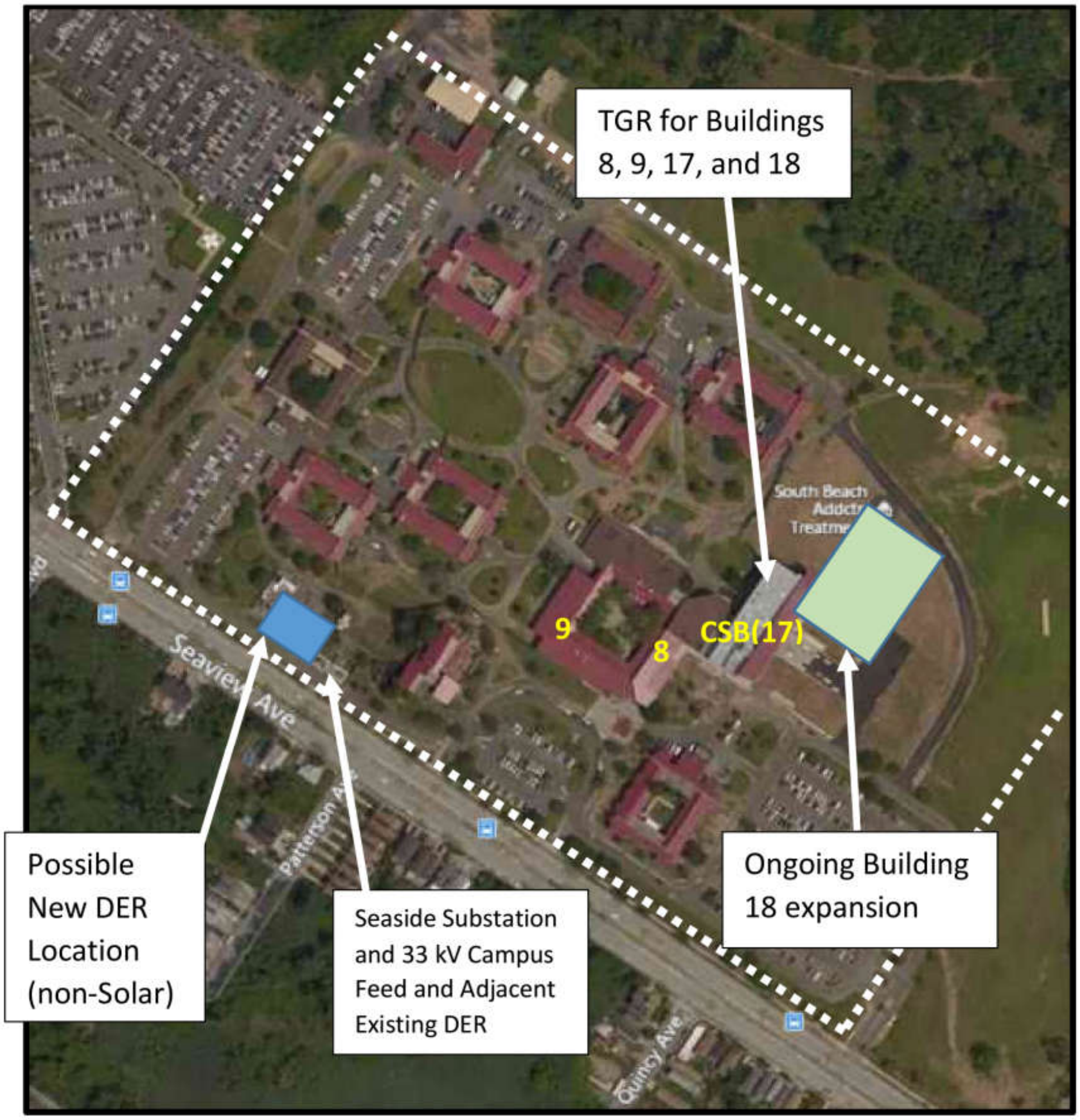


EXHIBIT 2.3.3 – SBPC LAYOUT (aerial photo courtesy of Bing Maps)

NYCHA Berry Housing

The NYCHA Berry Facility has a central point of utility interconnection on the northwest side of the property. From that point of interconnection, each building is fed through an individual transformer. The steam generation equipment is located in Building 1 at 1754 Richmond Road, which is adjacent to the utility connection point. Due to proximity of existing TGR's to the utility electrical feed, a new CHP could be considered for future MG DER/TGR additions and would logically be located on the north portion of the property as highlighted in Exhibit 2.3.5 following.

Alternately, the equipment could be located in Building 1 if older steam generation equipment was retired and demolished. An indoor location would not impact site common spaces and would increase the security and resiliency of the new plant.

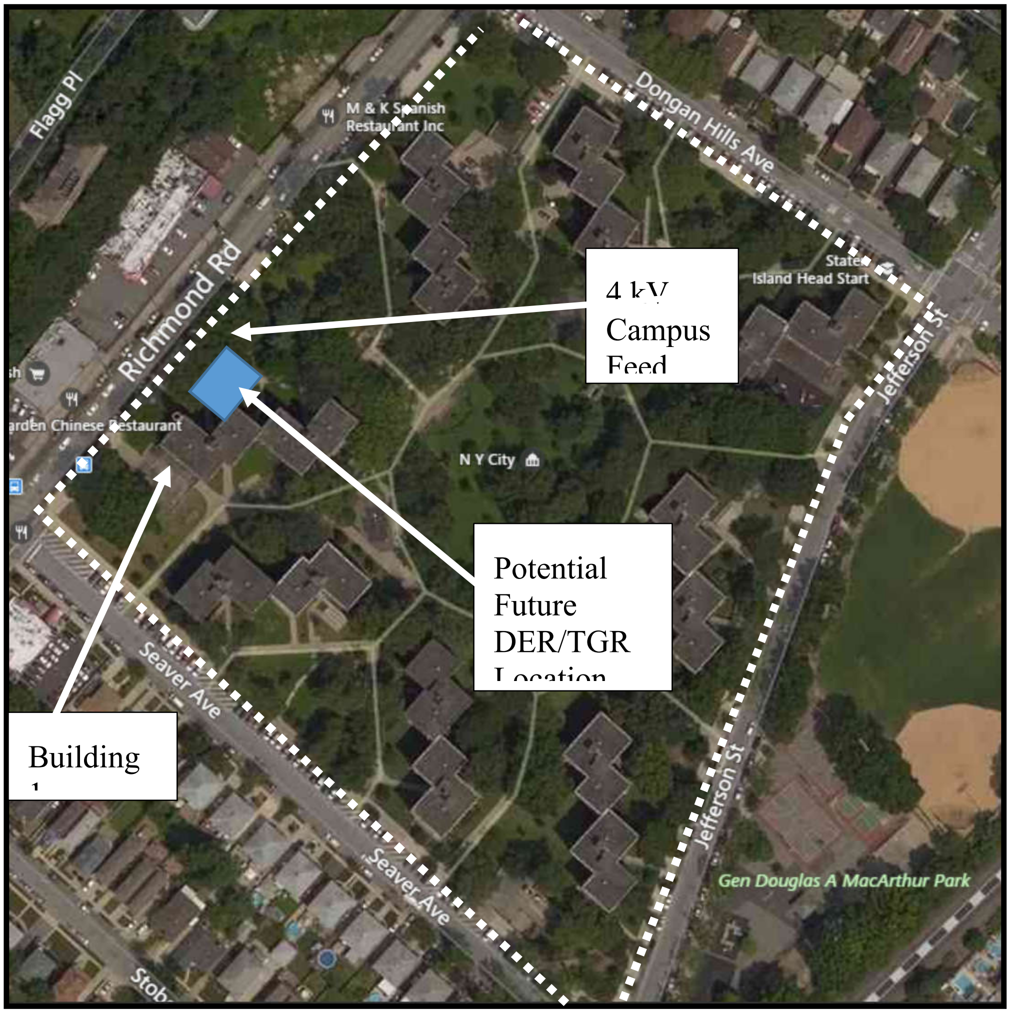


EXHIBIT 2.3.5 – NYCHA BERRY LAYOUT (aerial photo courtesy of Bing Maps)

As discussed above, the peak MG demand is approximately 14.1 MW. The MG average has been approximated as 7.7 MW, with minimum loads approximated at 5.5 MW. Reciprocating engines are being proposed as the primary DERs due to their high efficiency, thermal match for CHP, and ability to load follow / cycle. One engine would be installed with waste heat recovery. Solar photovoltaic units and battery storage would be deployed at SBPC, NYCHA Berry, School PS52, and Engine 159. The existing 2,400 kW reciprocating engine at SIUH will be connected to the MG as a backup.

The DERs proposed have adequate capacity to supply the MG demand. The peak demand is approximated at 14.1 MW. While this value is an aggregate of all peak demands at each facility, and may not represent actual coincident loads, the new MG DER's in combination with the existing DER's will have adequate capacity to serve this peak demand.

Thermal production would occur through heat recovery as a byproduct of electrical generation in a combined heat and power configuration. The new DER and TGR resources were chosen based on their ability to serve MG electrical loads as a whole in combination with serving local thermal loads. Exhibit 2.___ presents the DER's that have been identified to serve the MG electrical load.

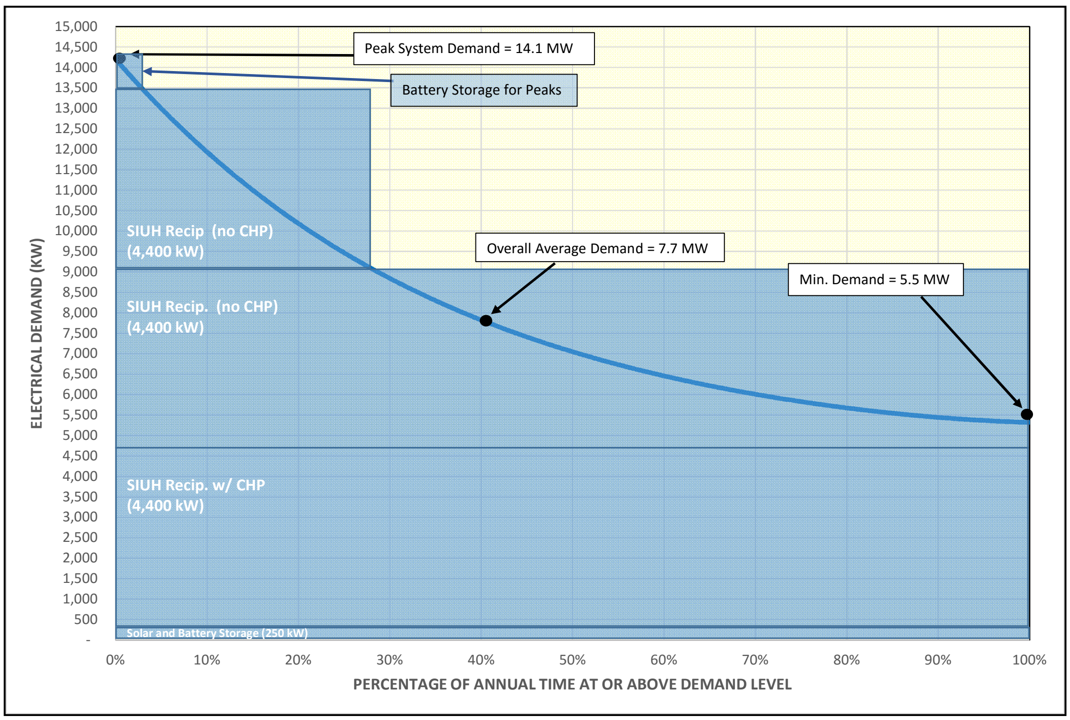


EXHIBIT 2.3.6 – MG DER/TGR SELECTIONS TO MEET ELECTRICAL DEMANDS

SIUH Thermal Loads

A new nominal 4,400 kW RICE unit will utilize heat recovery to supply approximately 5 mmBtu/hr total to the campus. Bypass stacks will be utilized to maximize flexibility for periods where the thermal demand is lower than 5 mmBtu/hr. Existing boilers will supplement this generation. The existing 2,400 kW RICE will become a backup with heat recovery to serve approximately 3 mmBtu/hr of the hospital's thermal load. The average thermal consumption of the campus is approximately 10 mmBtu/hr with a peak load of approximately 21 mmBtu/hr. Steam driven centrifugal or absorption chillers will be investigated to utilize waste heat during warm periods where the campus has lower heating demands.

SBPC Thermal Loads

Buildings 8, 9, and 17 (also referred to as CSB) are connected to a central thermal distribution system. All remaining buildings have dedicated boilers and hot water heaters. A new building (Building 18) is currently being installed and connected to the central hot water distribution system. SBPC is also installing new thermal generation equipment as well as backup generation.

SBPC thermal loads average approximately 3 mmBtu/hr and peak around 10.7 mmBtu/hr. During summer months, the thermal loads are below 1 mmBtu/hr. The potential to supply thermal energy generated from waste heat from the new RICE units at SIUH will be investigated, but may not be feasible due to the distance between thermal distribution infrastructures of SIUH and SBPC. If SIUH waste heat was utilized for SPBC use, it would likely serve Buildings 8, 9, 17, and 18. Existing TGR's will be utilized unless waste heat generation is deemed a viable option.

NYCHA Berry Loads

The Berry campus utilizes 5-10 psig steam for heating. The average load is approximately 9.8 mmBtu/hr with a peak load of approximately 42.8 mmBtu/hr. The minimum load is approximately 2 mmBtu/hr. A new combustion turbine with heat recovery could be used in the future to generate steam to meet the thermal loads and duct firing will be used for supplemental steam generation. During these periods, existing thermal generation resources would likely still be used.

In addition to DER/TGR assets, it was assumed that hardening measures will be required for the Seaside Substation. This substation plays a critical role in operation of the MG and would be hardened against forces of nature or other acts of vandalism/terrorism.

Flooding

DER/TGR locations and MG facilities were selected in consideration of updated FEMA flood maps (updated after Superstorm Sandy) as well as the Sandy flood line. Drawing SLD-01 presents the approximate Sandy flood line. New DER's would be located at higher elevations and with hardening measures to reduce the potential for flooding. For example, at SBPC, the new care facility is required to be designed at a minimum elevation of 17' AMSL. As an additional measure of conservatism, SBPC is building the new facility at 20' AMSL.

In addition, the ConEd Seaside Substation, located at the SBPC campus, may need similar measures taken to increase resiliency to flooding such as elevated transformers and switchgear. It was noted during a meeting at the SBPC that the Seaside Substation had flooded during Superstorm Sandy. The Seaside Substation is intended to provide means for distributing the microgrid's electric generation to other microgrid facilities.

Snow/Ice

Solar panels will be used to gather and potentially store electrical energy. However, the new MG will be designed such that these are used to supplement generation only. As such, they are expected not to operate with snow cover.

The MG will utilize diverse fuels to maximize flexibility to respond to fluctuations in availability and prices. This includes natural gas, fuel oil, and solar energy. Diesel fuel will also be used for emergency generators. Renewable fuels include biomass and refuse-derived fuel (RDF) are not anticipated due a variety of associated issues including environmental regulations, availability of fuel, and proven track records of reliability among others. Wind may be explored as a supplement to production, but is not likely to be installed on any scale. Newer wind generation technologies may be explored later. If the MG ties to the Staten Island Railroad (SIR), battery storage may be explored as an option to capture and store braking energy through regenerative breaking tied together with a flywheel system.

At this time, fuel availability and storage has not been confirmed and will be investigated further in future tasks. Exhibit 2.3.7 following provides a partial summary of existing fuel sources.

Facility	Existing/Planned Fuel Sources and Storage	New Fuel Sources and Storage
SIUH	Diesel for electrical generation (diesel storage tanks) Natural gas for hot water generators	TBD
SBPC	Diesel for electrical generation (3,300 gallon diesel storage tank) No. 2 Fuel Oil for hot water generators (68,500 gallons fuel oil storage) Natural Gas for hot water generators (Non-firm gas to	TBD

	all buildings except Bldg. 17 which has firm gas for DHW tank and heating hot water boiler pilot) – 6 inch supply to site	
NYCHA Berry	Firm natural gas for boilers Fuel oil backup only Fuel oil tanks	TBD

EXHIBIT 2.3.7 – FUEL SUMMARY FOR MG FACILITIES

Black Start

The MG would be capable of black start through use of reciprocating engines. These units would be capable of powering electrical bus equipment to allow for startup of other equipment.

Load Following / Part Load Operation

Load following can be accomplished through a variety of operational practices. CHP would be designed such that the base thermal load is satisfied for greater than 90% of the year while the prime mover operates at full load. Thermal load following would occur through modulating bypass dampers or through use of existing boiler equipment. The intent of the system design is that the CHP units will generate less electricity than the electrical demand. Electrical demand load following would then occur through part-load operation of non-CHP reciprocating engines, discharge of battery storage units, or other means. Another less preferable method would be to use a ConEd feed to load follow. However, the intent is to operate with self-sufficiency.

Reciprocating engines maintain a relatively high efficiency at part-loads. As such, non-CHP reciprocating engines or would be a good option for load following without greatly compromising system efficiency. For thermal demands, boilers can often operate at stable loads while turned down to between 10% and 20% of full load. While duct firing may be a viable option for load following, this method is less proven for heat recovery units on RICE units than with combustion turbines and, thus, boiler load following may be a better option.

Maintain Voltage / Frequency and "Ride Through" Events

Voltage and frequency control shall be achieved through the features and functions inherent in the MG logic controllers selected. Depending on the specific controller selected, the frequency control will be accomplished within the MG control, or coordinated with the local control of the generation assets. Voltage will be regulated within the controllers per the ANSI C84-1 standards. MG controllers will use set points to define voltage and frequency slip windows. Bias outputs may then be employed to regulate generator voltage and frequency.

Meeting Interconnection Standards (Grid-Connect mode)

Updated utility interconnection requirements were issued by the New York State Public Service Commission in July, 2015. These requirements are applicable to new distributed generation (DG) facilities connected in parallel with utility distribution systems. The maximum nameplate rating of 2 MW or less is required on the customer side of the point of common coupling (PCC). As of November, 2015, the Public Service Commission is reviewing proposed utility interconnection requirements which would raise the maximum nameplate rating of DG facilities to 5 MW. For this proposed MG, the total aggregate capacity at the SIUH PCC will exceed this 5 MW rating. As such, this PSC requirement will need to be explored further.

Coordination with ConEd is already taking place to determine the best means of isolating the MG from the utility grid. Through the design process for this proposed MG, an interconnection agreement will need to be put in place between ConEd and the MG facilities that will generate electricity to supply the local distribution. All interconnection standards at the state and Federal level will be investigated for applicability to this MG configuration. All applicable standards and requirements will be adhered to as the application for interconnection to the utility is submitted.

2.4 Electrical and Thermal Infrastructure Characterization

The MG will utilize the ConEd overhead, radial system to distribute energy throughout the MG. As a result, new feeders, lines and breakers will not be needed. ConEd's Seaside Substation, physically located on SBPC property, feeds the SBPC campus through a direct connection and also feeds the SIUH campus through the 33kV feeder 33R15. A switch will be placed on the 33R15 feeder to isolate the microgrid from the rest of ConEd's customers connected to that supply. Similarly, a switch will be placed along ConEd feeder 33R13, which is a redundant feeder into SIUH campus.

At Seaside Substation, in addition to the 33kV feeder 33R15, there is a second 33kV feeder, 33R40. This feeder does not service any microgrid participants and will need to be disconnected during microgrid island mode. A new switch will need to be installed to disconnect feeder 33R40 automatically during islanded operation.

Seaside Substation is one of the few substations on Staten Island that feeds a radial distribution area. As such, it is currently more susceptible to outages. The intent of the improvements implemented as part of the proposed microgrid is to increase reliability of this local distribution. The 4kV network out of Seaside Substation is comprised of four feeders, which are identified as feeders 304, 305, 306 and 307. Feeder 305 does not service any microgrid facilities and will be opened during islanded operation. Feeders 304, 306 and 307 do serve microgrid critical facilities in addition to other ConEd customers. It is intended that the microgrid DER's will be able to supply the microgrid critical facilities on these feeders as well as all other ConEd customers connected to these feeders. In this way, costly switches and feeder reconfiguration is not required to isolate the microgrid participants along this segment of the distribution network.

As critical facilities and other area loads are prepared for connection to the MG, additional relaying, metering, switching and instrument transformers may be required. These additional measures may be required before the critical facilities are set up to sell power into the utility grid during normal operation of the MG. Necessary facility upgrades are currently being assessed on a case by case basis.

For the purposes of this review, the assumption was made that the 4 kV distribution lines near NYCHA Berry could be reconfigured so that the facility could be fed from Feeder 306, instead of its current Feeder 254, due to its proximity to this feeder. This would allow NYCHA Berry to be fed by the proposed microgrid in island mode. However, load shedding will likely be required (particularly in peak conditions) to carry this load. Upon a cursory review of the Feeder 306 conductor capacity, simply adding the NYCHA Berry facility would most likely overload the feeder during periods of high demand. To prevent this from occurring during peak load, switches would be placed along Feeder 306 to shed other load, so that NYCHA Berry may be fed. It appears that two switches, strategically placed, could shed somewhere around a third of the transformers currently supplied by Feeder 306. It has been assumed for this review that this load shedding would be sufficient to add NYCHA Berry while remaining within the capacity limits of the feeder.

Electrical

As discussed above under 'Load Characterization', resiliency can be added to the electrical infrastructure by creating a looped distribution network. Greater resiliency can be achieved by installing this looped distribution network underground. While the urban setting poses challenges for right-of-way acquisition, existing underground obstructions, and overall cost, certain MG facilities are favorable candidates for an underground loop such as SIUH and SBPC. As the MG is expanded, additional underground circuits may be added at that time. For clarification, although the undergrounding of feeders and re-configuration to form loops would substantially improve reliability in the area, this scope of work and associated cost has not been included in our current analysis and would need to be investigated with ConEd at a future date.

With a radial overhead system, severe weather has the potential to disable the electrical infrastructure for varying degrees of time. Outages may occur as the infrastructure is damaged during severe weather. Outages can be momentary, as high winds cause distribution lines to contact phase to phase, or outages may last several days or weeks as infrastructure is rebuilt from downed lines, poles, and damaged transformers and other equipment.

During severe weather where a sustained outage occurs due to a damaged overhead system, the new underground circuits between the MG critical facilities may be largely unaffected. Exposed points in an underground circuit where the cables transition above ground to connect to the above ground structures they serve, may still be impacted by severe weather. However, these exposed points will be smaller in area than the exposed overhead system and their damage more easily identified, allowing them to be repaired faster than the overhead system.

During these occurrences where severe weather damages the overhead infrastructure as well as the new underground circuits added, the critical facilities may still rely on their emergency generators to serve their local loads. The SIUH and SBPC in particular are elevating their systems as mitigation efforts following Superstorm Sandy. They are placing their emergency generation above the 500 year flood plain identified as a minimum elevation of 16 feet. Depending on where the overhead system sustains damage, and how many underground feeders are added to connect MG facilities, will determine how many MG facilities are impacted during severe weather.

Our considered approach to improve the local grid resiliency and the chances that the microgrid would provide power to as many critical loads on the feeders as possible is to include automatic isolation switches on the 4kV feeder circuits as follows:

- On the (3) feeders with critical facilities (feeders 304, 306, and 307), two switches would be installed on each feeder. One switch would be installed closest to the point of connection to the 4kV Seaside Substation bus for isolation of the entire feeder if necessary. The other switch would be installed on the feeder at a point immediately after the last critical facility is connected, which would allow for shedding of the balance of the feeder should a point beyond the critical facility become compromised.

- On feeder 305, a single switch would be installed closest to the point of connection to the 4kV Seaside Substation bus for isolation of the entire feeder if necessary.

Thermal Infrastructure

Thermal infrastructure is primarily distributed by MG facilities within buildings, tunnels, or direct bury systems. As such, they are protected from the forces of nature. However, lines routed below grade or below the flood line would need to be evaluated for resiliency.

Interconnection

The MG will rely on the ConEd distribution network infrastructure. All proposed participants of the MG are currently connected to ConEd's distribution network. Any power generated by these MG facilities will be distributed through ConEd's feeders and distribution lines. This being the case, each facility participant of the MG will have its own unique point of common coupling (PCC) with the utility grid.

The SIUH campus is the exception. SIUH currently has two separate connections to ConEd. One connection is through ConEd feeder 33R15, the other supply is through ConEd feeder 33R13. A PCC for SIUH is identified at each ConEd feeder, as both feeders will require switching for microgrid isolation.

Infrastructure Investments Required

The main electrical infrastructure investment required will be the disconnect switches to isolate the MG from the local 33 kV distribution and the potential underground distribution between SIUH and SBPC. From preliminary investigations with Con Ed, it appears that three 33 kV isolation switches may be adequate for islanding and seven 4kV automatic isolation switches may be adequate for load shedding and resiliency. The Seaside Substation would be utilized as the primary point of distribution. The condition and life of Seaside Substation equipment is not known at this time and will need to be identified to better understand potential costs associated with its continued operation for the MG to meet resiliency needs.

The three reciprocating engines proposed for the SIUH campus would overload the existing bus and transformers at the hospital. These engines will need to be connected to the 33kV bus directly via new generator step-up transformers, network protectors and possibly switches. This additional infrastructure investment would be accompanied by any necessary protective relaying upgrades to protect the new transformers.

Rooftops for the proposed solar DERs at MG locations may not be load bearing. During the design phase for the proposed MG, the buildings will be evaluated by structural engineers and reinforcement to the roofs will be added if necessary. Solar technology being proposed at these locations will be distributed among multiple buildings at these facilities, and is estimated to only require 50-60% of the surface area per roof.

Protection Mechanism within MG Boundary

The MG controllers shall provide the protection mechanisms necessary to prevent cyber intrusion. The MG controllers shall adhere to the NERC CIP standards to provide secure controls and communication. Security features shall also include password protection, as well as a historian. Any federal regulations governing security and protection mechanisms for this MG application will be followed as well.

2.5 MG and Building Controls Characterization

Two control architectures are being considered for the proposed MG, and manufacturers of each will be invited to submit bids for supply of the control system during the design phase of the MG. One architecture solution would be to have a central MG controller, which would be a powerful management tool that would interface with generation assets' local controllers and any existing BEMS's. The benefit of this model is in the singularity of the controller, which provides a single point for control of the MG as well as a single point for maintenance of the control system.

The other architecture solution being explored is a decentralized model. MG controllers would be installed at each remote generation asset and at each remote load. Where a PCC is identified on the system, a MG controller would be installed to monitor the assets and or loads connected at that PCC. These remote MG controllers would interface with the DER's local controllers, as well as communicate back to the MG controller installed in the control room where an HMI would be located.

This decentralized architecture allows for the maintenance or replacement of a remote MG controller without affecting the rest of the MG. This flexibility allows the MG to avoid complete blackout in the case where a single central controller malfunctions or requires maintenance. The decentralized architecture also allows for the individual controllers to be less complex in design, providing for easier testing and troubleshooting of controls.

Whether the control architecture is centralized or decentralized, the controllers will monitor loads and communicate with DER's to optimize generation dispatch, perform load control and integrate renewables. The control system will communicate with any existing BEMS's to shed non-critical loads at the facility during islanded mode.

Several solutions currently on the market offer a robust control system where MGs are concerned. Some of the products being considered include: Siemens Spectrum Power MG Management System (MGMS), ABB's Renewable MG Controller (MGC600) in conjunction with ABB PowerStore, and Schneider Electric's MG Controller (MGC) in conjunction with Schneider's StructureWare software. Features found in commonality with each solution include:

- Automatically connecting and disconnecting from the grid
- Load shedding
- Black start and load addition
- Economic dispatch and load following
- Demand response
- Storage optimization
- Maintaining frequency and voltage
- PV observability and controllability; forecasting
- Coordination of protection settings
- Selling energy and ancillary services
- Data logging features

MG controls whether at the remote facilities or at the control room to be located at SIUH campus or SBPC, will be installed at an elevation above the 500 year flood plain identified as 16 feet minimum. Given this elevation and that the control equipment will be installed indoors, it is not anticipated that severe weather will impact the MG control equipment. The overall resiliency of the control system will largely depend on the resiliency of the communication infrastructure.

2.6 Information Technology (IT)/Telecommunications Infrastructure Characterization

Communication will be necessary between the remote generation assets, remote loads, remote switches for load isolation during islanding, the MG control center, and with the utility. Several technologies are being investigated to provide the communication infrastructure. These include:

- Cellular

- Radio
- Fiber
- Ethernet

Through discussion with ConEd, it was learned that ConEd currently communicates with their remote switches via cellular technology. As the proposed MG intends to use ConEd's overhead system for power distribution, it may also make sense to use cellular technology for the MG's communications network. Ethernet may be used locally at each facility where it makes sense to do so.

Devices will be placed at each facility to control and secure access points. This security may be performed by the MG controllers themselves, if they are to be deployed at each facility. Security measures put in place will meet applicable state and federal requirements. MG controllers currently being considered for this MG application are NERC CIP compliant. Further investigation is needed to determine if federal NISTIR requirements are applicable, and if the considered controls solutions are in compliance with these regulations.

Loss of Communications

Within the MG, communication will take place between the MG controllers, the generation assets, the loads and the MG control center. Should communication be lost at any MG node, that load or generation asset will no longer be able to be controlled. New generation assets proposed for addition to the MG are strategically being located to be outside of, or elevated above known flood plains.

Communication with the utility will take place between the MG control center, the utility control center, and the MG isolation switches along the utility overhead distribution network. With the utility control center, MG status information can be shared as well as revenue metered data.

Communication with the MG isolation switches is required to disconnect non-MG participants from the distribution network during islanded MG operation. This is necessary not only from a billing perspective but also because the generation assets of the MG will not have the capacity to feed all incidental loads along the distribution network, and between the MG facilities.

Control of these switches can be communicated directly to the utility control center, and then to the switches, or else both the utility control center and the MG control center may have direct communication with the MG isolation switches.

In the first case, loss of communication with the utility control center would disrupt the MG's operations. Control to the MG isolation switches would be lost. The MG would not be able to put generation onto the utility overhead distribution network as the load would exceed the MG generation capacity. However, the MG generation assets could isolate at their PCC's and feed their local facilities, as well as any MG facilities connected through the MG's underground feeders. In this way, operation of the MG would be diminished, but not completely interrupted.

In the second case, where both the utility and MG control centers have communication to the MG isolation switches, loss of communication with the utility control center would not affect the MG operation. As long as communication between the MG controllers and the MG isolation switches remains intact, the MG generation assets can dispatch generation to all MG participants.

Also, to automatically disconnect and reconnect from the utility grid, the MG controllers will rely on data from current and potential transformers at the PCC's to provide status of the utility grid. This functionality is unaffected by loss of communications with the utility.

Revenue meters shall be installed at each PCC along the MG. While information used for billing will be sent to the utility through the communication infrastructure, this information can be obtained from the meters locally in the case that the communications are disrupted.

Operational procedures and agreements with the utility will need to be put in place for execution of the second case above to be successful. Operational control of the MG isolation switches will need to be agreed on for parallel operation, islanded operation, and for parallel operation when loss of communication between MG and utility control centers has occurred.

Resiliency

The resiliency of the communications infrastructure will vary with the technology chosen. Communication technology will be selected through a bid and evaluation process during the design phase of the proposed MG. Several factors will be considered when selecting communication technology including reliability, resiliency, and cost.

Fiber cable would provide a reliable, physical connection. The resiliency of a fiber network would depend on whether the fiber cable is installed underground or overhead. An overhead communication network brings similar shortfalls in resiliency to the overhead power distribution network discussed.

Installing the fiber cable underground would greatly increase resiliency but may also add more cost. As with the distribution network, it is feasible to install fiber cable with underground feeders between likely candidates such as SIUH, SBPC and South Beach NYCHA. As other facilities are considered for inclusion in the MG, and if underground distribution were added at that time, it would also be feasible to include the communication cable with that installation.

Regarding cellular and radio technology, these are wireless communication mediums. Assuming continuous power could be provided to these devices at each end, these technologies should prove to be resilient when faced with severe weather. However, while resilient, these communications mediums may not prove reliable during severe weather. For instance, radio waves may experience interference during severe weather, causing intermittent or spotty communications. Further investigation and consideration of these factors is needed.

Deliverables: *Documentation of the work conducted under each sub-task under Task 2: Develop Preliminary Technical Design Costs and Configuration, organized by sub-task*

Screening-level opinions of probable capital cost were developed for this MG concept through use of a variety of reference points including previous project experience, industry rules-of-thumb, OEM input, and judgement. These costs are considered "typical" and do not account for variations in weather, availability of labor, material and equipment availability, labor productivity, contractor-specific construction means and methods, economic conditions, owner-specific requirements and preferences, and other factors that will impact the final project price. Exhibit 2.7.1 summarizes the capital costs and capacity information for this MG concept.

Note that the costs for adding an absorption chiller have not been included in this table, but is currently under consideration in order to improve utilization of the CHP waste heat.

Subtask	Capital Component	Installed Cost ($)	Nominal Added Capacity	Nominal Total Capacity *	Description of Component
2.3	SIUH Recip Plant	$31,000,000	13,200 kW	15,700 kW	New facility w/ recips & CHP
2.3	SBPC Solar/Battery	$1,400,000	200 kW	2,200 kW	Solar PV panels and battery storage
2.3	NYCHA Berry Solar / Battery	$400,000	50 kW	50 kW	Solar PV panels and battery storage
2.3	FDNY 159 Solar/Battery	$250,000	25 kW	25 kW	Solar PV panels and battery storage
2.3	PS52 Solar/Battery	$250,000	25 kW	25 kW	Solar PV panels and battery storage
2.3	Seaside Substation	$500,000	NA	NA	Hardening measures
2.4	ConEd 33kV Switches	$300,000	NA	NA	MG Isolation Switches
2.4	ConEd 4kV Switches	$450,000	NA	NA	4 kV load shedding switches
2.4	Connection to NYCHA Berry	$300,000	NA	NA	Reconfig. 4 kV feeders 254/306
2.5	Central Control	$1,000,000	NA	NA	Energy Management Controls
* Does not include emergency generators, as they are dedicated to the facility and not the microgrid. Standby generators are included.					

What dual fuel technology is being considered? Dual fuel (ng/diesel) RICE engines are relatively hard to come by and are not very efficient. Perhaps consider CNG/NG for fuel redundancy.

3 Assessment of the Microgrid's Commercial and Financial Feasibility

3.1 Commercial Viability - Customers

The Staten Island East Shore Microgrid provides a benefit to a broad region in a vulnerable part of the New York City Borough of Staten Island. The customers associated with this microgrid include those that own critical facilities, those that are physically connected to the energized microgrid feeders (but are not critical facilities themselves) and those who are indirectly impacted by the resiliency made possible in the region.

The major critical facility in the Microgrid is the Staten Island University Hospital North Campus. This facility would be expected to host the microgrid within its property. The hospital's position is that it serves the entire population of Staten Island, which amounts to 474,515. SIUH North Campus is the hospital's main campus and features their broadest range of services. There is a smaller SIUH campus and smaller specialized SIUH labs/clinics located on Staten Island (a total of 714 beds, including the North Campus) and one other major hospital, the Richmond University Medical Center (448 beds).

It is estimated that between 80,000 and 100,000 people in the area are directly served by the fire and police facilities proposed to be connected to the Microgrid.

As discussed in previous sections, after coordination with the local distribution utility, Con Edison, it was decided that a reasonable configuration for creation of an area microgrid would be the isolation and inclusion of four specific area feeders supplied by Con Edison's Seaside substation. Through minor modifications to the existing distribution architecture, the proposed Microgrid could supply power to these existing feeders, in their entirety, and thereby pick up the critical facilities as well as connected residential and commercial customers. Because of this, the proposed Microgrid would directly impact the following connected customers:

Primary Feeder	Residential Customers	Commercial Customers	Port Authority of the State of NY Customers	Total Customers
[redacted]				
[redacted]				

[redacted]				
[redacted]				

Large Customers:

Customer	Feeder #1
[redacted]	
[redacted]	
[redacted]	

Company	Feeder #1
[redacted]	
[redacted]	

Company	Feeder #1
[redacted]	
[redacted]	

These feeders are fairly unique in the Con Edison service territory in that they are radial feeders that do not interconnect between two different substations. By supplying these feeders from an alternative energy source, the reliability of this region of Staten Island is improved for Con Edison.

In return for these services, it is anticipated that the following revenue streams for the proposed Microgrid would be established:

- Payment for the provision of primary and standby electric and thermal energy through power and thermal sales agreements with the Staten Island University Hospital, the New York State Office of Mental Health South Beach Psychiatric Facility, and New York City Parks Department (for potential future connection to their Ocean Breeze facility)
- Compensation for peaking generation/capacity through Con Edison (or potentially the NYISO)
- Compensation for grid improvements (Microgrid switching) by Con Edison

- Compensation for grid reliability improvements by Con Edison (local rate base), New York City, and New York State, as applicable

In order to establish this arrangement and, due to the fact that the major stakeholders in the process are not in the energy production and distribution business, it is anticipated that the new facilities developed for the proposed Microgrid would be developed, owned and operated by a third party. In addition, existing building emergency and cogeneration generation could also be assumed (operated and potentially acquired) by this third party.

3.2 Commercial Viability – Value Proposition

The proposed Microgrid provides four main value propositions. First and foremost, it would provide resiliency to the southeast shore area of Staten Island by supplying power locally through distributed resources directly to the electrical distribution system in that area. This area is particularly vulnerable to storm flooding activity (as was evidenced during the Superstorm Sandy flooding) and it is also served by radial feeders from Con Edison, with limited network redundancy. As such, improvements in electrical supply and load shedding capability would create benefits for the region on a whole.

The second value proposition would be the generation of baseload power and thermal energy to the South Beach Psychiatric Center and to the Staten Island University Hospital. The use of state-of-the-art efficient engine-generator sets would allow for cost-effective energy and heat relative to current retail rates charged to both facilities.

The anticipated near-term CHP thermal load is relatively low, however, thus the CHP component of this Microgrid is not as significant as the proposed simple-cycle generation for peak power support and resiliency. As such, a third value proposition derived from the Microgrid would be generation capacity available for peak load support. During peak power periods, where wholesale purchases of electricity are high, Con Edison could dispatch energy from these resources to provide grid load relief (assume peak load constraints exist) and to provide potentially lower cost power to its customers.

The fourth identified value proposition is the ability to better integrate renewable energy resources into the local distribution feeders by balancing them with dispatchable resources.

Because of the nature of the region within Con Edison's distribution network, this project is more feasible to integrate with the distribution network than many other areas. As such, it is a natural pilot Microgrid project and could serve as a model for additional and more complex projects in the area. In fact, the original New York Rising Community Reconstruction Plan for Staten Island by the New York Governor's Office of Storm Recovery, which identified this project as Priority Project, also included a subsequent broader application of multiple connected microgrids. That broader Microgrid Network study is still listed for funding by GOSR as a Priority Project. As such the Project would serve as a building block for the broader microgrid network study.

Although the project is initially being considered as a single-owner project with central control, the microgrid controller could also serve as a regional distributed generation control and balancing platform, thus enabling a market for other third parties to connect distributed resources in a coordinated manner. With this opportunity comes the potential for additional business models and revenues to the microgrid operator and local utility.

SWOT Analysis

Strengths:

- Con Edison support of initial feasibility and selected configuration creates minimal impact on existing distribution infrastructure relative to breadth of microgrid coverage
- Resilient hub for south shore, Staten Island
- Support for community including both critical facilities and significant number of residential properties
- Potential ability to provide black-start resource to broader distribution grid
- A balance of generation, renewables and battery storage allow for optimization of energy usage
- Efficient energy generation through CHP configuration at SIUH and SBPC
- Reduction of emissions with new generators, solar energy and battery
- Resilience of critical services during outages and major events
- An increase in public safety by maintaining local traffic lights and street lights during outages
- Reduction of expense to primary and secondary critical facilities by preventing the need for backup generators
- Improved resiliency of existing overhead distribution feeders from Seaside substation due to added automatic isolation switches
- Microgrid controller provides a more efficient grid operation and allows for future expansion with added distributed resources
- Technology vendor agnostic approach, enabling flexibility and tailoring the solution to the most optimal configuration and phasing and considering all available technologies for potential applicability
- Leveraging of previous investment by State and Federal governments in resilience as part of the New York Rising Community Reconstruction Program.

Weaknesses:

- Resiliency measures and renewable power capital costs are difficult to recover under current rates

Opportunities:

- Potential new market through ability to attract new distributed resources (including those owned by other third parties) to an established microgrid where the infrastructure and commercial agreements have already been established
- Addition of solar, wind and batteries will help to diversify New York City's power supply during peak and off-peak hours, increasing resilience
- Reduction of the reliance on transmission grid
- Potential incremental expansion with new customers to broaden resilience and sustainability

Threats:

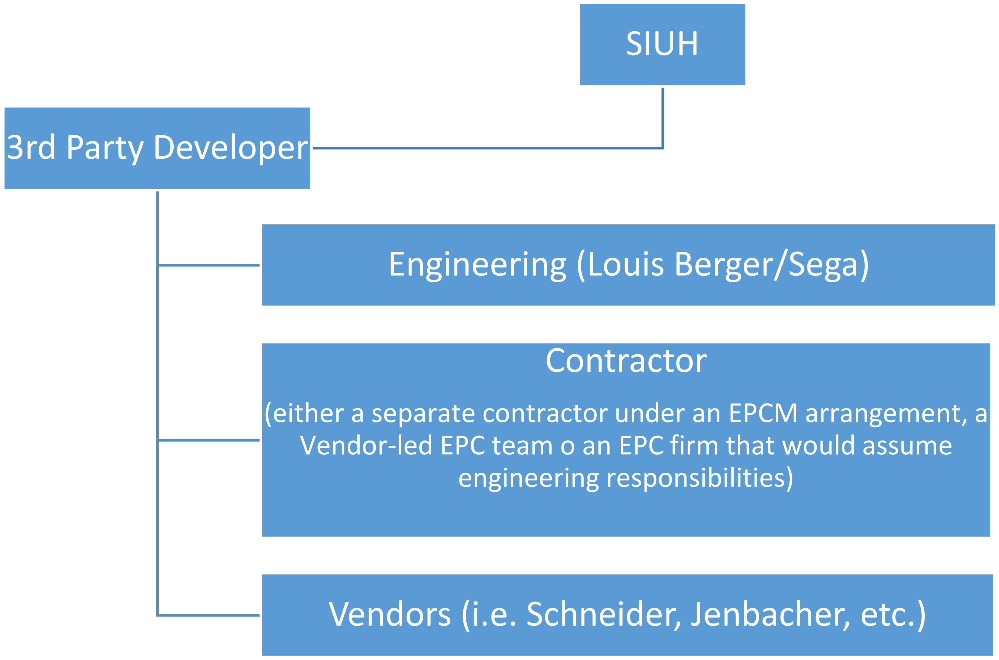
- Competing projects seeking similar resources for development
- Cost of components which add reliability without current means for revenue creation

3.3 Commercial Viability – Project Team

The proposed Microgrid is expected to have full support of its stakeholders. The current feasibility project team brings capabilities that could extend through detailed design and implementation, thus creating a seamless knowledge transfer through completion. The team had also solicited approvals from nearly all impacted stakeholders to support this study including:

- Con Edison
- New York City Mayors Office
- New York State Senate/Assembly
- Staten Island Borough President
- Staten Island New York Rising Committee (directly representing local community members)

Looking forward to project development and implementation, it is anticipated that the following organizational structure would be put in place:



Each of the proposed team members has relevant applicable experience in the development and implementation of projects similar to the proposed Microgrid. Northwell Health (formerly known as North Shore LIJ - SIUH parent organization) as the State's largest healthcare organization has significant experience in the management of facilities capital projects on their properties and is specifically experienced in power generation and CHP implementation. Louis Berger and Sega collectively have strong experience in power systems engineering and design as well as experience with the Dormitory Authority of the State of New York (DASNY) (including the New York Office of Mental Health), the New York City Department of Buildings (DOB), the Fire Department of New York (FDNY), The New York School Construction Authority (SCA), the New York City Housing Authority (NYCHA), the New York City Economic Development Corporation (EDC), the New York City Department of Planning (DCP), the New York State Department of Environmental Conservation (DEC), the New York City Department of Environmental Protection (DEP) and other applicable permitting and local authorities with jurisdiction as well as Con Edison. Louis Berger has also extensive experience with the local community and stakeholders, as it was instrumental in the development of the Staten Island Community Reconstruction Plan for the Governor's Office of Storm Recovery and worked closely with local stakeholders to identify and conceptualize microgrids as priority projects for Staten Island. This experience will lend itself to the proper and efficient design of the microgrid in accordance with prudent engineering practice and all local codes and standards and with full stakeholder support. The vendors being considered would be those with proven history of successful applications in systems similar to those considered in this Microgrid. It is also anticipated that the project would progress with a third party developer, such as Anbaric Microgrid LLC, who would finance, own and potentially operate the microgrid on behalf of the stakeholders and in cooperation with Con Edison. In addition, the developer would enlist the support of legal, regulatory and outreach specialists who would develop the terms and approach for all interfaces with authorities, community leaders and the local utilities. Anbaric, for instance, has significant experience in this area and has been developing projects in New York State and, more specifically, New York City.

3.4 Commercial Viability – Creating and Delivering Value

The power generation and controls equipment for the proposed Microgrid would be installed at the SIUH campus and other customer locations as identified in the technical section of this report. These components will, therefore, not require special easements but only typical permitting requirements.

The technologies proposed are intended to integrate with Con Edison's existing Outage Management System. Where applicable, the microgrid controller can also interface with Con Edison's SCADA system for coordination between the microgrid and the broader distribution network.

The technologies chosen are all proven. The engines were chosen due to their high efficiency, reasonable capital cost, and availability (these can be sourced from a number of reputable suppliers including GE/Jenbacher and Caterpillar). Although the specific battery technology is to be determined, the use of the battery would allow for peak load reduction and also serve as the voltage source for microgrid control during islanded operation, with the other energy resources synchronizing to the battery inverter (droop mode). This has been proven to provide reliable microgrid control when varying technologies are employed in parallel operation.

Further coordination with Con Edison would be necessary for the installation of the network isolation switches. Initial discussions and collaboration with Con Edison during this feasibility phase has created a degree of comfort that this would be a relatively straightforward task. In addition, the contemplated small quantity and general location of isolation switches allows for a relatively simple approach.

Many of the project team members are already intact, reducing the number of contract negotiations with third parties. The ownership and knowledge of the system will create a short design and construction timeframe to implement the Microgrid project– reducing costs on the rate (tax) payers. The maintenance of the new microgrid may require additional staff. Should the project be advanced to subsequent stages of development, the conceptual design would be detailed through engineering and specification documents. Many of the components are packaged and would require minimal engineering for integration. The microgrid controls architecture and programming would be sourced by dedicated teams within competent suppliers of the systems. Anbaric has worked with vendors, including Schneider Electric with their Struxureware platform, which has been proven to integrate the types of resources considered here. However, the team is vendor technology agnostic and would seek similar results from available vendors like Schneider who have architecture and track record demonstrating similar capability.

Since this project also has the potential to create load relief on the Con Edison distribution grid during periods of high peak demand, benefits from the utility and its ratepayers should be extended to the developers of the proposed microgrid (the value of grid upgrade deferrals).

3.5 Financial Viability

As discussed in Section 3.2 above, there are several potential revenue streams for the microgrid. Known initial potential revenue streams are the potential to collect energy and capacity revenues from the NYISO or Con Edison for the distributed generation resources; and the ability to offset costs to the SIUH and SBPC campuses for thermal and electrical energy.

Cost savings could be initially seen through peak shaving functions of the battery storage facility and through low cost energy produced by the renewable resources. Longer term cost savings could manifest from the ability of AMI infrastructure to drive demand reduction programs.

In addition to the above, it is likely that the infrastructure capital costs (including network switching, controls, fuel supply) and even the capital costs of the generating facilities will need to be offset through program funding (for resiliency purposes) or through the broader rate base due to the improvements made to the grid. The current NYISO Zone J capacity market has measures which make it challenging for new resources to qualify for capacity market payments for several years after they are constructed. Strategic projects are often developed under contracted arrangements (i.e. Power Purchase Agreements or "PPAs") with distribution companies to overcome this.

3.6 Legal Viability

The primary business model under consideration for the Microgrid identifies a third party developer as the project owner and operator. Most all new installations will take place on land currently owned by Staten Island University Hospital and The New York State Office of Mental Health; there will be minimal requirement for easements, rights of way leases, or land purchases for the project to proceed.

Construction of the microgrid is expected to have minimal negative effect on existing Con Edison customers (small planned interruptions are possible as network improvements are made) and will be coordinated with other maintenance activities.

4 Develop Preliminary Technical Design Costs and Configuration

4.1 Facility and Customer Description

The microgrid will serve identified critical facilities and the surrounding neighborhoods in Staten Island. The facilities were selected based on the existing configuration of the Con Ed distribution system. Feeders that could be more easily isolated on the Seaside substation, and the customers they serve, were included in the microgrid.

Table 4.1: List of primary (critical) and secondary facilities

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
ConEd Customers on 4kV Feeders [redacted] (not including PS52, Mason Pump Station, SB Pump Station, Engine 159, and NYCHA Berry)	Residential	[redacted] [redacted]	Residential	[redacted]	[redacted] * Load shedding req'd to limit MG demand to this value	85% * Depending on coincident loads	24
Staten Island University Hospital	Large Commercial/Industrial (>50 annual MWh)	Hospital	All other industries	26,280	5.6	100%	24
South Beach Psychiatric center	Large Commercial/Industrial (>50 annual MWh)	Health Care/Residential	All other industries	7,800	2.0	100%	24
School PS52	Large Commercial/Industrial (>50 annual MWh)	Public Elementary School	All other industries	1,310	0.3	100%	24
Mason Pump Station	Large Commercial/Industrial (>50 annual MWh)	Wastewater Pump Station	All other industries	440	0.1	100%	24
South Beach Pump Station	Large Commercial/Industrial (>50 annual MWh)	Wastewater Pump Station	All other industries	440	0.05	100%	24

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Engine 159	Large Commercial/Industrial (>50 annual MWh)	FDNY Station	All other industries	440	0.05	100%	24
NYCHA Berry	Residential	Public Housing Complex; 506 apartments with approx. 994 residents	Residential	3,940	1.0	100%	24

4.2 Characterization of Distributed Energy Resources

Table 4.2.1 describes the DERs in the East Shore Microgrid. The East Shore Microgrid is expected to provide emergency power supply in addition to reduce the need for bulk energy suppliers to expand generating capacity, by directly providing peak load support.

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
Unit 1 (CHP)	SIUH	*Natural Gas*	4.4	38,550	106	7.9	MMBtu/MWh
Unit 2	SIUH	*Natural Gas*	4.4	26,330	72	7.9	MMBtu/MWh
Unit 3	SIUH	*Natural Gas*	4.4	4,200	12	7.9	MMBtu/MWh
SBPC Solar	SBPC	*Solar*	0.80	1,750	4.8	N/A	Choose an item.
SBPC Battery	SBPC	*Battery*	1	N/A	N/A	N/A	Choose an item.
PS52 Solar	School PS52	*Solar*	0.10	250	0.7	N/A	Choose an item.
PS52 Battery	School PS52	*Battery*	0.25	N/A	N/A	N/A	Choose an item.

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
FDNY159 Solar	FDNY Eng 159	*Solar*	0.10	250	0.7	N/A	Choose an item.
FDNY159 Battery	FDNY Eng 159	*Battery*	0.25	N/A	N/A	N/A	Choose an item.
NYCHA Berry Solar	NYCHA Berry	*Solar*	0.20	500	1.4	N/A	Choose an item.
NYCHA Berry Battery	NYCHA Berry	*Battery*	0.5	N/A	N/A	N/A	Choose an item.

Table 4.2.1: East Shore Microgrid Distributed Energy Resources

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)
Unit 1 (CHP)	SIUH	4.4
Unit 2	SIUH	4.4
Unit 3	SIUH	4.4
SBPC Battery	SBPC	1
MG Batteries	School PS52, FDNY Eng 159, NYCHA Berry	1

Table 4.2.2: East Shore Microgrid Peak Load Support Facilities

The East Shore Microgrid is anticipated to avoid expansion of the transmission network by approximately 14MW

4.3 Costs

The capital costs of the East Shore Microgrid are listed in Table 4.3.

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
SIUH Recip Plant	$31,000,000	25	New facility w/ recips & CHP
SBPC Solar/Battery	$1,400,000	25	Solar PV panels and battery storage
Seaside Substation	$500,000	25	Hardening substation (single point of failure)
FDNY 159 Solar/Battery	$250,000	25	Solar PV panels and battery storage
PS52 Solar/Battery	$250,000	25	Solar PV panels and battery storage
NYCHA Berry Solar / Battery	$400,000	25	Solar PV panels and battery storage
ConEd 33kV Switches	$300,000	25	MG Isolation Switches
ConEd 4kV Switches	$450,000	25	MG Isolation Switches
Central Control	$1,000,000	10	Energy Management Controls
Connection to NYCHA	$300,000	25	Tie in NYCHA Berry Facility to MG (reconfigure 4 kV feeders 306/254)

Table 4.3: East Shore Microgrid Capital Costs

4.3.1 Planning and Design costs

Planning and design costs for the East Shore Microgrid are listed in Table 4.3.1.

Initial Planning and Design Costs ($)	What cost components are included in this figure?
1,000,000	Engineering, permitting

Table 4.3.1: Freeport Downtown Microgrid Planning and Design Costs

4.3.2 Operation and Maintenance Costs

Operation and maintenance costs for the East Shore Microgrid are listed in 4.3.2.1 and 4.3.2.2.

Fixed O&M Costs ($/year)	What cost components are included in this figure?
$500,000	Labor, Overhead, Insurance, General

Table 4.3.2.1: East Shore Microgrid Fixed Operation and Maintenance Costs

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
10	$/MWh	Maintenance, consumables, waste disposal

Table 4.3.2.2: East Shore Microgrid Variable Operation and Maintenance Costs

4.3.3 Fuel Costs

Fuel costs for the East Shore Microgrid are listed in Table 4.3.3. These costs include the fuel costs for the reciprocating engines. There are no fuel costs for the renewable energy systems.

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
Unit 1 (CHP)	SIUH	7	5800	MMBtu
Unit 2	SIUH	7	4300	MMBtu
Unit 3	SIUH	7	1000	MMBtu

Table 4.3.3: East Shore Microgrid Fuel Costs

4.3.4 Emissions Control Costs

The East Shore Microgrid will not require mandates to purchase emissions allowances. The emissions control costs for the East Shore Microgrid are included in Table 4.3.4.1. These costs include the urea injection for NOx control. The anticipated emissions are in 4.3.4.2.

Cost Category	Costs ($)	Description of Component(s)	Component Lifespan(s) (round to nearest year)
Capital Costs ($)	Included in above	SCR, CO Catalyst	20
Annual O&M Costs ($/MWh)	[Urea, $7/ton CO2)		

Table 4.3.4.1: East Shore Microgrid Emissions Control Costs

Emissions Type	Emissions per MWh	Unit
CO_2	0.58	Short tons/MWh
SO_2	0.0000145	Short tons/MWh
NO_x	0.000086 (controlled)	Short tons/MWh
PM	0.000150 (filterable)	Short tons/MWh

Table 4.3.4.2: East Shore Microgrid Emission Factors

4.4 Ancillary Benefits

The East Shore Microgrid is designed to provide ancillary services for frequency support, voltage and reactive power support and black start capability (Table 4.4).

Ancillary Service	Yes	No
Frequency or Real Power Support		
Voltage or Reactive Power Support		
Black Start or System Restoration Support		

Table 4.4: East Shore Microgrid Ancillary Services

4.5 Power Quality and Reliability

The East Shore Microgrid will improve power quality for the facilities on the microgrid.

The estimated SAIFI and CAIDI of the existing grid is in Table 4.5.

Estimated SAIFI	Estimated CAIDI
0.11	3.09

Table 4.5: SAFI and CAIDI of existing grid

4.6 Backup Generation Capabilities

Table 4.6 lists the facilities on the East Shore Microgrid with known back generation capabilities, available generation, fuel consumption and one-time and on-going operating costs.

Facility Name	b	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
SIUH	Gen 1	Natural Gas	2.5	100	45	390	MMBtu/ Day	0	1,350
SIUH	Gen 2	Diesel	5	100	90	770	MMBtu/ Day	0	2,700
SBPC	Gen 1	Diesel	2	100	36	310	MMBtu/ Day	0	1,080
SBPC	Gen 2	Diesel	0.35	100	6.3	60	MMBtu/ Day	0	190
SBPC	Gen 3	Diesel	0.4	100	7.2	70	MMBtu/ Day	0	220
SBPC	Gen 4	Diesel	0.8	100	14.4	130	MMBtu/ Day	0	440

Table 4.6: Facilities with backup generation capabilities

4.7 Costs of Emergency Measures Necessary to Maintain Service

Table 4.7.1 lists the facilities on the Freeport Downtown Microgrid with backup generation capabilities and the non-fuel costs incurred during an outage.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
SIUH	*Ongoing Measures*	*Staffing, generator operations*	*1,000*	*$/hour*	*Year-round*
SBPC	*Ongoing Measures*	*Staffing, supplies*	*20,000*	*$/day*	*Year-round*

Table 4.7.1: Cost of Maintaining Service while Operating on Backup Power

Table 4.7.2 lists the outage cost at facilities on the East Shore Microgrid when no backup generation capabilities are available.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
SIUH	*Ongoing Measures*	*5MW Generators rental or relocating patients*	*10,000*	*$/day*	*Year-round*
SBPC	*Ongoing Measures*	*Additional staffing, bussing, supplies*	*75,000*	*$/day*	*Year-round*

Table 4.7.2: Cost of Maintaining Service while Backup Power is Not Available

4.8 Services Provided

Table 4.8 lists each facility and level of service that can be maintained for each facility during an event when backup generation is available and when backup generation is not available.

Facility Name	Percent Loss in Services When Using Backup Gen.	Percent Loss in Services When Backup Gen. is Not Available
SIUH	30%	100%
SBPC	50%	100%

Table 4.8: Percent loss in service when using backup generation is and when backup generation is not available during outages

Fire: The FDNY garage in the microgrid area supports a population of 86,000. It is estimated that a 77% increase in response time is incurred during widespread power outages in the area. The next closest apparatus bay is 1.3 miles away.

Hospital/Medical: Staten Island University Hospital, the center of the microgrid serves a population of 474,515. This figure represents the total Staten Island population, as there is no breakdown of population served by this hospital facility.

Wastewater: The wastewater pumping station in the East Shore Microgrid serves a total of approximately 20,000 residential and commercial customers.

Retail: Several facilities on the Hylan Boulevard retail corridor would be supplied by the microgrid.

Schools: PS52 is connected to the microgrid.

4.9 Benefits-Cost Analysis

Industrial Economics, Inc. (IEc) conducted a Benefit Cost Analysis (BCA) for the East Shore Microgrid. The BCA report is in Appendix A. The calculated present value costs of the East Shore Microgrid is $172M and the East Shore Microgrid provides a present value benefit of $609M and a net present value benefit of $438M to the southeast region of Staten Island. The results of the BCA indicate that the benefit to cost ratio is 3.6. The analysis results are in Table 4.9.1.

The positive benefit to cost ratio did not require IEc to run another model for average annual duration of major power outages required for project benefits to equal costs. The project team ran a several scenarios of the BCA model to determine the outage benefit and benefit to cost ratio during major outages and events.

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,000,000	$88,200
Capital Investments	$36,400,000	$2,930,000
Fixed O&M	$5,670,000	$500,000
Variable O&M (Grid-Connected Mode)	$20,400,000	$1,800,000
Fuel (Grid-Connected Mode)	$42,300,000	$3,730,000
Emission Control	$3,310,000	$292,000
Emissions Allowances	$4,020	$355
Emissions Damages (Grid-Connected Mode)	$62,600,000	$4,090,000
Total Costs	**$172,000,000**	
Benefits		
Reduction in Generating Costs	$44,400,000	$3,910,000
Fuel Savings from CHP	$4,260,000	$376,000
Generation Capacity Cost Savings	$25,300,000	$2,230,000
Distribution Capacity Cost Savings	$26,100,000	$2,310,000
Reliability Improvements	$813,000	$71,800
Power Quality Improvements	$469,000,000	$41,300,000
Avoided Emissions Allowance Costs	$24,400	$2,150
Avoided Emissions Damages	$39,800,000	$2,600,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$609,000,000**	
Net Benefits	**$438,000,000**	
Benefit/Cost Ratio	**3.6**	
Internal Rate of Return	**N/A**	

Table 4.9.1: BCA Results

Figure 4.9.1 illustrates the results of the benefits and costs of the East Shore Microgrid BCA analysis. The major costs are the capital investments for the two new engines and the new circuits and conduits, and the emission control costs associated with the new reciprocating engines. The major benefits are from the power quality improvements to the microgrid customers and reduction in generating costs.

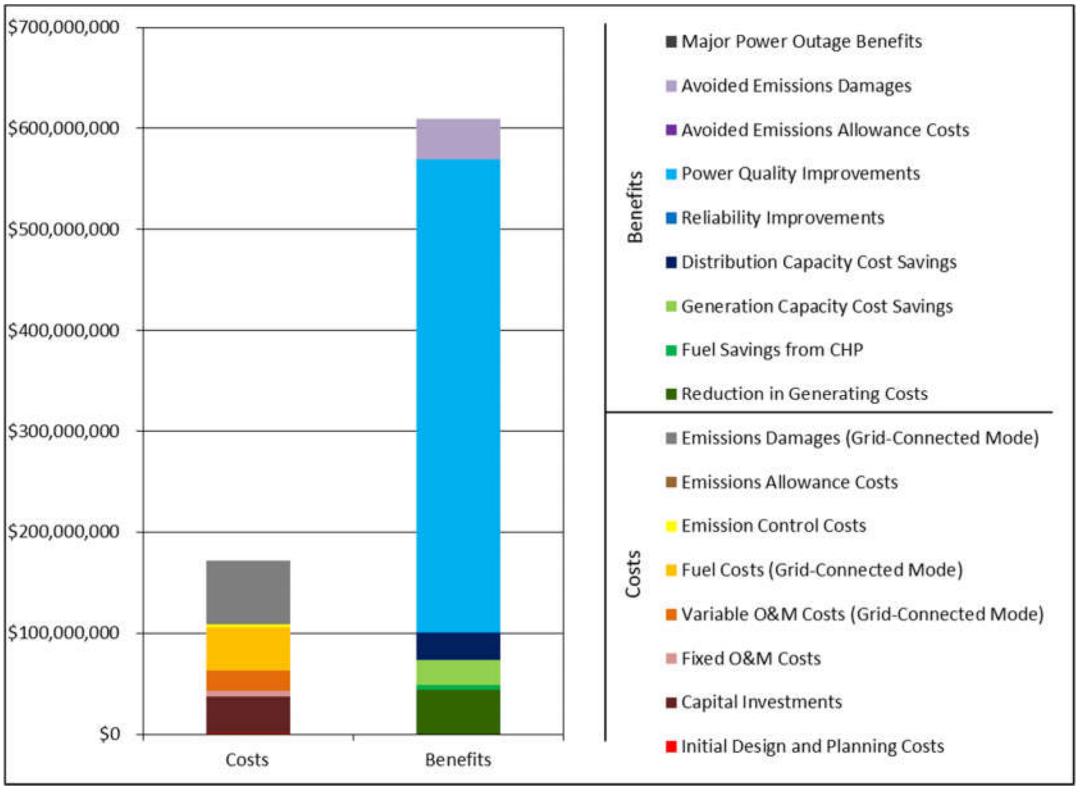


Figure 4.9.1: BCA Results

5 Conclusions, Recommendations and Lessons Learned

The Staten Island East Shore Microgrid is an exciting opportunity to bolster a region's resiliency through the ability to isolate and power a vulnerable part of Con Edison's electric grid in southeast Staten Island. Utilizing local generation, controls and circuit isolators, the critical facilities at the core of the microgrid and the surrounding residential and commercial community are supported during baseload operation (CHP), peak load periods and emergency events.

The project has received strong stakeholder support during this Phase 1 effort from the core facilities, the city, the community and utility.

While the project offers strong social benefits, the current avenues for revenues pose challenges to its realization. Based on our analysis of the project economics, we have arrived at the following conclusions:

- Project capital cost, as conceived, is approximately $36.85 million; total NPV of project cost (capital cost plus fixed and variable operating costs) at 10% discount rate is calculated at approximately $75 million
- The following factors impact project viability:
    - We assume that there is potentially no revenue stream for the added generation capacity, assuming NYISO Zone J market would require a mitigated entry period for the generators
    - The ability to produce CHP thermal energy is limited to the baseload of the Office of Mental Health South Beach Psychiatric Facility, thus a majority of the generation is simple cycle of nominally 8 MMBtu/MWh heat rate
    - The project provides important resiliency to a vulnerable radial portion of Con Edison's grid but there is currently no mechanism by which the value this provides to the utility is remunerated

To improve the economic feasibility of the project, it would require additional benefit, including any combination of the following:

- A revenue stream for its capacity (Con Ed, NYISO, etc)
- A modified funding structure made available from the NY Prize
- A reduced scope for the microgrid
- Additional grants or programs to offset microgrid component costs

Appendix A

Industrial Economics Social Benefit/Cost Analysis Report

Benefit-Cost Analysis Summary Report

Site 23 – City of New York (Staten Island)

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the New York City borough of Staten Island has proposed development of a microgrid that would serve 2,573 residential customers and 280 commercial/industrial customers. The critical service providers served by the microgrid include a firehouse, two wastewater pumping stations, and the Staten Island University Hospital. In addition, the microgrid would serve the John C. Thompson Elementary School, the South Beach Psychiatric Center, and the New York City Housing Authority's Berry Houses, as well as approximately 312 commercial customers and 11 additional facilities operated by the Port Authority of New York.[1]

Staten Island's microgrid would be powered by a new 13.22 MW natural gas-fired combined heat and power (CHP) system and 1.2 MW of new solar photovoltaic arrays. Each of these resources would produce electricity for the grid during periods of normal operation, as well as in islanded mode during power outages. The microgrid would also include 2 MW of battery storage. The system as designed would have sufficient generating capacity to meet average demand for electricity from all facilities on the microgrid during a major outage. The project's consultants also indicate that the system would be capable of providing frequency regulation, reactive power support, and black start support to the grid.

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.

[1] The microgrid will be connected to a 4 kV feeder line and be able to support 85 percent of the usage of the customers currently on this line. The project team estimates that the feeder line serves 2,432 residential, 312 commercial, and 11 Port Authority of New York customers. Since the project team is unable to provide detailed electricity usage information for each load group, this analysis has made two simplifying assumptions: 1) the 312 commercial customers are small commercial establishments that use less than 50 MWh annually; and 2) the 11 Port Authority of New York customers are large commercial or industrial customers that use more than 50 MWh annually.

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.[2] It also calculates an annualized estimate of costs and benefits based on the anticipated 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.[3]

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[2] 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 discount rate, to value CO_2 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 SO_2, 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.]

[3] 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.

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 even if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's benefits would be more than triple its costs.

Since the results for Scenario 1 suggest a benefit-cost ratio greater than one, the report does not present a detailed analysis of the impact of major power outages under Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio. The discussion that follows provides additional detail on these findings.

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
Net Benefits - Present Value	$438,000,000	Not Evaluated
Benefit-Cost Ratio	3.6	Not Evaluated
Internal Rate of Return	N/A	Not Evaluated

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)

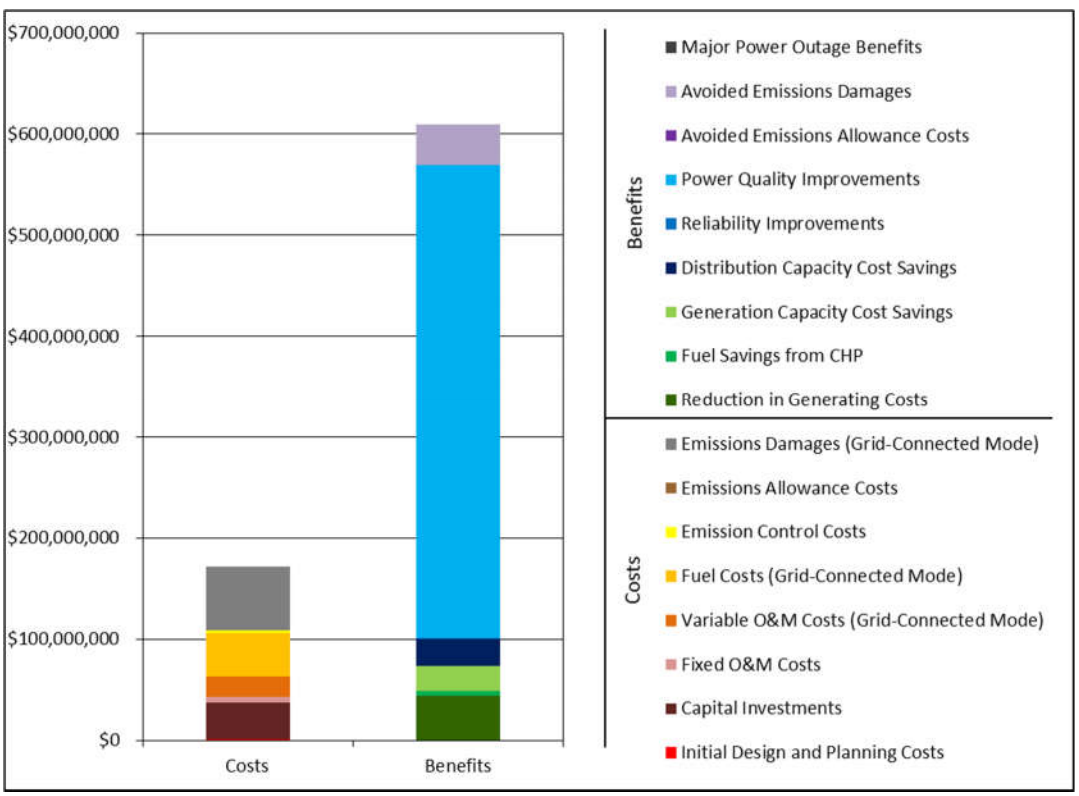

Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,000,000	$88,200
Capital Investments	$36,400,000	$2,930,000
Fixed O&M	$5,670,000	$500,000
Variable O&M (Grid-Connected Mode)	$20,400,000	$1,800,000
Fuel (Grid-Connected Mode)	$42,300,000	$3,730,000
Emission Control	$3,310,000	$292,000
Emissions Allowances	$4,020	$355
Emissions Damages (Grid-Connected Mode)	$62,600,000	$4,090,000
Total Costs	**$172,000,000**	
Benefits		
Reduction in Generating Costs	$44,400,000	$3,910,000
Fuel Savings from CHP	$4,260,000	$376,000
Generation Capacity Cost Savings	$25,300,000	$2,230,000
Distribution Capacity Cost Savings	$26,100,000	$2,310,000
Reliability Improvements	$813,000	$71,800
Power Quality Improvements	$469,000,000	$41,300,000
Avoided Emissions Allowance Costs	$24,400	$2,150
Avoided Emissions Damages	$39,800,000	$2,600,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$609,000,000**	
Net Benefits	**$438,000,000**	
Benefit/Cost Ratio	**3.6**	
Internal Rate of Return	**N/A**	

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 million. The present value of the project's capital costs is estimated at approximately $36.4 million. In addition to the new CHP plant ($31 million), significant investments include the $2.3 million for new solar photovoltaic arrays and battery storage, $500,000 to harden the Seaside Substation, and $2.05 million in switches and energy management controls.

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 $5.67 million (approximately $500,000 annually). These costs include parts, preventative maintenance, and monitoring for all energy resources, as well as additional labor costs and insurance.

Variable Costs

Among the most significant variable costs associated with the proposed project is the cost of natural gas to fuel operation of the system's new CHP plant. 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.[4] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $42.3 million.

The BCA also considers the project team's best estimate of the microgrid's variable O&M and emissions control costs (i.e., O&M and emissions control costs that vary with the amount of energy produced). These costs cover general operations and maintenance, including the cost of urea injections to control emissions. The present value of these costs is estimated at $23.7 million, or approximately $29.06 per MWh.

In addition, the analysis of variable costs 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. In this case, emissions from the new CHP plant will require the purchase of emissions allowances with a 20-year present value of $4,020 and cause damages of approximately $4.09 million annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $62.6 million.

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 $44.4 million; this estimate assumes the microgrid provides base load power. In the case of Staten Island's proposed microgrid, this assumption is consistent with the project's team operating profiles for the proposed photovoltaic arrays and new natural gas fired CHP plant. Cost savings would also result from fuel savings due to the new CHP system; the BCA estimates the present value of fuel savings over the 20-year operating period to be approximately $4.26 million. The reductions in demand for electricity from bulk energy suppliers and reduction in fuel consumption for space heating purposes would also avoid emissions of CO_2, SO_2, NO_x, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $24,400 and avoided emissions damages with a present value of approximately $39.8 million.[5]

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.[6] The project team estimates that microgrid resources will be able to supply 15.2 MW of

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[4] 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.

[5] Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model values emissions of CO_2 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 SO_2 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.

[6] 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.

additional peak load capacity. Based on resource operating profiles, this analysis estimates the potential impact on system-wide distribution capacity requirements to be approximately 10.2 MW per year. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $25.3 million over a 20-year operating period. The present value of the project's potential distribution capacity benefits is estimated to be approximately $26.1 million over a 20-year operating period.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, in the form of frequency regulation, reactive power support, and black start 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 $71,800 per year, with a present value of $813,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[7]

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.[8]

The estimate takes into account the number of small and large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers.[9] It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[10] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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.

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[7] www.icecalculator.com.

[8] The reported SAIFI and CAIDI values are for Consolidated Edison in 2014.

[9] In the absence of site-specific data on the characteristics of the customers the microgrid would serve, the analysis relies on the ICE calculator's default values for NY State. In addition, since the microgrid can only support 85 percent of the feeder line load during a power outage, the analysis assumes that only 85 percent of the customers on the microgrid (i.e., 2067 residential, 265 small commercial/industrial, and 9 large commercial/industrial customers) would avoid each outage.

[10] http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1.

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. In the case of Staten Island's proposed microgrid, the project team has indicated that approximately 150 power quality events would be avoided each year.[11] The model estimates the present value of this benefit to be approximately $469 million over a 20-year operating period.[12] Power quality improvements therefore represent the largest category of benefits for the proposed Staten Island microgrid.[13]

In reality, some customers for whom power quality is important (e.g., medical facilities) may already have systems in place to protect against voltage sags, swells, and momentary outages. If this is the case in Staten Island, the BCA may overstate the power quality benefits the project would provide. To test the sensitivity of the results to different assumptions about the project's impact on power quality, we conducted a breakeven analysis. We found that the project would yield positive net benefits as long as, on average, 10 or more system-wide power quality events are avoided each year. Conversely, the complete exclusion of power quality benefits would yield net *costs* of $30.9 million. In that event, the microgrid would need to provide additional benefits – e.g., by protecting the facilities it serves from major power outages – in order for its net benefits to remain positive.[14]

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 3.6; i.e., the estimate of project benefits is greater than that of project costs. Accordingly, the analysis does not consider the potential of the microgrid to mitigate the impact of major power outages in Scenario 2. Consideration of such benefits would further increase the net benefits of the project's development.

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[11] The project team notes that this is an estimate, as they were unable to obtain data from Consolidated Edison regarding the actual frequency of power quality events.

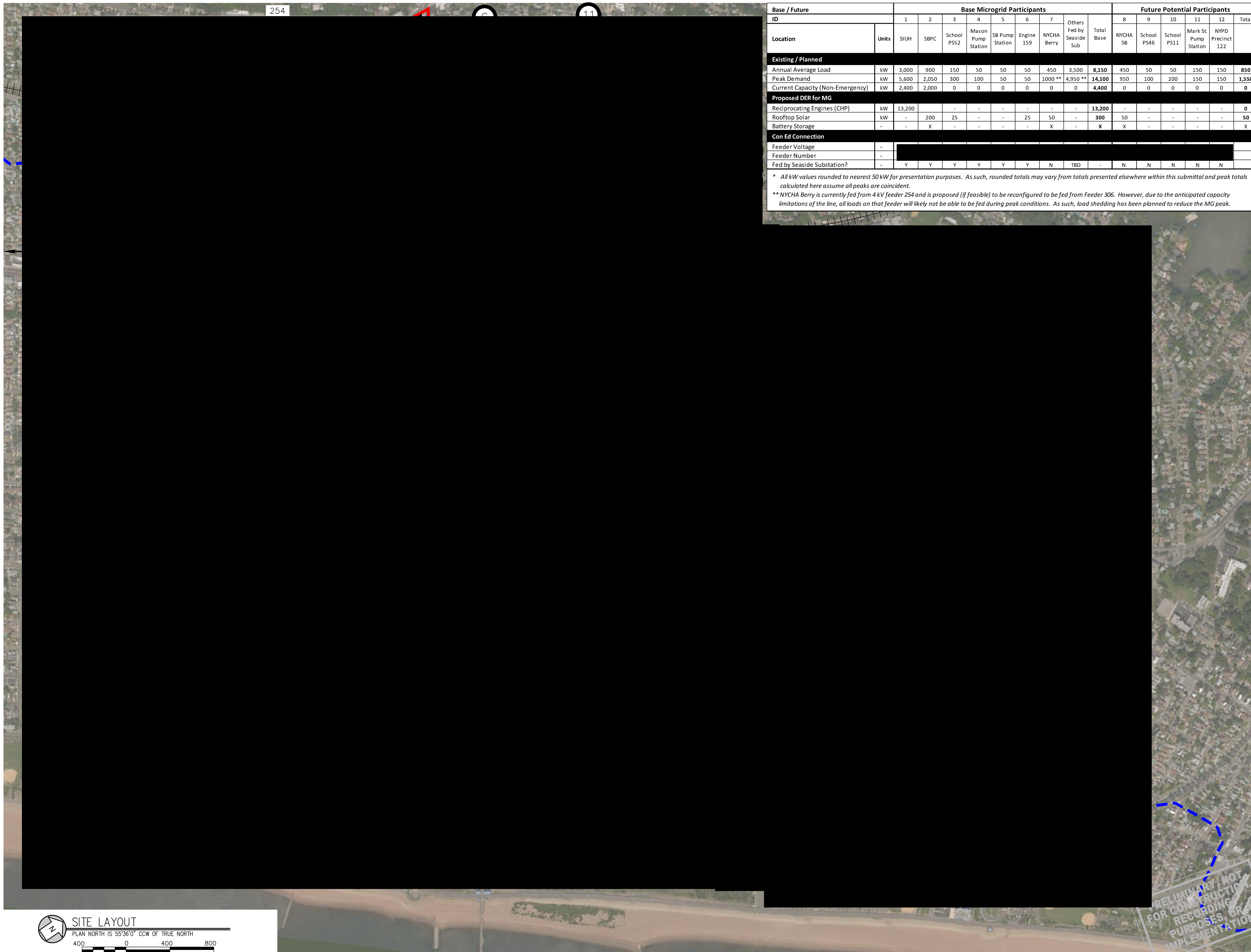
[12] As previously noted, the microgrid can only support 85 percent of the feeder line load. To take this into account, the analysis assumes that 85 percent of the customers on the microgrid (i.e., 2067 residential, 265 small commercial/industrial, and 9 large commercial/industrial customers) would avoid 150 power quality events each year.

[13] Importantly, the model relies on average costs per power quality event for customers across the United States, based on a meta-analysis of data collected through 28 studies of electric utility customers between 1989 and 2005. These costs therefore incorporate assumptions about the distribution of customers across economic sectors and other key characteristics, such as the prevalence of backup generation and power conditioning, which may not reflect the characteristics of the proposed microgrid. This is likely to be the case for Staten Island. Based on information provided by the site team, Staten Island's proposed microgrid will serve few, if any, customers in the construction, manufacturing, and mining sectors, which typically have the highest costs per power quality event. Instead, the proposed microgrid's customers are more likely to fall into the retail and public administration sectors, which typically experience substantially lower costs per event. [See: Sullivan, Michael J. *et al*. Estimated Value of Service Reliability for Electric Utility Customers in the United States. LBNL-2132E: June 2009.]

[14] Complete exclusion of power quality benefits would necessitate consideration of Scenario 2. Preliminary evaluation of that scenario suggests that the microgrid would need to protect its customers from an average of approximately 0.4 days of major power outages each year in order for the project to break even.

Appendix B

Project Single Line Diagram



[redacted]

Base / Future		Base Microgrid Participants									Future Potential Participants					
ID		1	2	3	4	5	6	7			8	9	10	11	12	Total
Location	Units	SIUH	SBPC	School PS52	Mason Pump Station	SB Pump Station	Engine 159	NYCHA Berry	Others Fed by Seaside Sub	Total Base	NYCHA SB	School PS46	School PS11	Mark St. Pump Station	NYPD Precinct 122	
Existing / Planned																
Annual Average Load	kW	3,000	900	150	50	50	50	450	3,500	**8,150**	450	50	50	150	150	**850**
Peak Demand	kW	5,600	2,050	300	100	50	50	1000 **	4,950 **	**14,100**	950	100	200	150	150	**1,550**
Current Capacity (Non-Emergency)	kW	2,400	2,000	0	0	0	0	0	0	**4,400**	0	0	0	0	0	**0**
Proposed DER for MG																
Reciprocating Engines (CHP)	kW	13,200		-	-	-	-	-	-	**13,200**	-	-	-	-	-	**0**
Rooftop Solar	kW	-	200	25	-	-	25	50	-	**300**	50	-	-	-	-	**50**
Battery Storage	-	-	X	-	-	-	-	X	-	**X**	X	-	-	-	-	X
Con Ed Connection																
Feeder Voltage	-	[redacted]														-
Feeder Number	-															-
Fed by Seaside Substation?	-	Y	Y	Y	Y	Y	Y	N	TBD	-	N	N	N	N	N	-

** All kW values rounded to nearest 50 kW for presentation purposes. As such, rounded totals may vary from totals presented elsewhere within this submittal and peak totals calculated here assume all peaks are coincident.*

*** NYCHA Berry is currently fed from 4 kV feeder 254 and is proposed (if feasible) to be reconfigured to be fed from Feeder 306. However, due to the anticipated capacity limitations of the line, all loads on that feeder will likely not be able to be fed during peak conditions. As such, load shedding has been planned to reduce the MG peak.*

SITE LAYOUT

PLAN NORTH IS 55°36'0" CCW OF TRUE NORTH

400 0 400 800

SCALE IN FEET

Sega
ENGINEERING & TECHNICAL SERVICES
16041 Foster
P.O. Box 1000
Overland Park, Kansas 66085-1000
(913) 681-2881
www.segainc.com
Sega Inc. dba Sega Engineering, PA PC
New York State Certificate # 0010427

PROJECT LOCATION:
NEW YORK, RICHMOND CO., NEW YORK

ANBARIC MICROGRID

Louis Berger

LEGEND:

- FEMA CRITICAL FACILITY
- NY PRIZE CRITICAL FACILITY
- VULNERABLE POPULATION
- CENTRAL THERMAL GENERATION FACILITY
- MAIN FACILITY ELECTRICAL FEED LOCATION
- POTENTIAL LOCATION FOR MICROGRID CONTROL
- SUBSTATION
- MG ISOLATION SWITCH
- POTENTIAL FUTURE PARTICIPANTS
- 33KV DISTRIBUTION NETWORK
- SANDY FLOOD LINE
- OPEN SWITCH BETWEEN CIRCUITS (W/ADJACENT CIRCUIT NO. LABLED)
- CIRCUIT [redacted]
- CIRCUIT
- CIRCUIT
- CIRCUIT

REV.	DATE	DESCRIPTION	DWN	CHK
B	2-2-16	ISSUED FOR REVIEW	JPS	NKN
A	1-8-16	ISSUED FOR REVIEW	JPS	NKN

IF SEALED, IT IS A VIOLATION OF THE STATE EDUCATION LAW (ARTICLE 145 – SECTION 7209) FOR ANY PERSON TO ALTER AN ITEM IN ANY WAY, UNLESS THEY ARE ACTING UNDER THE DIRECTION OF A LICENSED ENGINEER.

THIS MEDIA SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT

PRELIMINARY: NOT FOR CONSTRUCTION, RECORDING PURPOSES, OR IMPLEMENTATION

North Shore LIJ Staten Island University Hospital

SIUH MICROGRID STUDY

SIMPLIFIED LAYOUT DIAGRAM
(SUBTASK 2.1)

DESIGN BY: N. NINEMIRE	CHECKED BY: B. ROMINES
DRAWN BY: J. SEE	DATE: 7-15-15
CLIENT I.D. SEG001.02	SEGA PROJECT NO. 15-0146
CADD FILE NAME: 00-C100	
DRAWING NO. SLD-01	REV. B