18 - Clarkson Ave. (Brooklyn)

August 2016

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Clarkson Avenue Microgrid

July 14, 2016

Microgrid Feasibility Study

NY Prize Community Grid Competition
Stage 1: Feasibility Assessment
NYSERDA RFP 3044

Prepared By

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Project Summary

The conceptualized microgrid at Clarkson Ave would provide power resilience and reliability to Kings County Hospital (KCH), State University of New York Downstate Medical Center (SUNY DMC), and Kingsboro Psychiatric Center (KPC). This very large and unique cluster of health and medical emergency related facilities has provided over time a complete range of health, medical, and emergency services to millions of people in Brooklyn and the surrounding metropolitan area. KCH, the largest municipal hospital in New York City, is a Level 1 Trauma Center serving 2.6 million residents of Brooklyn and Staten Island. It is the official training site for the United State Army Reservist Medical Staff prior to their deployment. Together with SUNY-DMC, the two emergency centers have almost 4,000 visits per week. And with more than 1,500 patient beds, in- and out-patient visits total more than 17,000 per week, or almost 900,000 per year. Kingsboro Psychiatric Center houses 175 patients, and the Kingsboro Homeless shelter has more than 400 beds for men with substance abuse problems. Lastly, roughly 1,600 medical students are enrolled at SUNY DMC, and more than 20,000 people are employed at these facilities.

The Clarkson Avenue microgrid would ensure that critical services are maintained during a protracted grid emergency. Brooklyn and the whole of New York City are vulnerable to major storms such as Hurricane Sandy or Hurricane Irene, tornadoes, flooding, cold, and blizzards. Kingsboro Psychiatric Center can be used as an evacuation center for other centers in the area, as it did during Sandy when half of building #3 was used as a shelter for South Beach Psychiatric Center residents. Aside from major weather events, the area is also susceptible to electrical infrastructure failures such as widespread transmission outages, failure of area substations, or network collapse from multiple cascading feeder failures. Historic blackouts occurred that affected the Clarkson Ave area in 1965, 1977, and 2003. The blackout of 1977 was notable as it took place during a time of distress over the Son of Sam murders and economic downturn and the result of the blackout was widespread looting and vandalism. Crown Heights, which is only one neighborhood north of the proposed microgrid, was hit the hardest in terms of destruction due to the looting and vandalism.

The Clarkson Avenue microgrid will provide public benefit not only during major weather events or in widespread blackouts, but on a day-to-day basis as well. The proposed microgrid site is in the heart of the area served by Con Edison’s constrained Brownsville Substation. The electric load of the so-called Brooklyn-Queens Demand Management (“BQDM”) zone is often beyond the capacity of the Brownsville Substation throughout the peak load season from June through September. The proposed microgrid could lower demand on this substation by 8 MW or more and thus help avoid costly substation expansion and installation of new transmission feeders.

Task 1.1 – Minimum Required Capabilities

The Contractor shall demonstrate that the proposed microgrid has the following minimum required capabilities:

- **Serves at least one but preferably more, physically separated critical facilities located on one or more properties.**

The design will include representation of all the critical facilities located on separate properties within a pre-defined microgrid area. The facilities of the proposed microgrid are listed below and further shown in Figure 1:

- **Specific Information Regarding Critical Facilities**

In total, the proposed microgrid covers a total of over 4 million square feet of land. The proposed location for battery and fuel cell facilities on the Kingsboro Psychiatric Center grounds covers approximately 41000 square feet at 55 feet above sea level.

SUNY Downstate Medical Center (SUNY DMC)

- Serves 1660 students on a 13 acre campus
- Consists of the numerous health related colleges and the University Hospital of Brooklyn
- Total facilities account for over 2.5 million square feet of space
- A central boiler plant provides heating, cooling, and steam to the campus
- Power is supplied by the New York Power Authority (NYPA) but distributed by ConEd
- Facility has multiple diesel emergency generators in various locations
    - One 1000 kW generator in the Basic Sciences Building
    - Four 750kW generators in the University Hospital
    - One 1000kW generator in the Health Science Education Building

Kingsboro Psychiatric Center (KPC)

- Twenty eight building campus serving inpatient, outpatient, and crisis psychiatric patients
- Central plant consists of multiple infrastructure facilities:
    - Two 450-ton electrical centrifugal chillers
    - Three dual fuel steam boilers (2-500 HP and 1-350HP)
        - Natural Gas
        - No. 2 Oil
    - Two 1000 MBH condensing boilers for hot water
    - Two 1000 MBH summer boilers for reheat systems
- Facility has examined solar PV and CHP capabilities for efficiency upgrades
- New boiler controls, PRV station upgrades, BMS integration, and chiller optimization also considered
- Three diesel generators onsite:
    - One 1000kW generator
    - Two 800kW generators
    - During an emergency, KPC can generate 1300kW of electrical power
- Building #3 serves as an evacuation center for South Beach Psychiatric Center
- Building #3 in particular was severely impacted by Hurricane Sandy

Kings County Hospital Center (KCHC)

- Campus contains 16 active buildings totaling around 2.6 million square feet of space
- The hospital contains 620 beds and employs roughly 3300 daily employees
- Contains 17 diesel backup generators, varying in size from 75kW to 2MW

New York City Homeless Services Kingsboro Shelter

- Housing facilities with 400 beds for area homeless people located on the Kingsboro Psychiatric Center's grounds.

1. https://www.wbdg.org/ccb/VA/VASUSTAIN/chp_hospital_guidebook.pdf

The map below shows facilities included in the proposed microgrid:

Figure 1

The map below shows the location of the proposed microgrid to the Brownsville Substation. All of the microgrid facilities are within the targeted Brooklyn Queens Demand Management zone that Con Edison has forecasted to be overloaded in the near future.

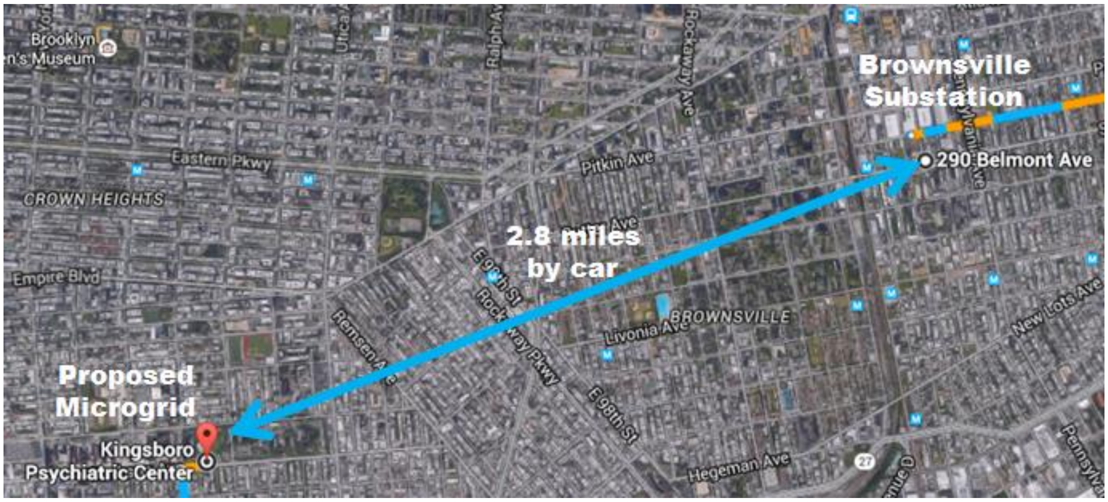


Figure 2

- **The primary generation source capacity cannot be diesel-fueled generators.**

A variety of non-diesel generation systems were assessed as primary power sources for the microgrid. Based on preliminary facility and energy usage assessments, coincident electric demand is estimated to range from a base-load of 5 MW to a peak of 16 MW. A combination of fuel cells, CHP, rooftop solar PV and energy storage are thought to provide resilient and reliable sources of power to serve the microgrid load in an islanded condition. A large, 5-10 MW CHP system on vacant KPC land on the western edge of the site closest to Kings County Hospital was assessed as a means of providing a significant cost savings and added resilience. Delivering the system's steam across (under) Albany Avenue to Kings County Hospital as the CHP thermal output would far exceed the heating requirements of KPC was determined to be infeasible. Based on that, Kings County Hospital is pursuing a smaller CHP system (< 1.3 MW) on their campus, though siting and constructability are challenging given the lack of space. Fuel cells perform best technically and economically when base loaded, while the combination of PV, battery storage and existing backup generation are more suited to load following and peak reduction. These performance characteristics were taken into account as part of the initial system configuration, modeling and optimization efforts.

- **A combination of generation resources must provide on-site power in both grid connected and islanded mode;**

Presented below are initial DER considerations and applications:

Combined Heat and Power (CHP) or Cogeneration

CHP is thought to have application in the Clarkson Avenue Microgrid as it requires a consistent thermal/heat sink. The three primary facilities, Kings County Hospital Center (KCHC), SUNY Downstate Medical Center (SUNY DMC), and Kingsboro Psychiatric Center (KPC) have year round thermal requirements that could be served by CHP. Base-loaded CHP would provide important load relief to Con Edison as part of their efforts to reduce electric demand in the Brownsville-Queens Demand Management initiative. As part of unrelated work, Burns Engineering has already completed Level 1 CHP assessments for KCHC and SUNY DMC, with the results indicating viable financial performance with payback periods under 10 years possible depending on the cost of natural gas. A separate Level 1 CHP assessment was performed by another company for KPC and the results were similar – depending on the cost of natural gas.

Solar PV

The estimated combined rooftop capacity of the microgrid facilities is estimated to be 700 kW – 1,000 kW. This estimated range is based on nameplate capacity with peak output occurring on a few hours during peak sunny days in summer. Questions related to roof load bearing capacity, local wind regimes, and mechanically attached vs ballasting remain to be assessed.

Battery Storage

The role of potential battery storage in the Clarkson Avenue microgrid will most likely be tied to complementing intermittent renewable resources, specifically solar PV. Battery storage would also help to mitigate electric load variability and ensure higher levels of power quality and microgrid stability. Space to locate batteries, while generally limited at KCHC and SUNY, is less constrained at KPC based on the significant open land area on the grounds of KPC. Rough estimates suggest that several megawatts of storage could reasonably be located on KPC grounds, assuming no other competing uses are planned or being considered.

Fuel Cells

The Clarkson Avenue microgrid can incorporate fuel cells based on available area and access to natural gas. Fuel cells need to operate in a base-loaded condition as they are not well suited to following electric loads. Also, some systems such as the Bloom Fuel Cell have high electrical efficiency (50% - 60%) and don't provide waste heat utilization, while other technologies do feature combined heat and power functionality. To gain economies of scale with a fuel cell deployment, facilities with large and consistent loads, namely KCHC and SUNY DMC, are being considered as preferred off-takers of the power.

Wind Power

Small-scale wind power, most likely building mounted, has limited application in the Clarkson Avenue microgrid due to the relatively poor siting options and low power output. Other obstacles are related to permitting, noise, aesthetics, and concerns for birdlife.

Backup Generators

The installed capacity of backup generation within the proposed microgrid exceeds 17 MW. Some of the units are only a few years old. Depending on the nature and duration of the events or circumstances causing the prolonged islanded condition, it is expected that in most instances the installed base of backup generation would serve to provide transitional power, incremental load during peak demand periods and redundancy in the event of a major failure of primary distributed energy resources.

- **The Project Team will consider both grid-connected and islanded mode in the microgrid design;**

The Team considered several possible solutions for the Microgrid Control System. Along with the advanced microgrid controller being developed in a DOE project by GE, NREL and others, a set of commercial platforms are also available as candidate solutions. The available commercial microgrid control platforms vary in functionality, and a complete control solution will typically be comprised of an integrated suite of both hardware and software components. Depending on the microgrid site use cases, the control solution will often require some level of custom code development or configuration scripting to support integration with electric distribution equipment, the building energy management systems (BEMS), controllable loads, and generation assets within to the microgrid, as well as the utility enterprise systems (EMS/DMS/OMS) and the ISO control center.

The key components comprising the Microgrid Control System will include one or more of the following platforms as needed to support site-specific requirements:

Microgrid Transfer Switch

The transfer switch subsystem is the primary integration point between the switching and protection components in the power delivery system and the microgrid controller unit. Key performance aspects being analyzed are: ability to facilitate seamless disconnect/reconnect, switching transition (make-before-break vs. break-before-make), transfer speed, cost, availability, fault-current contribution, and maintenance requirements. Other performance aspects include coordination with the microgrid controller unit to provide voltage and frequency support at the POC, transfer of critical load, and fast shedding of non-critical load during disconnect. Several commercial transfer switching and interconnection solutions exist. Mechanical switching solutions built on conventional breakers and relays tend to be less expensive and least performing in terms of transfer speed. Higher performance, and higher cost, is offered by advanced solid-state switches that could provide seamless, high-speed disconnect and load transfer in less than a quarter-cycle.

Microgrid Controller

The microgrid controller unit enables automation of the core microgrid operations and dynamic control of grid support functions. Existing commercial solutions differ by vendor and support various levels of functionality such as: generation optimization and optimal dispatch; renewables integration; asset monitoring and scheduling; and integration adapters for common protocols such as Modbus/DNP3/BACnet. In available commercial microgrid control solutions, renewables are usually integrated via the specific generation system controller (e.g. solar panel and inverter system package and controller). Several commercial microgrid controllers have configuration options for renewables and limited functionality to integrate energy storage. CHP is usually addressed as part of the broader microgrid system design and its integration might span several site-specific generation components and buildings. More advanced microgrid controller units, such as the DOE controller being developed by GE and other evolving systems, are projected to include advanced distribution grid support functions, optimized energy storage and renewables integration, energy market functions supporting dynamic pricing and ancillary services, and tools for advanced data collection, situational awareness, and operations analytics.

Building Energy Management System (BEMS) Adapters

Several of the commercial microgrid control platforms provide integration with building energy management systems via the BACnet protocol. The vendors which provide these platforms have developed a library of adapters during recent years from participation in various microgrid pilot projects. The adapters offer various levels of control integration between the microgrid controller and the legacy BEMS platforms deployed in facilities within the microgrid. This facilitates control of building systems, such as HVAC and lighting, interfaced through the BEMS in support of microgrid load shedding or routine load shifting/balancing activities. Availability of these adaptors can also enable significant cost savings for an integrated microgrid control solution.

Microgrid Energy Management System (MG EMS)

The Microgrid EMS is an evolving software component. Existing microgrid controller units offer basic tools for configuration of the microgrid asset network and monitoring of operations. The Microgrid EMS is the envisioned next generation of the existing microgrid management tools. The MG EMS provides an extended suite of automation and grid support functions and visualization and planning tools supporting the configuration and dynamic orchestration of microgrid operations. Current IEEE 1547 and P2030 standards working groups are addressing requirements and data models for microgrid controller interfaces and grid support functions for the evolving Microgrid Controller Unit and the MG EMS solution space. A commercial Microgrid EMS is not available at this time; however, a vendor that provides a microgrid controller and demonstrates that they have a microgrid EMS solution in development for their specific controller platform offers a highly desirable platform with growth potential. The major vendors in the space are in fact working on microgrid EMS applications; the smaller niche players which lack the capital for such development are somewhat static, offering their baseline operator tools and options to purchase customized development for additional functions or asset adapters.

DER Management System (DERMS)

DERMS is another evolving software platform. Some vendors are working to integrate functionality across their demand response platform, microgrid control platform, and various DER controllers (e.g. Battery Energy Storage System, Solar Plant, Wind Farm, etc.) plus provide deep integration with utility DMS/OMS/EMS systems. A DERMS solution is not required for a site specific community microgrid. However, when selecting a microgrid controller, it is important to consider the vendor's development cycle and ultimate vision for the platform. A vendor with a forward looking view of holistically developing their microgrid control solution across their other platforms and ultimately reaching a DERMS enterprise-scale solution, will offer a well thought out and long term solution with great modularity.

- **Must be able to form an intentional island;**

Islanding is the situation where distributed generation or a microgrid continues energization of a feeder, or a portion of a feeder, when the normal utility source is disconnected. For a microgrid to sustain an islanded subsystem for any extended duration, the real and reactive power output of the generation must match the demand of that subsystem, at the time the event occurs. Exact real and reactive power equilibrium on a subsystem is improbable without some means of control. If there is a mismatch, the subsystem voltage and frequency will go outside of the normal range, and cause the DG to be tripped on over- or under-frequency or voltage protection. The amount of time required for voltage or frequency excursion to trip the DG is a function of the mismatch, parameters of the circuit, as well as the trip points used. Without active voltage and frequency regulation controls providing stabilization, an island is very unlikely to remain in continuous operation for long. The Project Team will consider switching technologies (described in the response above) that would allow the microgrid to seamlessly and quickly transition to islanded mode, and also incorporate the appropriate communications and controls technologies (also discussed above) that would allow the microgrid to remain electrically viable and persist for the duration of the emergency, subject to fuel availability. Many utilities have been historically resistant to intentional islanding, however, with the correct IEEE 1547 settings in the protective relays, and the potential to incorporate utility direct transfer tripping, this obstacle is expected to be overcome.

- **Must be able to automatically separate from grid on loss of utility source and restore to grid after normal power restored;**

The design will include power and communication equipment necessary to separate from the grid in the microgrid design. Furthermore, strategies for re-connecting and the equipment necessary to accomplish these strategies will also be considered.

- **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/day and seven days per week utilization of the power produced by these resources;**

Resources will be allocated and dispatched to ensure that manufacturer required service and maintenance will not negatively impact operations or safety. The microgrid will be designed and configured such that intermittent resources will be paired with dispatchable energy resources including natural gas-fired generation equipment and battery storage as appropriate.

- **If information is available, provide an overview of historical reliability of the electric supply for the particular microgrid, such as major interruptions by date, and/or average number and length of interruptions;**

Con Ed is the electric distribution utility serving all of Brooklyn. Con Ed has experienced an average of 2.27 power interruptions per 1000 customers spanning an average length of 4.58 hours per interruption. However, the 2013 New York State Department of Public Service ("DPS") data also clearly shows that the total customer hours of interruption due to major storms has increased substantially over the last two decades, particularly since 2010. With this in mind, the Project Team will develop a resilient design that incorporates hardening strategies commonly practiced by systems engineers in areas exposed to storms and outage events. This includes flood avoidance and flood control measures applied to generators, transformers, and switchgear, fault-tolerant and self-healing network designs, redundant supply or reconfigurable supply where it makes sense, remote monitoring and diagnostic equipment, robust construction, undergrounding where possible, and a host of other time-tested measures.

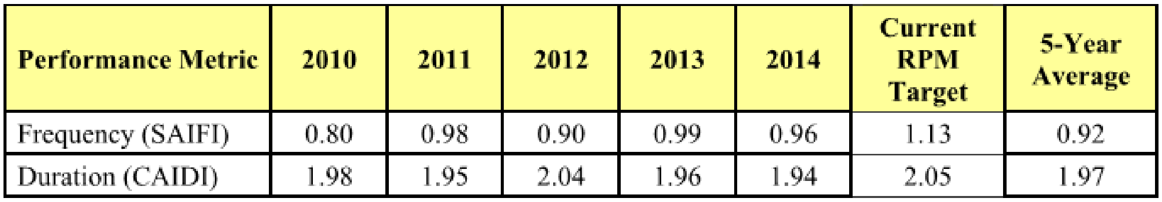
History has shown that while “blue sky” outage events are stochastic, they can be clustered during times of high demand when the system is stressed. Also, major storm-related events (hurricanes, ice, snow, tornadoes, etc.) are more likely during certain seasons or months of the year than others.

Most routine maintenance can be accomplished during off-peak periods, eliminating the possibility of incurring peak demand penalties from system down-time. More lengthy maintenance can be scheduled for off-peak hours. The Project Team will consider reliability-centered maintenance (RCM) strategies that focus more attention on critical pieces of equipment that could affect the microgrid operation (such as rotating machines, transfer switches, breakers) and recommend periods during the day, week, and year when routine maintenance would be less likely to coincide with an outage event. This is a data-driven task that is likely to become more effective given a longer operating history.

Clarkson Avenue History of Extreme Weather and Major Outage

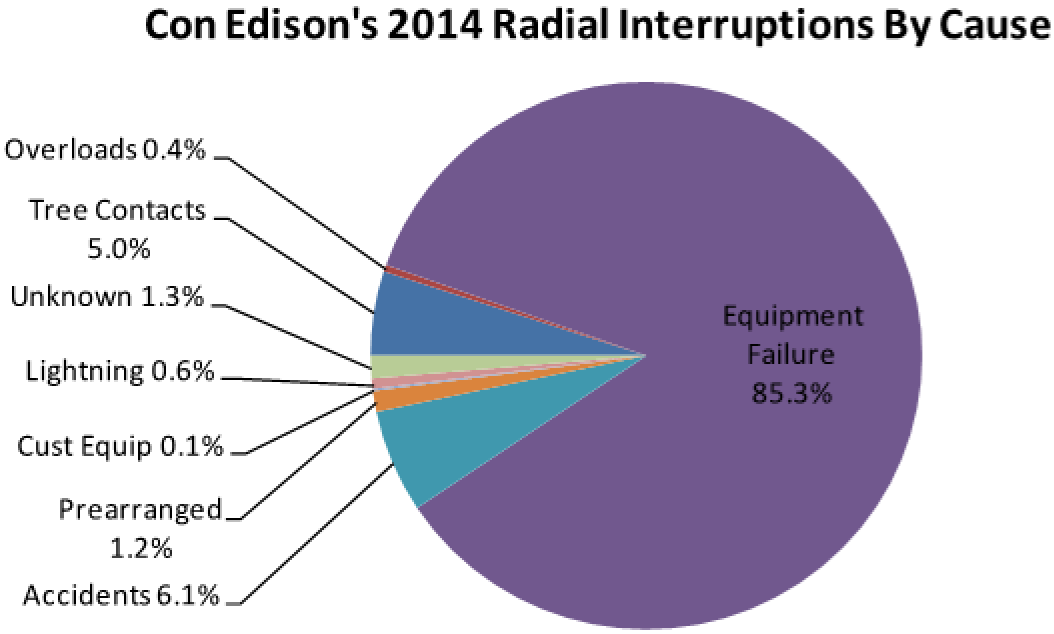
As with any major metropolitan area along the east coast, New York City and the borough of Brooklyn are vulnerable to hurricanes and tropical storms, including most recently Superstorm Sandy and Hurricane Irene. Several times in recent years, tornadoes have struck Brooklyn and Queens, resulting in widespread street flooding and extensive property and infrastructure damage. Additionally, the city is prone to extreme cold, snowstorms and blizzards. During Sandy, KPC accepted patients from other mental facilities including South Beach Psychiatric Center in Staten Island that was forced to evacuate.

Historic blackouts have also occurred in 1965, 1977 and 2003, with the blackout of 1977 resulting in widespread damage from looting and vandalism.



Performance Metric	2010	2011	2012	2013	2014	Current RPM Target	5-Year Average
Frequency (SAIFI)	0.80	0.98	0.90	0.99	0.96	1.13	0.92
Duration (CAIDI)	1.98	1.95	2.04	1.96	1.94	2.05	1.97

A majority of faults and loss of power in the Con Edison territory are the direct consequence of equipment failure or accidents.



- **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 with the American National Standards Institute (ANSI) c84-1 standards when islanded;**

The microgrid's functional design will consider both the sufficiency and control and communication capability for generation to maintain voltage and frequency while in islanded mode. The study will also explore the economics of energy storage both as a resource for capturing variable renewable energy, if any, to ensure reliability of meeting load during emergency or engage in energy arbitrage with the grid, and for providing ancillary services to the grid.

When considering the load / generation mix, several classifications of load may be considered. Generally, these classifications fall into critical, discretionary, and deferrable. At a minimum, the generation and storage mix must be sufficient to meet critical load at all times, i.e. the microgrid will be sized to meet the critical load (constituting the baseload) at all times during normal and emergency periods. The microgrid will attempt to meet the discretionary load during the emergency period, provided there is sufficient supply from internal generation. However, in a variety of likely circumstances, available generation might exceed critical load. In such cases, additional load may be served, but sufficient controllability must be incorporated in the design to shed load if the need arises. In a contingency, the microgrid will incrementally shed discretionary loads until load and supply balance is achieved. Curtailable load is the load that will be immediately dropped at the onset of the interruption of power delivery from the larger grid. Additionally, some load has flexibility to be scheduled, which adds an additional layer of control to the load / generation mix. If storage is feasible for the design, the load / generation mix will also consider charge / discharge needs for the storage system.

While the islanded operation of the microgrid will likely be the primary driver for determining the load / generation mix, size and operating modes and import / export in grid-connected mode may also be evaluated. The import / export of power to and from the microgrid will be determined from the Load & Supply Analysis and comparison of variable costs of microgrid generation with the applicable hourly prices to buy from or sell to the larger grid.

For instance, previous work by the Project Team on another microgrid feasibility study indicated that during normal conditions (i.e., non-emergency periods) a natural gas based microgrid may purchase power from the utility / electricity supplier or the NYISO market at some of the hours, and self-generate or even sell to the grid in other hours; all depending on the relative cost of self-generation compared to the hourly wholesale zonal prices (as buyer of power from either the utility/electricity supplier, or from the NYISO) or compared to the locational marginal prices (LMP) (as a wholesale market seller to the NYISO). That analysis was based on simple economic comparison, ignoring regulatory hurdles or ISO qualification requirements.

Dispatch of internal generation will be based on both economic (i.e., efficiency) and reliability considerations, with the least expensive generation resource running as baseload and incrementally more expensive resources running in cycling or peaking mode, and stacked on top of the baseload generation (i.e., microgrid's merit order curve).

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

The Team has begun considering design options for this task. Important information has recently been requested from both the utilities and facilities, which if made available, will provide details on in-place networks and protocols that possibly could be leveraged in support of this requirement (e.g. leverage for cost saving and interoperability purposes).

The first step is to determine if the microgrid solution will leverage existing networks or if there is a need to design and deploy new communications systems. Once the network platform is identified we will move to select platform and protocol compatible monitoring services as well as security services to satisfy the cyber security protection functions.

The Team evaluated the use of existing communications systems in two important areas:

Cost Savings and Interoperability

Reuse of existing communications systems can provide cost savings as the microgrid developer will not be required to deploy an entirely new communications fabric. Individual network segments or complete reuse of the communications system can be applied and significant cost savings can be achieved. Additionally, where reuse is leveraged, protocols and data models can be selected to achieve maximum interoperability and performance.

Security and Resilience

There is a trade-off between cost savings acquired via reuse of existing communications systems and the reduced security and resilience attributes in older communications technology and design approaches. This trade-off will be analyzed, and cost and security considerations will be balanced to accommodate the site-specific functional requirements.

Maximum weather resilience and performance is achieved when underground fiber optic networks are deployed. Additional surety can be obtained by creating redundant fiber rings and including two-way communications. The use of fiber, redundant networks, and underground deployment makes this the most reliable and resilient method, but it is also the most costly option. The generation portfolio for the microgrid and potential use cases during connected and islanded modes would go a long way in determining the performance requirements for the communications infrastructure.

Cyber security addresses protection against hacking and malicious intent. The team will consider options such as: modern hardware platforms and network nodes that incorporate device level authentication and authorization; adding security services to the microgrid control nodes and control center to address encryption of data at rest and data in motion; and adding a security architecture that applies defense in depth design principles which includes segmenting of data and system components across different levels of security zones to offer a hierarchy of authorization constraints and system access barriers. Note that cyber security services can be added as a security layer on top of existing communications when reusing networks but cannot change the existing physical security, resilience or performance limitations of the existing networks or device nodes.

- **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 three main anchor facilities (SUNY DMC, KPC, and KCHC) are all critical hospital and emergency care facilities that serve a number of socially and economically vulnerable populations. In the case of KPC, during and after Superstorm Sandy the site served as a refuge and accepted patients from remote and related psychiatric care centers including South Beach Psychiatric Center in State Island that were flooded in other parts of the City.

- **Must include an uninterruptable fuel supply or minimum of one week of fuel supply on-site;**

The natural gas fired plants are supplied by pipeline. Renewable resources would be constrained by the extent of storage deployed in the microgrid and the intermittency of the renewable source.

- **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;**

The microgrid design will take into account GE EC's findings from its NJ Storm Hardening Project performed for the NJ Board of Public Utilities. The proposed microgrid site is approximately 55 ft. above sea level, so vulnerability to flooding is limited to localized events that may occur during heavy rains or from water main failures. On-site power generation mitigates the risk of excess load on underground wires, and the underground distribution system is not vulnerable to power cuts due to high winds and icing.

The Project Team expects that natural gas power generation should be able to run for days without an operator being on-site; however, the Project Team will work with City authorities and stakeholders to ensure that clearing of snow or dirt and debris from solar panels and providing access to microgrid assets has a high priority.

- **Provide black start capability;**

The proposed microgrid will be designed to provide black start capability. It will be designed to be automatic based on a specified time frame of sustained utility outage and/or a command from the microgrid operator to transfer from grid-connected to microgrid operations. The on-site power systems will have the ability to start and operate using battery power and UPS devices and controls to start from a state of zero power to a state of sustained power production as matched to the microgrid load. Based on criticality and necessity, certain critical loads will be given a priority during black-start operation.

Task 1.2 – Preferable Microgrid Capabilities

The Contractor shall indicate to what degree the microgrid includes the following preferred capabilities:

- **Integrate and demonstrate operation of advanced, innovative technologies in electric system design and operations, including, but not limited to, technologies that enable customer interaction with the grid such as, Microgrid Logic Controllers, Smart Grid Technologies, Smart Meters, Distribution Automation, Energy Storage;**

The proposed microgrid is a microcosm of the modern electric power system, and to that extent, the application of advanced automation and control technologies will be explored to enable enhanced visualization, monitoring, control and interaction. The ultimate goal of “advanced, innovative technologies” is to enable safe, reliable, economic operation of the microgrid, in both grid-connected and islanded mode. This includes: consideration of best in class distributed energy resources, including demand response, energy efficiency measures and energy storage, to supply the instantaneous demand; smart grid and distribution automation technologies, such as solid-state transfer switches, and automatic fault location isolation and service restoration (FLISR) schemes, to ensure reliability and power quality; and smart relays, adaptive protection, special protection schemes, and Smart Grid/Distribution Automation (SG-DA).

Reliability-oriented SG-DA, including automated field devices (switches, sensors, and reclosers) and decentralized or centralized control, improves reliability by accelerating the detection and isolation of faults and reconfiguring the delivery system to restore service more quickly to more customers (wherever feasible). This benefit is now well established for normal “blue sky” operations, with several examples in literature of 20-40% reduction in the standard industry outage metrics, depending on circuit and system characteristics. The precise benefits of SG-DA to storm resiliency and recovery are harder to quantify (due to the lack of available methodologies and metrics), but anecdotal evidence suggests they are real and potentially substantial. The Project Team will explore the application of SG-DA solutions to the community microgrid to ensure reliability in both connected and islanded mode and to enable rapid, seamless transfer when the grid is down.

Strategic placement of field devices can enhance the flexibility and innate reliability of the microgrid area, whether it is in grid-connected or islanded mode. Reclosers, sectionalizers, and fuses are the mainstays of conventional utility overcurrent protection schemes. Digital sensors and measurement devices, such as transformer monitors, remote fault sensors, and Advanced Metering Infrastructure (AMI) Smart Meters all help to provide additional situational awareness to both the utility operations center and the microgrid control system. During storm operations and post-storm recovery, increased situational awareness provides faster detection of fault conditions to allow operators to respond more rapidly – both through automation and dispatch of field crews. D-SCADA and Integrated DMS/OMS are emerging technologies that provide the operator interface for monitoring remote sensors, as well as the control fabric for communication with switching devices on the distribution system. When the microgrid is in islanded mode, it is possible for a mature microgrid controller to take on features of a DMS/OMS, monitoring the system for fault events and automatically isolating faulted areas and reconfiguring the system so that as little of the load is affected as possible. The Project Team will assess the existing SG-DA investment and plans by the utility and determine, conceptually, how they impact the microgrid operations and what additions may be feasible.

- **Include an active network control system that optimizes demand, supply and other network operation functions within the microgrid;**

The Project Team is evaluating the current set of available commercial microgrid controllers. A best of breed selection will be made to obtain alignment with the microgrid site's requirements. From recent microgrid studies, the Project Team is aware that available commercial microgrid controllers primarily support various levels of the most fundamental operating functions, such as load shedding, optimal dispatch, integration of renewables or energy storage, forecast and scheduling, and basic situational awareness. Advanced functions like deep control integration with external SCADA or DMS systems or deep monitoring integration with AMI and other data collection and analysis systems is typically a custom developed adapter built to support a specific microgrid use case and system configuration.

- **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;**

The Project Team considered all opportunities to incorporate renewable resources into the generation mix for the Clarkson Avenue microgrid. The project's functional design is based on the generation resource mix (as determined by the availability and potential costs-benefits) and desired environmental requirements.

- **Include energy efficiency and other demand response options to minimize new microgrid generation requirements;**

Energy efficiency options are being considered and/or underway at the primary sites to drive down electric and fuel usage. The energy efficiency of the system will be based on the choice of new equipment and devices that will be included in the microgrid. The designed microgrid will include demand response functionalities for scheduling and control of the demand response resources included in the microgrid.

Energy efficiency does not imply any change in operations or consumption behavior. Energy efficiency is driven by equipment choice. It does not impact the comfort of the consumers/occupants or the usage of end-use devices and equipment. Energy efficiency can be achieved through replacement of less energy efficient components or equipment in the microgrid with more efficient components or equipment. These include both electricity producing and consuming elements, and also thermal generation and usage. Energy efficient equipment simply deliver more kWh or Therms for each kWh or Therm of primary fuel consumed. The decision to replace existing equipment and systems with more efficient substitutes is based on economic considerations such as net present value comparisons and payback periods, which are in turn influenced by the availability and size of financial incentives, rebates, tax breaks, and such.

Demand response, on the other hand, implies a change in operations and consumption behavior. This study considered potential options for demand response. In fact, the adoption of capability to treat electric and thermal loads differently according to their classification as critical, discretionary, and curtailable, constitutes demand response functionality of the microgrid. The curtailable load, as the name implies, is the load that can immediately be curtailed (i.e., shed or dropped), similar to interruptible load of the traditional demand-side management programs. Discretionary load is more akin to more recent demand response programs. However, the main signal to activate the demand response's action is the microgrid's own assessment of availability of supply instead of utility's price or event signal.

This study considered the demand response options by working together with the facility owners/managers to identify potential demand response resources (curtailable and discretionary loads) and their size and location, and take them into consideration in the functional design of the control and communications infrastructure.

- **Address installation, operations and maintenance and communications for the electric system to which interconnection is planned (e.g., underground networks, overhead loops, radial overhead systems);**

Given the options available for modern microgrid design, the existing infrastructure will often be the differentiating factor in design decisions. Considerations such as the interconnecting network construction and topology will govern many of the design decisions. When feasible, ease of maintenance and installation as well as operational synergy will be factored into design decisions. However, it should be noted that primary microgrid design criteria, such as stability and resiliency, will generally have priority over operations and maintenance concerns.

The team will work with the utility to develop an understanding of the relevant features of the electric distribution system and identify the current distribution network challenges in terms of parsing out a microgrid out of the current grid and ensuring that the larger grid will not be adversely impacted.

The type and the configuration of the underlying electric network of the microgrid will be highly dependent on the current distribution network, locations and distances of the microgrid facilities on the feeders, and the technical requirements that need to be considered in the functional design of the microgrid electrical infrastructure. A very important consideration will be the overall cost of various grid type options.

Based on the selected grid type (overhead, radial, underground), the Team will assess the requirements for the interconnection or interconnections between the microgrid and the larger grid, in terms of installation, operations, maintenance, and communications, and describe such requirements in the functional design of the microgrid and its point or points of contact with the larger grid.

- **Coordinate with the Reforming the Energy Vision (REV) work to provide a platform for the delivery of innovative services to the end use customers;**

The proposed microgrid will be expected to advance innovative energy solutions, including market-based technologies, products, services, and new business models, in the State of New York. The Project Team will explore the market opportunity for the utility, its customers, and competitive solutions providers to establish public-private partnerships and develop efficient and resilient microgrids. The project will test the demand for enhanced reliability/resiliency services, promote clean and distributed generation, and determine value steams that can be quantified and captured by the parties as well as commercial structures that may be replicated and used to engage additional customers. The Project Team will use its best efforts to address technical, regulatory, and contractual challenges and develop a framework that paves the way for future microgrids.

BQDM and the Brownsville Substation

Because the proposed microgrid is supplied electrically by Con Ed's strained Brownsville substation, the opportunity exists to provide significant value and benefit to Con Ed and its ratepayers by lowering demand by as much as 5-10 MW and avoiding the need for costly substation expansion and new transmission feeders. Representatives from Con Ed have been in contact with each of the three primary facilities to explore the deployment of on-site generation which would be subsidized by Con Ed as part of their Brooklyn Queens Demand Management (BQDM) initiative. Con Ed, for reasons to do with permitting and speed of installation appears to prefer the deployment of fuel cells. In contrast to fuel cells, CHP requires considerable engineering, and the permitting process would also be protracted because emissions from CHP far exceed those from fuel cells.

- **Take account of a comprehensive cost/benefit analysis that includes, but is not limited to, the community, utility and developer's perspective;**

The Project Team will provide input needed for the NYSERDA cost/benefit analysis tool to evaluate both the net societal benefits and also the costs and benefits from the perspectives of the various stakeholders.

On the cost side, the Team will identify (a) various costs elements, covering the design, development, and deployment of the microgrid, capital costs of various components, fuel, variable operations and maintenance (VOM), and fixed operations and maintenance (FOM) cost of generation and demand side resources, (b) costs of the electrical network infrastructure, (c) costs of the control and communications infrastructure.

On the benefit side, the Project Team will identify various potential revenue sources such as utility demand side programs, and those from participating as a virtual plant in the NYISO wholesale market. Additional benefits include estimation of avoided costs of power interruptions for different facilities within the microgrid.

- **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;**

The Benefit-Cost Analysis (BCA) will include potential benefits and costs from various perspectives, including the microgrid as a single entity, and also from the view point of the facility owners and the utility.

In addition, the BCA will include societal net benefits/costs. The Project Team's contribution will be based on learnings from the original NYSERDA-DPS-DHSES 5-site study (Microgrids for Critical Facility Resiliency in New York State, NYSERDA Report Number 14-36), which included consideration of various financial benefit and cost streams and was supplemented by accounting for other non-tangible benefits and costs, including environmental benefits and avoided interruption costs. This last item (avoided interruption costs), which is more difficult to quantify, can be estimated based on available benchmarks depending on the classification of the facility's type, critical loads impacted, number of persons impacted, and the duration of emergency period.

- **Demonstrate tangible community benefits, including but not limited to, (e.g. jobs created, number of customers served, number of buildings affected, scale of energy efficiency retrofits, etc.);**

The project will positively impact thousands of Clarkson Avenue residents as it will enhance both the grid's reliability and resilience in response to extreme weather events and other grid emergencies, provide for operational continuity and, reduce local emissions from the burning of #6 fuel oil by the Kings County Hospital boiler plant and #2 oil by the SUNY DMC and KPC boiler plants. Also, more than 15 hospital and patient care facilities will be supported by the proposed microgrid.

- **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 Project Team will consider the options for interaction of the microgrid with the surrounding power grid, including both the distribution utility and the NYISO. The interaction with the surrounding grid across a Distribution System Platform (DSP) through market animation is a major aspect of the New York Reforming the Energy Vision (REV).

For instance, one possible innovation that may be considered within the REV framework is optimal economic operation of the resilient microgrid during blue sky days (i.e., during normal, non-emergency periods), by participation in the utility demand response programs and also NYISO's energy, ancillary services, and capacity markets.

An active and dynamic scheduling of microgrid operations that would maximize the economic efficiency and technical reliability of the microgrid and the surrounding system will require both technical innovations and also reform of regulatory and policy regime that would enable market participation. The Project Team will elaborate on needed innovations and requirements that would enable such market participation. These may include complementary hardware that would provide more flexibility, such as integrated energy storage, and the smart scheduling software.

The Project Team will describe the actionable information that would need to be made available to customers for economically efficient and technically reliable operation and scheduling of the microgrid generation. These include real-time load and supply status of the microgrid and the underlying variable costs of operations and the applicable seller and buyer prices on the DSP and/or NYISO. It should also be noted that such actionable information, although accessible to customers when requested or queried, would function and be used mostly in the background in automated microgrid systems.

Section 2 – Preliminary Technical Design Costs and Configuration

Executive Summary

The Clarkson Avenue microgrid will connect the SUNY Downstate Medical Center (SUNY DMC), Kingsboro Psychiatric Center (KPC), and Kings County Hospital Center (KCHC).

These facilities provide a complete range of health, medical, and emergency services to more than one million people in Brooklyn and other boroughs and employ more than 20,000 people.

The proposed Clarkson Avenue microgrid includes 6MW of existing diesel generators that are being converted to dual fuel, 8MW of fuel cells, and 300kW of solar panels. The fuel cell, solar panels, and 1MW of dual fuel generation will be at Kingsboro. 2MW of dual fuel generation will be at Kings County and the rest of the dual fuel generation will be at SUNY Downstate.

The microgrid control system (or energy management system) is responsible for monitoring the microgrid resources in grid connected mode and controlling the voltage and frequency in islanded mode. This is accomplished via a hierarchy of controller devices that communicate through a new dedicated wireless or fiber-optic network. Besides dispatching optimal levels of generation and managing load in the microgrid facilities, the main task of the control system will be to coordinate the switching devices at the interconnection points with the surrounding distribution network.

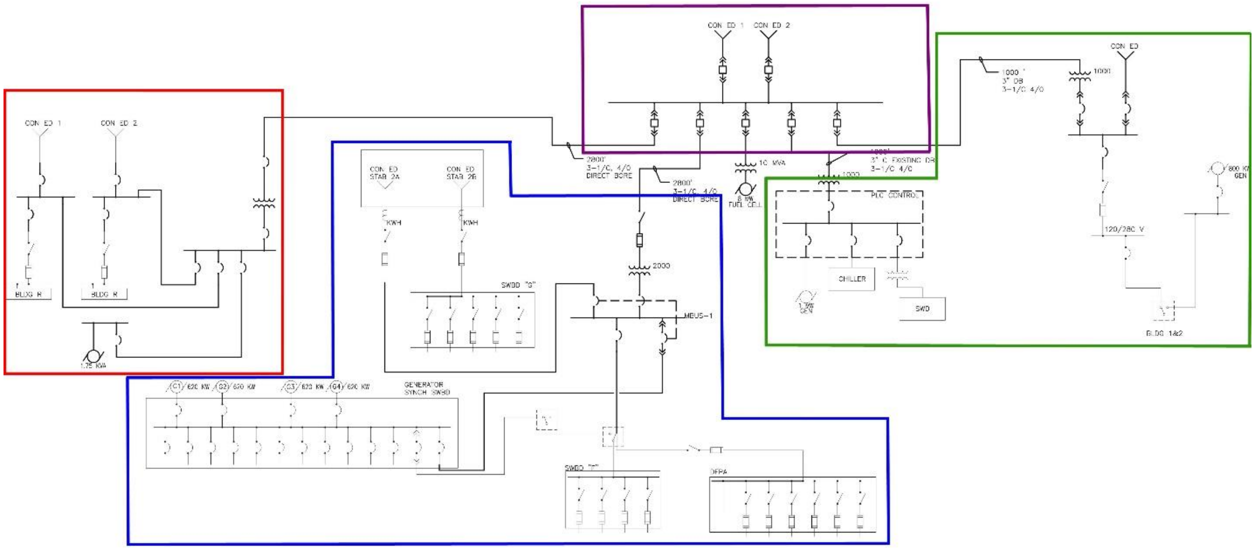
Task 2.1 – Proposed Microgrid Infrastructure and Operations

2.1.1 – Provide a simplified equipment layout diagram and a simplified one-line diagram of the proposed microgrid, include location of the distributed energy resources (DER) and utility interconnection points. Identify new and existing infrastructure that will a part of the microgrid.

The figure below shows a simplified layout of the Clarkson Avenue microgrid highlighting the electrical interconnection between the proposed fuel cell installation at Kingsboro Psychiatric Center (KPC), and facilities at Kings County Hospital Center (KCHC) and SUNY Downstate Medical Center (SUNY DMC). The proposed route for new electrical conduit is shown in red. The route involves construction of approximately 5,000 feet of new conduit via direct-boring from the fuel cell site at KPC crossing Albany Avenue to KCHC and finally crossing Clarkson Avenue to SUNY DMC.

Simplified Layout of Clarkson Avenue Microgrid Showing Facilities and Routing of Electrical Connections
Figure 2-1

Figure 2-2 below shows a simplified one-line diagram of the microgrid with the location of the distributed energy resources (DERs) and the utility interconnection points. The major additions, besides generation, are the 25-kV class cables connecting KPC, KCHC and SUNY-DMC and the accompanying transformers and switchgear.



Rewire King's County with 208V Electronic Breakers.

1) Fuel Cell Connection parallel to CONED
2) During outage, existing generators start, then fuel cell will come on to reduce runtime.

Rewire SUNY Downstate with 208V Electronic Breakers.

1) Fuel Cell Connection parallel to CONED
2) During outage, existing generators start, then fuel cell will come on to reduce runtime.

Clarkson Avenue Microgrid One-Line Diagram Showing Generation Sources and Major Equipment
Figure 2-2

2.1.2 – Provide a brief narrative describing how the proposed microgrid will operate under normal and emergency conditions. Include description of normal and emergency operations.

All three facilities, KPC, KCHC and SUNY-DMC, currently receive power via several dedicated network transformers or spot networks of Con Edison's 27 kV feeders. None of the facilities are powered directly off the street network, which significantly reduces the number of interconnection points with the grid. The spot networks are designed to N-2 standard (meaning loss of two feeders or transformers would not interrupt load), and all construction is underground and designed to be submersible. This is an extremely reliable design that is likely only compromised by a transmission system failure, substation failure, or a network collapse.

Normal Conditions

Under normal condition the microgrid facilities will be served by Con Edison's 27-kV system, as well as the Fuel Cell Array (FCA) located at KPC and PV generation at KPC and SUNY DMC. The new tie cable shown in Figure 2-2 may or may not be connected during blue sky days. These decisions will be made by the microgrid controller, which will be able to utilize distributed assets based upon the economic market. As the coincident normal load for these three facilities is typically over 10 MW, the fuel cell generation will be consistently loaded at rated capacity.

Emergency Conditions

When power is lost to the facilities due to, for example, a catastrophic event on the bulk power system, loads in all the facilities will be unserved. The microgrid controller which is monitoring the points of interconnection (POIs) with the main grid will sense loss of voltage or frequency and the DERs (Fuel Cell and Dual Fuel units) will go off-line (in accordance with anti-islanding protection procedures). Interconnection points with the utility (and between the facilities if the tie line is active) will open and the converted dual fuel and existing diesel backup generators at all three locations will start up to supply facility emergency life safety loads. The dual fuel generators will start using diesel as the pilot fuel to ignite the natural gas, while still maintaining NFPA 110 starting requirements.

Once the facilities are isolated from the utility system, the Fuel Cell units will restart and synchronize with the online backup generation (5-10 minutes). When the generation is stabilized, the microgrid tie-line is closed in and load at all three microgrid locations can be sequentially transferred from the backup generators to the Fuel Cell and Dual Fuel units. Once the island is stable and active, PV would reconnect and begin generating. During islanded operation, the microgrid controller would actively monitor voltage and frequency in the island. Loads on some breakers could be shed and some backup generation might remain online or be brought online to maintain stable operation. Diesel generators will then be safely shut down and load will be transferred back to the microgrid system. This enables a reduction of diesel generator run time usage and helps alleviate any issues or reliance on fuel delivery trucks during an emergency.

In cases when the grid is stressed but there is no forced outage, “seamless” transition to microgrid mode is possible. In this scenario the Fuel Cell and Dual Fuel units would remain online during the transition, and the microgrid controller would shed load quickly or bring backup generation online to maintain balance in the island.

Task 2.2 – Load Characterization

2.2.1 – Fully describe the electrical and thermal loads served by the microgrid when operating in islanded and parallel modes: Peak KW, Average KW, annual/monthly/weekly KWh, annual/monthly/weekly BTU (consumed and recovered) and identify the location of the electrical loads on the simplified equipment layout and one-line diagrams.

In parallel mode, the Fuel Cell Array will be running at close to full capacity if the electrical tie between the microgrid facilities is active. Power will be imported from the grid to make up any shortfall over the load cycle.

In islanded mode the FCA will serve base load and dual fuel units will modulate output to match the electrical demand of the island. Whenever demand exceeds total generation capacity, curtailable load will be shed and/or diesel backup generation will be brought online to fill the gap. The backup generation at all three facilities are dual fuel units, and the total combined diesel storage is Adequate for three full days of operation

No thermal load will be included as part of the microgrid DER. The fuel cell generation, dual fuel generators, and PV generation/storage will supply only electrical load to the three facilities.

The tables below detail average usage and peak demand information for each of the three sites included within the Clarkson Avenue microgrid:

Table 0-1 Microgrid Electrical Usage

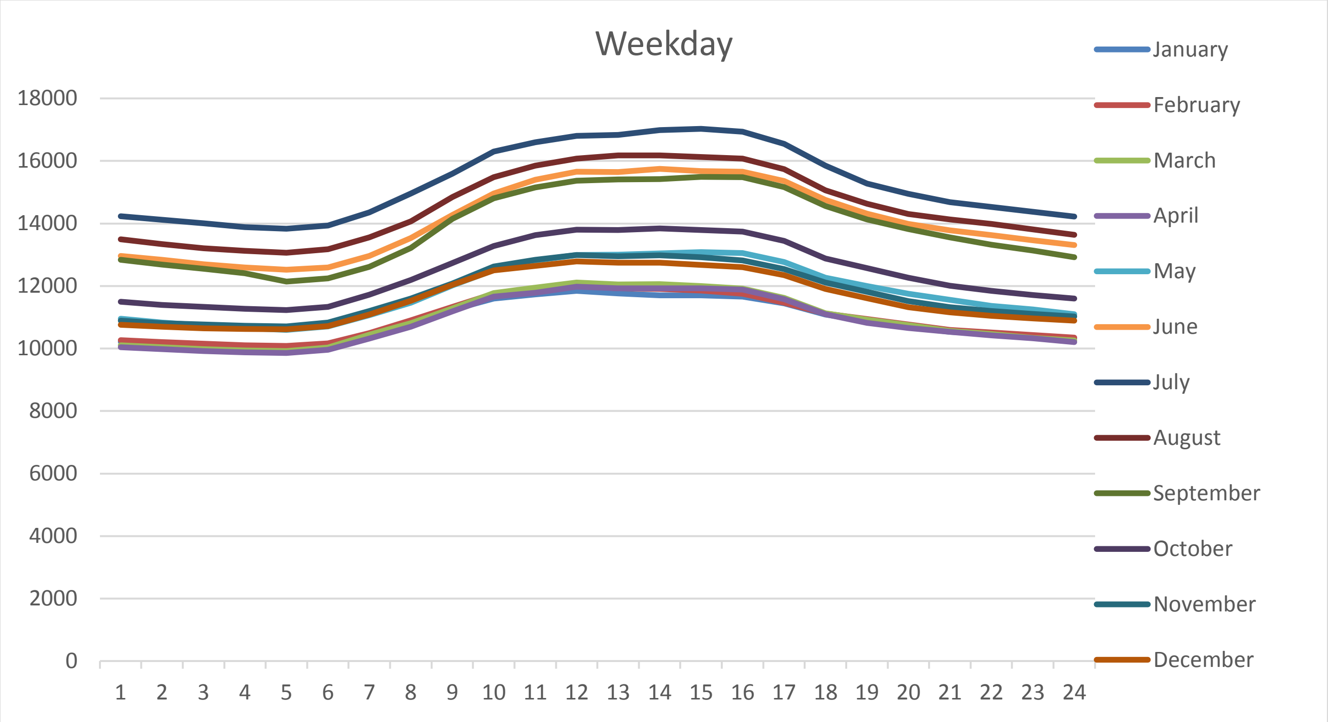
Monthly Electrical Usage (kWh)			
	Kingsboro Psychiatric Center	Kings County Hospital Center	SUNY Downstate Medical Center
Jan	53,400	4,559,040	3,923,390
Feb	487,200	4,087,360	3,684,216
Mar	459,600	4,086,080	3,509,626
Apr	428,000	4,431,440	3,537,580
May	377,200	4,632,080	3,870,054
Jun	542,000	5,060,400	4,028,298
Jul	625,200	6,289,920	4,427,892
Aug	614,400	5,392,320	4,471,598
Sep	508,400	5,341,560	4,295,936
Oct	435,600	4,937,120	3,591,120
Nov	528,400	4,193,280	4,050,442
Dec	468,800	4,355,600	3,495,444
Total	5,528,200	57,366,200	46,885,596

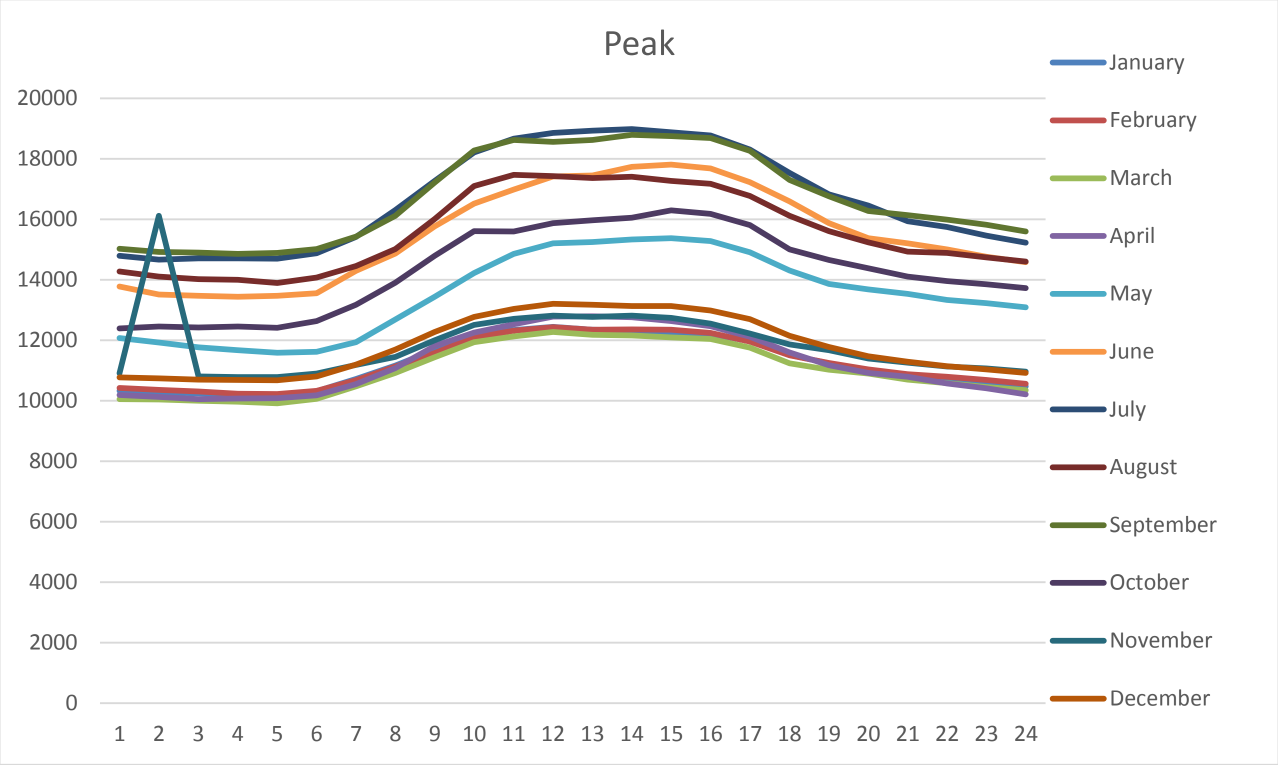
Table 0-2 Microgrid Electrical Demand

Monthly Electrical Peak Demand (kW)			
	Kingsboro Psychiatric	Kings County Hospital	SUNY Downstate Medical
Jan	862	6,406	6,178
Feb	844	5,074	6,292
Mar	826	5,074	6,119
Apr	790	5,976	6,658
May	1,029	6,772	7,231
Jun	1,232	7,876	7,999
Jul	1,311	8,722	7,939
Aug	1,140	7,916	7,546
Sep	1,159	8,346	7,676
Oct	946	7,300	6,914
Nov	823	6,330	6,456
Dec	856	5,390	6,067
Total	1,311	8,722	7,999

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

The source of data for the hourly load profiles of each facility is electric billing statements. The monthly energy information was used and applied to various 12 x 24 load profiles from the DER-CAM model for appropriate facility types in order to develop individual load profiles. These individual profiles were then aggregated into the total microgrid load.




Peak
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14000
12000
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2.2.3 – Provide a written description of the sizing of the loads to be served by the microgrid including a description of any redundancy opportunities (ex: n-1) to account for equipment downtime.

The microgrid total load is based on the loads of the individual facilities to be served by the microgrid, as shown in Figure 2-1. The load sizes for DER are based off of information provided for 3 years' worth of electrical usage and demand data. This demand and usage data can be seen in Table 2-1 and Table 2-2. There was no thermal load included within the analysis due to the fact that no CHP technologies were chosen for this microgrid.

The microgrid generation includes 8MW of fuel cell generation, 300kW of Solar PV paired with small (~50kW) storage, and a number of dual fuel generators. Kingsboro PC has 1MW of dual fuel generation. Kings County Hospital Center has a single, 2MW dual fuel unit included within the microgrid, while SUNY Downstate Medical Center has four, 750kW dual fuel units included; these DER total to 14.3MW of generation.

When addressing N-1 redundancy, it is important to note that the 8MW of fuel cell generation is modular in nature. It is comprised of a thirty-two 250kW rated energy servers. Maintenance on any particular unit can be completed without interrupting the other 250kW energy servers that are operational. This modular framework eases the utility requirements during normal conditions and provides 99.998% availability. Diesel backup generation is also available at each of the three facilities to dispatch if required in an islanding mode and maintenance on a fuel cell energy server is required.

Task 2.3 – Distributed Energy Resources Characterization

2.3.1 – Provide information regarding Distributed Energy Resources (DER) and thermal generation resources that are a part of the microgrid:

Table 0-3 Microgrid Generation Resources

DER Type	Facility Name	Energy Source	Name plate Capacity (MW)	Average Annual Production Normal (MWh)	Average Daily Production Emergency (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
8 MW Fuel Cell Array	All	Natural Gas	8	66576	192	6.56	MMbtu/ MWH
Backup Generator G-22	KPC	Dual Fuel	1	0	11.56	20.4	MMbtu/ MWH
300 kW Solar Panel	KPC	PV/Storage	.3	657	1.8	N/A	N/A
Backup Generator Genset No.2	KCHC	Dual Fuel	2	0	42	8.17	MMbtu/ MWH
SUNY UHB-1	SUNY	Dual Fuel	0.750	0	18	9.06	MMbtu/ MWH
SUNY UHB 2	SUNY	Dual Fuel	0.750	0	18	9.06	MMbtu/ MWH
SUNY UHB 3	SUNY	Dual Fuel	0.750	0	18	9.06	MMbtu/ MWH
SUNY UHB 4	SUNY	Dual Fuel	0.750	0	18	9.06	MMbtu/ MWH

2.3.2 – If new DER or other thermal generation resources are a part of the microgrid, provide a written description of the approximate location and space available. Identify the DERs on the simplified equipment layout and one-line diagrams. Differentiate between new and existing resources.

New generation resources and their locations are listed in Table 0-3. The new Fuel Cell generation will be located at Kingsboro Psychiatric Center (KPC). KPC currently has three generators with a maximum capacity of 1,300 kW. SUNY-DMC currently has four 750 kW dual fuel units and KCHC has a 2 MW dual fuel unit. There is approximately 27,000 square-feet of space on the roof of the buildings on the KPC campus, sufficient for a total of 300 kW of solar PV at that site. Figure 2-2 shows the conceptual interconnection between all three of the sites to be served by the microgrid. The dual fuel backup generating units are also shown on this conceptual single line diagram.

2.3.3 – Provide a written description of the adequacy of the DERs and thermal generation resources to continuously meet electrical and thermal demand in the microgrid.

The DER CAM model takes into consideration the average electrical and thermal profile of the aggregate loads at KPC, KCHC and SUNY-DMC. DER-CAM optimizes the generation required, as well as the appropriate electrical dispatch for those generation units. The DER-CAM model dispatches all the generation resources based on the comparative economics of on-site generation versus purchase from the utility. Shown below is the input electrical data optimized within DER-CAM based on the average hourly electrical demand over the course of a typical week day, weekend day, and peak usage day.

Table 0-4 Microgrid 12x24 Electrical Load

Month	Day-type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
January	Week	10213.43	10152.88	10107.78	10065.56	10040.31	10153.2	10437.57	10827.77	11239.88	11598.98	11734.26	11842.12	11758.42	11701.75	11704.08	11657.19	11441.33	11086.72	10884.04	10700.28	10531.05	10472.04	10400.49	10327.17
February	Week	10267.26	10205.27	10150.57	10098.03	10085.11	10165.84	10494.2	10900.09	11329.51	11755.75	11878.23	12004.03	11926.14	11908.98	11856.18	11755.32	11466.11	11116.3	10943.25	10768.1	10593.29	10512.59	10434.43	10346.8
March	Week	10104.42	10038.33	9983.952	9940.447	9916.269	10036.12	10437.83	10813.67	11279.7	11776.17	11945.76	12108.68	12050.61	12058.7	11994.23	11917.43	11616.1	11132.02	10918.46	10744.33	10566.57	10461.81	10342.18	10259.04
April	Week	10042.15	9980.973	9918.688	9874.462	9858.529	9956.222	10318.15	10699.53	11185.34	11658.76	11787.61	11979.71	11924.56	11923.47	11929.66	11882.05	11576.37	11096.06	10820.33	10652.33	10535.75	10422.82	10332.54	10203.47
May	Week	10951.89	10835.02	10738.59	10660.67	10592.04	10705.57	11070.14	11462.82	12014.43	12512.78	12817.31	12992.09	13003.2	13040.48	13080.29	13051.04	12762.78	12268.51	12001.6	11749.16	11559.45	11362.44	11250.78	11092.86
June	Week	12965.17	12839.09	12696.78	12596.27	12525.02	12592.13	12959.75	13534.22	14267.52	14953.6	15397.24	15652.26	15649.13	15744.32	15677.76	15657.65	15356.5	14752.28	14315.19	13984.51	13782.85	13630.86	13460.34	13306.05
July	Week	14232.77	14120.77	14004.08	13887.36	13833.21	13933.13	14356.99	14955.76	15597.37	16302.61	16599.04	16805.48	16833.58	16985.88	17027.92	16930.51	16550.96	15852.34	15280.6	14943.94	14677.22	14533.19	14371.15	14217.78
August	Week	13492.83	13337.13	13211.47	13120.84	13061.47	13172.48	13551.99	14071.51	14841.01	15483.33	15852.07	16073.74	16172.65	16182.27	16130.07	16079.87	15741.21	15062.63	14631.84	14299.73	14131.27	13986.45	13810.3	13633.79
September	Week	12833.17	12687.66	12548.58	12411.29	12145.36	12240.81	12610.75	13220.18	14148.24	14800.41	15151.29	15368.07	15411.49	15415.11	15492.03	15482.79	15163.81	14557.23	14132.53	13823.78	13551.05	13321.63	13137.49	12916.29
October	Week	11497.98	11396.38	11336.81	11275.42	11233.78	11336.86	11721.33	12194.37	12736.3	13282.03	13628.05	13798	13790.02	13843.43	13792.08	13741.43	13440.61	12875.08	12568.07	12263.81	12010.89	11845.09	11712.13	11597.32
November	Week	10891.28	10809.64	10764.91	10723.81	10705.5	10830.58	11200.39	11594.31	12078.37	12617.81	12838.31	12986.59	12953.01	12979.7	12919.74	12818.44	12542.07	12107.48	11818.67	11518.29	11317.57	11202.74	11107.72	11025.78
December	Week	10759.08	10693.33	10650.12	10625.67	10617.7	10719.38	11089.06	11530.06	12040.84	12499.75	12644.59	12789.68	12749.67	12750.25	12678.43	12602.62	12343.56	11905.58	11605.89	11318.5	11153.12	11048.96	10958.51	10890.67
January	Peak	10325.36	10281.1	10242.7	10203.52	10186.78	10315.17	10722.07	11168.19	11686.87	12182.1	12336.17	12448.23	12344.18	12317.7	12267.87	12214.07	11971.84	11513.99	11239	11007.64	10774.88	10687.33	10604.28	10478.61
February	Peak	10422.11	10362.08	10306.74	10230.82	10221.27	10322.21	10681.31	11128.1	11577.34	12095.72	12317.18	12437.09	12352.07	12359.02	12346.47	12238.11	11954.61	11502.15	11252.67	11037.69	10880.55	10796.65	10683.9	10558.56
March	Peak	10056.18	10039.18	9998.446	9964.922	9913.925	10059.79	10473.43	10923.4	11433.96	11932.7	12129.46	12276.68	12181.38	12154.26	12099.07	12043.06	11752.67	11242.17	11029.67	10895.62	10692.54	10581.04	10454.85	10352.02
April	Peak	10188.55	10128.2	10048.49	10068.54	10080.4	10180.12	10550.15	11078.81	11807.79	12256.94	12532.41	12784.05	12788.52	12762.92	12637.43	12467.07	12116.8	11593.84	11169.99	10915.6	10797.54	10571.17	10410.75	10207.04
May	Peak	12072.84	11926.74	11767.08	11667.13	11587.86	11622.85	11941.26	12683.8	13437.62	14221.57	14858.75	15203.57	15244.7	15334.57	15370.99	15281.48	14908.34	14305.51	13857.24	13683.3	13532.55	13337.07	13222.74	13086.75
June	Peak	13775.94	13514.47	13473.24	13440.97	13465.66	13558.26	14300.5	14871.19	15770.27	16515.64	16984.32	17419.88	17451.33	17737.01	17806.78	17687.33	17228.83	16587.76	15876.17	15376.95	15208.41	15010.38	14764.98	14586
July	Peak	14798.27	14662.02	14711.54	14711.28	14703.12	14881.84	15420.3	16305.97	17272.22	18211.85	18671.26	18854.49	18930.43	18986.38	18873.84	18775.65	18303.47	17539.52	16831.02	16451.88	15937.34	15743.85	15463.18	15231.3
August	Peak	14277.17	14110.26	14019.09	14001.01	13893.08	14074.82	14450.4	15017.03	16007.72	17100.81	17467.86	17427.83	17367.89	17409.58	17273.52	17173.02	16775.49	16113.6	15604.1	15233.21	14931.69	14891.43	14736.92	14600.82
September	Peak	15022.66	14923.54	14896.28	14857.53	14889.66	15013.7	15423.53	16113.8	17218.37	18278.89	18619.7	18566.39	18629.78	18793.74	18749.27	18683.34	18269.51	17306.52	16765.63	16271.79	16140.16	15986.46	15822.92	15595.95
October	Peak	12395.74	12449.46	12420.89	12454	12415.23	12633.18	13178.57	13908.73	14788.81	15609.97	15594.16	15871.96	15972.64	16054.02	16297.5	16184.36	15807.69	15005.29	14659.44	14385.39	14103.16	13960.37	13852.67	13724
November	Peak	10906.28	16119.12	10799.28	10781.8	10778.11	10899.57	11188.85	11445.99	12001.35	12507.45	12712.11	12811.36	12773.62	12809.63	12738.82	12547.01	12225.93	11864.59	11670.36	11400.1	11262.09	11128.95	11064.11	10961.02
December	Peak	10774.58	10744.85	10702	10691.26	10675.24	10801.16	11198.22	11692.08	12279.57	12777.26	13034.02	13203.42	13172.71	13134.95	13126.75	12984.05	12693.9	12152.1	11773.68	11470.92	11291.55	11146.83	11032.99	10922.2
January	Weekend	10016.49	9981.403	9945.925	9913.698	9898.103	9909.864	10104.58	10351.32	10531.46	10672.06	10752.94	10819.9	10776.92	10802.36	10767.67	10744.76	10687.24	10613.84	10554.11	10436.15	10332.18	10259.98	10196	10120.71
February	Weekend	10086.07	10007.84	9995.059	9964.406	9947.683	9970.315	10194.65	10470.31	10628.85	10793.16	10910.58	11024.04	10963.44	10965.26	10922.35	10896.96	10818.35	10704.9	10662.99	10538.49	10438.57	10364.38	10303.62	10244.5
March	Weekend	9969.42	9900.567	8893.632	9830.268	9796.524	9773.425	9926.552	10121.79	10183.15	10265.2	10330.78	10427.09	10374.91	10385.22	10389.52	10381.08	10346.18	10256.36	10287.87	10243.58	10166.18	10094.85	10021.43	9982.557
April	Weekend	10004.93	9919.773	9866.383	9798.397	9764.248	9704.497	9821.736	9987.397	10085.22	10201.94	10271.39	10367.18	10306.09	10391.65	10483.67	10508.04	10450.76	10313.07	10313.92	10244.47	10229.41	10175.13	10068.83	9996.032
May	Weekend	10923.39	10753.01	10652.21	10585.72	10508.65	10487.96	10520.91	10695.53	10874.78	11106.5	11301.52	11489.04	11536.13	11644.89	11722.27	11722.02	11706.13	11498.45	11447.47	11360.18	11261.62	11162.98	11089.08	10978.01
June	Weekend	12245.55	12167.42	12070.55	11961.45	11940.5	11829.54	11892.58	12121	12449.46	12647.4	12877.35	13086.9	13140	13128.76	13220.03	13249.8	13213.37	13047.68	12921.65	12681.14	12585.36	12531.95	12430.11	12277.35
July	Weekend	13466.41	13358.36	13265.6	13192.01	13194.89	13122.29	13238.3	13411.5	13731.53	13946.8	14167.32	14369.35	14452.46	14518.56	14481.86	14569.76	14596.73	14518.22	14373.34	14233.38	14200.9	14151.21	14051.18	13964.76
August	Weekend	13011.74	12851.22	12770.94	12712.18	12645.5	12635.71	12755.07	12932.57	13250.25	13474.77	13611.19	13799.01	13807.84	13944.18	13927.59	13970.21	13897.49	13769.9	13696.94	13565.43	13500.19	13444.41	13336.25	13241.84
September	Weekend	11419.07	11314.48	11226.44	11128.75	11130.42	11147.82	11297.22	11503.74	11659.37	11966.28	12133.72	12349.89	12424.13	12458.9	12495.1	12558.99	12479.01	12326.87	12262.72	12194.34	12030.49	11900.16	11725.88	11498.71
October	Weekend	11048.79	10997.42	10901.42	10859.8	10826.68	10815.21	10980.56	11221.61	11297.4	11431.79	11563.92	11659.24	11597.91	11640.59	11682.54	11661.41	11577.33	11414.44	11361.56	11238.52	11107.3	10987.53	10915.52	10806.62
November	Weekend	10723.47	10670.27	10631.02	10585.99	10566.31	10587.54	10658.31	10798.37	11008.49	11071.19	11164.04	11226.05	11168.78	11179.72	11163.7	11181.72	11163.04	11153.25	11132.31	11027.61	10931.13	10859.28	10798.56	10747.09
December	Weekend	10659.25	10600.79	10560.17	10535.13	10509.49	10537.63	10612.09	10879.9	10811.13	11006.1	11025.24	11103.5	11050.79	11085.31	11063.74	11051.16	11073.45	11098.7	11043.68	10933.66	10848.34	10775.21	10716.99	10683.74

2.3.4 – Describe how resilient the DERs and thermal generation resources will be to the forces of nature (severe weather) that are typical to and pose the highest risk to their operation (for example, reduced or zero output due to snow cover over PV panels, potential flooding of low lying areas, etc.)?

The new Fuel Cell Array will be installed above the flood plain and therefore protected from most severe weather incidents and flooding. Individual fuel cell stacks that make up the fuel cell module have a lifetime of 3-5 years before replacement is required (replacement costs are factored into the overall cost of power delivered to the microgrid as part of the power purchase agreement – this is discussed more in Section 3 – Commercial Viability). The Fuel Cell system does not have a defined maintenance schedule per year, as each energy server is designed to operate 24 hours a day, 7 days a week. The fuel cell manufacturer provides remote monitoring to alert the microgrid sites of any potential issues at the individual stack level, the module level or if there's a larger issue with the full array. This will help minimize the downtime and impact of unexpected maintenance that may be required. Due to inherently redundant system architecture, the manufacturer is able to claim 99.998% availability. The Fuel Cell Array, along with the solar PV and existing generation at three sites therefore results in a collective power system with very high reliability that is insulated from the forces of nature. The expected forced-outage rate of the entire power plant, considering all generation sources, will be analyzed in Stage 2.

According to National Grid, natural gas supply has proven to be extremely resilient during past major events. Therefore supply to the Fuel Cell or dual fuel units is not expected to be interrupted in most emergencies (barring seismic activity or sabotage).

The roof-top PV panels are at some risk of being partially or completely covered with snow cover during 4-5 months of the year. However, the actual contribution of these panels to the overall power profile is not substantial enough to warrant additional action besides an occasional cleaning during these months. The existing backup generation at the sites is more than enough to compensate for any energy lost due to snow cover on PV panels. The microgrid controller should be able to recognize when PV panels are under-producing relative to normal operation, and can generate an inspection/maintenance signal.

2.3.5 – Provide a description of the fuel sources for DER. Describe how many days of continuous operation of the microgrid can be achieved with current fuel storage capability? If additional fuel storage is required, provide a written description of needs required for this.

Natural gas and solar are the primary fuel/energy resources used for base load generation in this project. Table 0-3 above shows the average annual production for microgrid generation resources under normal circumstances. The table also shows the fuel consumption for each kWh produced.

Discussions with the local gas utility provider have shown that there is adequate capacity for such an installation. Minor utility infrastructure upgrades will be required, but do not appear to be cost prohibitive to a microgrid installation.

As previously stated, the 8MW FCA is expected to be operational 24 hours a day, 7 days a week barring unforeseen major repair or maintenance tasks. Natural gas supply does not experience the same types of intermittent outages that electric utility service does during weather events. The solar/storage installation will be available for as many days as there is available solar irradiation.

The dual fuel generators, however, do have run time limitations before they will need additional fuel delivery. The target operating scenario for all dual fuel units is presently 14 days without additional fuel resources required.

2.3.6 – Provide a written description of the capability of DERs including, but not limited to the following capabilities; black start, load-following, part-load operation, maintain voltage, maintain frequency, capability to ride-through voltage and frequency events in islanded mode, capability to meet interconnection standards in grid-connected mode.

All three facilities have backup dual fuel units in addition to diesel engines which are excellent for black start and load-following applications. During the formation of a microgrid, it is expected that the backup diesels will be online for the transition, providing black start power for the microgrid. Once the Fuel Cell Array and dual fuel units are back online, the backup generators that are not part of the microgrid may go offline, unless they are needed for frequency regulation. Frequency regulation may be required from backup generators due to the fact that inverter based systems, such as a fuel cell, are not always capable of handling the types of inrush currents that are associated with motor starting among other situations. One benefit of inverter based systems is that they are more readily able to meet interconnection standards per IEEE 1547.

In connected mode (parallel to the grid), microgrid generation resources would not be required to regulate frequency, and would likely have a small role if any in voltage regulation. These services are provided by the bulk power system and the surrounding distribution system. However, in islanded mode, microgrid resources will need to provide for power balance/frequency control and reactive power balance/voltage control.

Dual Fuel generation units will be critical assets to provide the droop functionality necessary to maintain and regulate both voltage and frequency. Additionally, these assets allow for the addition of large block loads to the microgrids, which fuel cells and solar panels are unable to provide.

The specific roles of the different generation assets will be determined through study, and the microgrid controller will manage these assets in response to changing conditions.

New York State and Con Edison interconnection requirements with respect to voltage and frequency response will apply to the microgrid generation when it is in grid-connected mode. Whenever voltage or frequency at the POI are outside the allowable bands, the microgrid controller should initiate a disconnect sequence. However, the microgrid generation and control system have the ability to ride-through grid events and regulate voltage and frequency at the POI to help in fault recovery. This action can be coordinated with the utility operations center if needed.

Task 2.4 – Electrical and Thermal Infrastructure Characterization

2.4.1 – Provide a high-level written description of the electrical infrastructure (feeders, lines, relays, breakers, switches, current and potential transformers (CTs and PTs) and thermal infrastructure (steam, hot water, cold water pipes) that are a part of the microgrid. Identify the electrical and thermal infrastructure on the simplified equipment layout (with approximate routing) and one-line diagrams (electrical only). Differentiate between new, updated and existing infrastructure.

The electrical infrastructure supporting the microgrid is shown in 2-2. The major portion of new infrastructure is a medium voltage class underground cable system interconnecting generation and loads at KPC, KCHC and SUNY-DMC. Accompanying the cable are requisite step up and stepdown transformers and switchgear to connect and disconnect the connection as needed. As discussed earlier, the Team has identified a viable option for installing the cable in conduit via direct-boring. In this direct-boring option, a single feeder will be run from the switchgear located at Kingsboro Psychiatric to the utility service entrances at both Kings County and SUNY Downstate. Each facility getting a dedicated feeder from the Fuel Cell Array switchgear will allow for added resiliency. It is expected that spare conduits with be direct-bored as well for any expansion or feeder replacement that will need to be completed in the future.

There are no DER equipped with heat recovery as part of this microgrid application and no upgrades to the current thermal infrastructure of the three facilities is expected as a result.

2.4.2 – Describe how resilient the electrical and thermal infrastructure will be to the forces of nature that are typical to and pose the highest risk to the location/facilities. Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time. Discuss the impact of severe weather on the electrical and thermal infrastructure.

The proposed microgrid is currently served by an underground 27-kV feeder system that also serves a secondary network system. This particular microgrid site has historically experienced very high levels of reliability during blue sky conditions due to the supply configuration.

Major storm events, such as Hurricane Sandy, have shown to have negative consequences despite most of the electrical distribution being underground. About half of Kingsboro Psychiatric Center's Building #3 is used as the evacuation center for South Beach Psychiatric Center and was severely impacted by Hurricane Sandy. It is expected that with this microgrid that this facility will be able to serve as an emergency and evacuation center with a higher level of reliability.

The largest risks to the electrical infrastructure are: 1) a widespread transmission outage, such as the 2003 Northeast blackout, 2) failure of the Area Substation, 3) network collapse from multiple cascading feeder failures (Jeopardy).

The microgrid electrical infrastructure is underground, hardened, and submersible. During a widespread emergency (such as a blackout, substation transformer failure, or network collapse), the microgrid infrastructure would likely not be affected and would be able to form an island. The gas supply line is also resilient according to the utility, and will allow the microgrid to be operational for as long as capacity exists. The backup diesel generation at all three sites have been simulated for two weeks of continuous operation. Refueling of these assets, which was a critical flaw to many during Sandy, will be extended by turning off diesel generators and transitioning to the fuel source sources. The major risk to the microgrid infrastructure is a seismic event or a major dig-in accident onsite. Direct boring, as designed in this project, will help to alleviate these concerns as boring depths are far below those typically utilized for utility ductbanks

2.4.3 – Provide a written description of how the microgrid will be interconnected to the grid. Will there be multiple points of interconnection with the grid. What additional investments in utility infrastructure may be required to allow the proposed microgrid to separate and isolate from the utility grid. Provide a written description of the basic protection mechanism within the microgrid boundary.

Figure 2-2 shows the multiple points of interconnection with the grid at KPC, KCMC and SUNY-DMC. Because all three facilities are on dedicated network transformers or spot networks, there is no connection with the meshed street grid, which significantly reduces the number points that need to be controlled. A low voltage breaker or disconnect switch downstream of each network transformer secondary bus will be required to isolate the microgrid from the grid, in accordance with New York State Standardized Interconnection Requirements.[1] These breakers will be used by the microgrid controller to island the system or reconnect to the main grid. Each point will have instrumentation (not shown) to allow the microgrid Energy Management System (or Controller) to monitor the voltage, current and frequency at the POI.

Because the microgrid has distributed sources including both rotating machines and inverter based generation, traditional protection schemes based on high fault currents will likely not be applicable when in islanded mode. Coordination of the protection schemes between grid-connected and islanded mode will require relays capable of being remotely switched between multiple modes or set-points.

In addition to Instantaneous/Timed Overcurrent protection (Functions 50P/50G/51P/51G), the microgrid protection scheme will employ some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

Task 2.5 – Microgrid and Building Controls Characterization

2.5.1 – Provide a high-level written description of the microgrid control architecture and how it interacts with DER controls and Building Energy Management Systems (BEMS), if applicable. Identify the locations of microgrid and building controls on the simplified equipment layout diagram. Differentiate between new and existing controls.

The proposed microgrid control architecture consists of four control device types:

- **Microgrid Energy Management System** (MG EMS) (1 per microgrid)

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[1] http://www3.dps.ny.gov/W/PSCWeb.nsf/All/DCF68EFCA391AD6085257687006F396B?OpenDocument

The MG EMS orchestrates all control actions as well as provides the utility interface. It serves as a main microgrid configuration and dashboard station. For instance, a station operator is able to provide scheduling policies through its web interface. The data historian and possibly other data bases are stored at MG EMS which also provides analytics applications.

- **Microgrid Master Control Station (1 per microgrid)**

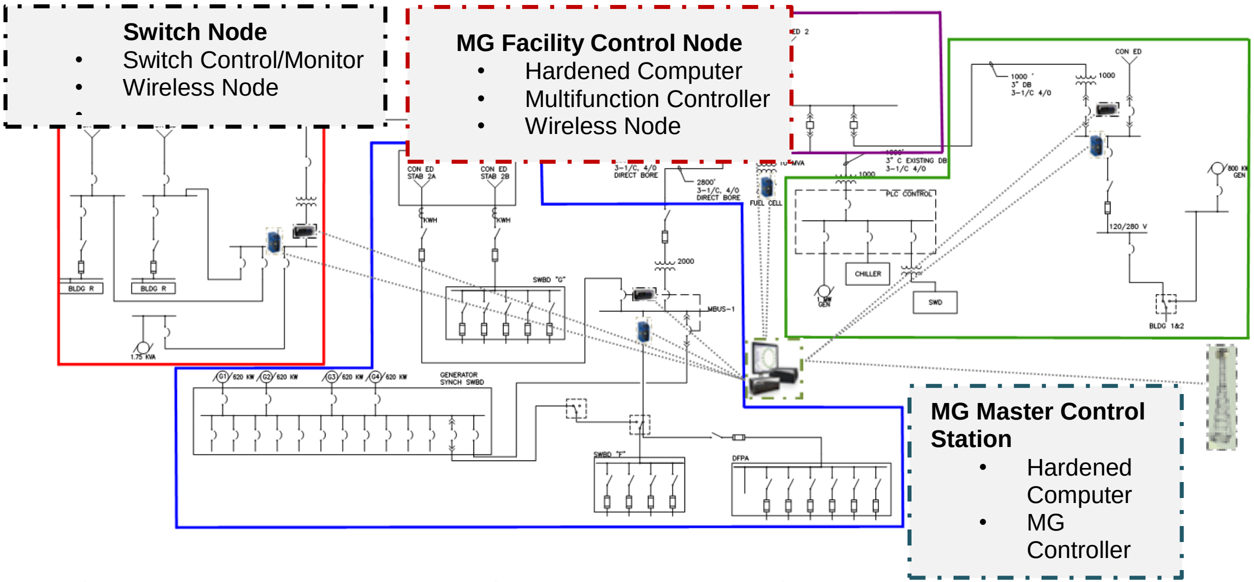
Master Control Station is a hardened computer that hosts critical real-time monitoring and control services. It performs forecasting, optimization and dispatch functions.

- **Microgrid Facility Control Node (1 per facility)**

Facility Control Node coordinates control across multiple buildings composing a specific facility. This controller abstraction is utilized also for any building in the microgrid with local control functions, i.e. a building that hosts a generation unit or building management system (BEMS). Most facility control nodes would also be hardened industrial computers.

- **Microgrid Edge Control Node (1 per facility)**

Edge Control Node is an automation controller or a feeder management relay with a direct switching interface to loads in a building. This is typically a multifunction controller/IED providing automation and physical interface to switchgear and sensors. Figure 2-9 shows control devices for the proposed Clarkson Avenue microgrid as an overlay on the electrical one-line diagram.



Clarkson Ave Microgrid Electrical One-Line Diagram with Control and Communications Overlay
Figure 2-9

The microgrid master control station performs economic optimization, i.e. it periodically determines a combination of generation units to bring on or keep on such that the total cost of operation is minimal. This includes the Fuel Cell, the solar PV units, and even the backup generation, which will be tied into the control system with Edge Control Nodes. The start/stop commands as well as optimal setpoints for real power, and sometimes even for reactive power, are sent to each generation unit.

The proposed Fuel Cell Array will be equipped with microprocessor-based controllers that regulate the inverter-based power conditioning system. During a typical operation, while a unit is in standby or parallel mode, the controller issues power setpoints, while continuously adjusting the output to optimize efficiency.

All mentioned local controller devices can interface with the external hierarchical control system via Modbus communications. This interface would be used to communicate necessary information between a microgrid facility control node and the local controller of the generation unit located in that facility. The facility control node would act as Modbus master, and the local controller would act as the Modbus slave, sometimes called a remote transmitter unit. The master device initiates all communication, sending commands or requests for information. The local controller would relay all of the AC power related information back to the facility control node including the voltage, current, frequency, and power factor. Thus, this interface will allow the microgrid control system to individually start, stop, and change the setpoint of any microgrid generation unit, as well as read all of its inputs and outputs.

The microgrid master controller will likely include load management for the economic optimization of microgrid assets. In such cases, it will communicate with building energy management systems to determine and set load set points. The diagram in Figure 2-9 assumes that the KPC, KCHC, and SUNY-DMC energy management systems will be included in microgrid optimization. Thus, we recommend that the microgrid control architecture be built on one of the open software control platforms such as Tridium JACE (Java Application Control Engine). Such a platform can be used to control a variety of BEMS systems, HVAC and DDC devices. This platform supports most of the open protocols for building automation systems sector such as LonWorks, BACnet, and Modbus.

2.5.2 – Provide a brief written description of the services that could be provided by the microgrid.

Automatically Connecting to and Disconnecting from the Grid

At all times in grid connected mode, the microgrid control scheme must maintain enough generation, to supply the critical microgrid loads. When an event occurs, the microgrid control system would initiate a sequence of operations to transition from grid-connected to islanded mode. Seamless transition during an unplanned event is not foreseen due to current interconnection rules governing DER operation. However, it is conceivable that a planned seamless transition can be achieved.

Automatic Disconnection: The Clarkson Avenue microgrid will be interconnected to the surrounding distribution system at multiple locations at each hospital facility. At the point of interconnection, the microgrid will sense abnormal grid conditions such as loss of voltage (on all feeds) and automatically isolate from the grid. The microgrid will then proceed as follows:

- Detect abnormal conditions
- Isolate microgrid from utility system
- Isolate uninterruptable microgrid from the rest of microgrid
- Stabilize generation and uninterruptable loads
- Add loads and generation to core the microgrid
-

Automatic connection: The microgrid will also be capable of automatically reconnecting to the grid if desired. However, since the microgrid will be reconnecting into a network, the microgrid may be required to power down before reconnection. If automatic reconnection is desired, when the microgrid senses that the utility feed has returned to normal for a period of time, the microgrid will sense the phase and magnitude of the voltage at the utility interconnection point. Using either active or passive synchronization, the microgrid controller may close the breaker that ties the microgrid to the utility system.

At the time of reconnection, the net load to the system from the microgrid will be minimal. The microgrid can coordinate the return of the additional microgrid loads to normal status with the utility to avoid undue stress on the recovering grid. Depending on the final design of the microgrid, this return to normal may be a combination of automatic and manual operations.

Load Shedding Schemes

Load management is also integral in islanded mode and in the transition to islanded mode. During microgrid formation, load will likely be shed to allow seamless transition for the uninterruptable loads on the microgrid. Once the microgrid is established, controllable loads may be used in much the same was spinning reserve generation. On the facility load panels, the critical loads are already isolated on the hospitals segregated emergency panels. Separation inside hospitals between normal, life safety, and critical equipment, is already mandated by NFPA 99, and therefore, load shedding should be a minimal concern.

Black Start and Load Addition

During an unplanned event, the microgrid must be capable of black-starting or energizing without an existing power system. Many grid-forming generators can be used for black-starting. Once the generator has been started and the core microgrid formed, the formation of the microgrid may proceed normally.

For the Clarkson Avenue microgrid, either the standby generators or the dual fuel generators may be used to blackstart. Once the generators are up and running, the Fuel Cell generation (as needed) may be added to the grid.

Generators designed for standby operation such as those at the Clarkson Avenue microgrid facilities are capable of maintaining voltage, frequency, and real and reactive power balance when the larger grid is not present; however, protection may be currently in place to prevent feeding a larger grid. The protection and control schemes of the standby generators will be evaluated to make sure the selected standby generators are capable of supporting the blackstart scheme.

Demand Response

In December of 2014, the New York State Public Service Commission (PSC) approved CONED's Brooklyn/Queens Demand Management Program that is aimed at addressing the overload of sub-transmission feeders serving Brownsville 1 and 2 substations. This particular program involves roughly 52MW of non-traditional utility and customer-side solutions. The 8MW of fuel cell generation proposed at Kingsboro Psychiatric is believed to be a viable option for this program.

In the event that demand response is required, the 8MW of fuel cell generation can be directly exported to CONED. The site's 18MW of generation could handle facility load.

Maintaining Frequency and Voltage

When in grid-connected mode, the primary focus of the microgrid control systems will be to maintain system voltage within the acceptable range. This range is generally specified in ANSI C84.1 but may also be coordinated with utility conservation voltage reduction schemes.

For the Clarkson Avenue microgrid, a large portion of the generation will be the Fuel Cell stack (8 MW). This generation will act as base-load generation and provide a reserve margin. The faster acting generators such as the existing dual fuel units will be used to manage fluctuations in load as well as variation in power output caused by solar. If additional control is needed, curtailable load may be used to help maintain the microgrid frequency, and PV generation may be curtailed or taken offline. The microgrid controller will assign the load-generation mix based on what is needed to satisfy the primary control objectives.

For reactive power/voltage control, existing generators may be used. The microgrid controller will determine the appropriate control modes (voltage, pf control, VAR control, etc.) and set-points for the various microgrid assets.

PV Observability and Controllability; Forecasting

PV production will be monitored by the microgrid controller and data will be communicated and stored so that it is available to microgrid operators and owners through a web interface. The controls and communications interface is shown in Figure 2-9. The total nameplate capacity of PV installations is 300kW, less than 2% of the non-coincident peak load.

The supplementary battery storage systems at the two solar sites would provide partial generation and load flexibility to reduce the PV variability.

Coordination of Protection Settings

When the microgrid is in islanded mode, some key protection functions will be under the purview of the microgrid controller. Where fault current is insufficient to ensure that secure, safe, dependable, reliable operation of protection systems (such as fuses), the Team may consider another layer of protection that predicated on transfer trip signals from the controller.

Selling Energy and Ancillary Services

In general, with the potential enactment of a new policy to allow "behind the meter net generation" or "BTM:NG" by the end of 2016, it is expected that the microgrid will sell ancillary services to the grid and receive new ongoing revenue as a result. The magnitude of these potential revenues is difficult to predict at this stage given the emerging nature of these grid services and markets.

Data Logging Features

According to the control architecture presented above, data logging is both local (at microgrid facility control nodes) and global (at microgrid master control station). These controllers, typically industrial PCs, record system data at regular intervals of time. A Human Machine Interface client for accessing data through a web interface exists at least at the master control station.

The data is stored in a round robin database that overwrites oldest values. The standard storage solutions (e.g. 1TB) are sufficient to store data for at least a full year. Depending on the devices that a facility control nodes regulates, such a node may be equipped with an event recorder that captures asynchronous events with high time resolution. This allows for fast, sub-second, data collecting and analysis.

2.5.3 – How resilient are the microgrid and building controls? Discuss the impact of severe weather on the microgrid and building controls.

The standard industrial-grade control and communication devices can withstand extreme operational temperature range of -40^0 C to +70^0 C. In addition, they are often enclosed in rugged aluminum chassis tested for shock and vibration according to military standards. Control boxes will also be elevated for flood avoidance

Task 2.6 – Information Technology (IT)/Telecommunications Infrastructure Characterization

2.6.1 – Provide a high-level written description of the IT/Telecommunications Infrastructure (wide area networks, access point, ethernet switch, cables etc.) and protocols. Identify the IT and

telecommunications infrastructure on the simplified equipment layout diagram. Differentiate between new and existing infrastructure.

Due to the lack of existing dedicated communication infrastructure, for the microgrid communications backbone we are proposing a wireless field network. The Microgrid Master Control Station is a hardened computer hosting monitoring, optimization and control services. It communicates to the utility wide area network through 3G/4G, WiMax, or 900MHz communication links.

In addition, each microgrid facility is equipped with a Control Node, a hardened computer hosting local control applications. In both facilities control nodes will integrate with the existing building management systems. Communication with the master control station is achieved through 900 Mhz or WiMax field network.

If there is enough space in the proposed new underground cable that will connect the two facilities or the existing thermal conduit, another solution for communications is possibly a dedicated fiber-optic link. Such a solution would yield the highest performance when it comes to bandwidth and reliability, although potentially at significant cost to the microgrid stakeholders. Since the length of a fiber optic link, i.e. the distance between the two microgrid facilities, is not relatively short (about 600 feet), efficient multimode fiber cables can be used.

In either case the communications network will provide at least 100 Mbit/s Ethernet which is expected to be sufficient for all monitoring and control applications and for the network of this size. The application-layer protocols will be selected among DNP3, Modbus TCP/IP, Modbus Serial, OPC or IEC61850 depending on MG deployed devices (e.g. IED's, PLC, switchgear, relay, sensors, meters, etc.).

2.6.2 – Provide a written brief description of communications within the microgrid and between the microgrid and the utility. Can the microgrid operate when there is a loss in communications with the utility? How resilient are the IT and telecommunications infrastructure?

When the lack of communication signals from the utility is set as an abnormal condition, the microgrid can isolate from the utility and thus operate when there is a loss in communications with the utility. From that moment the local generation and load devices are under the control of the microgrid controller.

The suggested communication infrastructure design assumes industrial-grade, long range, point-to-multipoint wireless communication with MIMO (Multiple-In, Multiple-Out) antennas that provide robust communications. The other option that would utilize fiber optic link can be made more reliable by connecting all the controller devices through a ring topology network. In such a network, in the event that a fiber link is broken, the traffic can be redirected.

Section 3 – Assessment of Commercial and Financial Feasibility

Task 3.1 – Commercial Viability – Customers

The Contractor shall describe the commercial terms/relationship between participants in the microgrid project, products expected to be produced by the microgrid and arrangements for sharing of benefits by addressing no less than the following questions:

3.1.1 – Identify the number of individuals affected by/associated with critical loads should these loads go unserved (e.g. in a storm event with no microgrid)?

Combined, Kings County Hospital (KCH), SUNY Downstate Medical Center (SUNY-DMC) and Kingsboro Psychiatric Center (KPC), provide a complete range of health, medical and emergency services to more than a million people in Brooklyn and the other boroughs. KCH, the largest municipal hospital in New York City, is a Level I Trauma Center serving 2.6 million residents of Brooklyn and Staten Island. It is the official training site for the United States Army Reservists Medical Staff prior to their deployment. Together with SUNY-DMC, the two emergency centers have almost 4,000 visits per week. And with more than 1,500 patient beds, in- and out-patient visits total more than 17,000 per week, or almost 900,000 per year. Kingsboro Psychiatric Center houses 175 patients, and the Kingsboro Homeless shelter has more than 400 beds for men with substance abuse problems. Lastly, roughly 1,600 medical students are enrolled at SUNY DMC, and more than 20,000 people are employed at these facilities.

3.1.2 – Identify any direct/paid services generated by microgrid operation, such as ancillary services, or indirect benefits, such as improved operation, to the utility or NYISO? If yes, what are they?

The Clarkson Avenue Microgrid's participation in ancillary services is expected to be limited because the microgrid's peak generators are existing emergency generators converted to dual fuel and the hospitals may be reluctant to use them for this purpose. However, indirect benefits related to reducing load on the Brownsville substation are expected to be significant.

3.1.3 – Identify each of the microgrid's customers expected to purchase services from the microgrid?

New York State Office of Mental Health (OMH), SUNY Downstate Medical Center, the New York City Health and Hospital Corporation, and New York City Homeless Services.

3.1.4 – Identify other microgrid stakeholders; what customers will be indirectly affected (positively or negatively) by the microgrid?

As detailed previously in Section 3.1.1, more than 1 million people are served by the health, medical, emergency and homeless facilities that comprise the Clarkson Avenue Microgrid. Stakeholders include patients, local and regional communities, a homeless shelter, students, the U.S. Army's Reservists Medical Staff, area businesses, and facility employees. Con Edison ratepayers will also benefit because the microgrid will significantly reduce loads on the Brownsville SS and thus help defer rate increases related to the substation expansion.

3.1.5 Describe the relationship between the microgrid owner and the purchaser of power

A third party commercial entity will likely develop and own the microgrid, and the microgrid participants will enter into long-term agreements to purchase power from the microgrid owner/operator.

3.1.6 – Indicate which parties/customers will purchase electricity during normal operation? During islanded operation? If these entities are different, describe why.

All of the participants in the microgrid will purchase power during both normal and islanded operation.

3.1.7 – What are the planned or executed contractual agreements with critical and non-critical load purchasers?

It is anticipated that long-term Power Purchase Agreements (PPAs) or Energy Services Agreements (ESAs) will be entered into with the microgrid owner/operator. These will include performance and up-time guarantees, and to the extent applicable, revenue sharing arrangements. Additional information on the ESA follows:

Governs sales of electricity, heating, cooling, and related services, such as provision of back-up power, securing supply and delivery of power from the local utility and/or competitive suppliers, purchasing natural gas and other fuel, and the billing and/or metering mechanism

Establishes appropriate standards and benchmarks for operations and maintenance, including performance and up-time guarantees

May authorize or require the payment of management fees, resiliency fees, and/or customer subscription fees

May be separate Fuel Cell and/or Solar PPAs between the system owner and off-takers.

There are no executed contractual agreements with critical and non-critical load purchasers currently in place. In addition to ESA/PPA described above, planned contracts may include Engineering, Procurement and Construction Agreements, Site Lease/Ownership Agreements, and Site Improvement Agreements.

Specific terms, conditions, roles, and responsibilities will be negotiated by the parties as the project progresses through the detailed design and structuring phases.

3.1.8 – How does the applicant plan to solicit and register customers (i.e. purchasers of electricity) to be part of their project?

A financially and technically qualified private enterprise will be selected to build, own and operate the microgrid; this entity will be responsible for soliciting and registering the microgrid participants/customers.

3.1.9 – Are there any other energy commodities (such as steam, hot water, chilled water) that the microgrid will provide to customers?

This is expected to be predominantly electric commodity; it is possible a small cogeneration unit (< 2 MW) could be deployed in which case thermal energy would also be sold.

Task 3.2 – Commercial Viability – Value Proposition

3.2.1 – What benefits and costs will the community realize by the construction and operation of this project?

By enhancing reliability and resilience of this very large and unique cluster of health and medical emergency related facilities, the proposed microgrid will ensure that critical services are maintained even during a protracted grid emergency. The combination of renewable and low/no emission generation technologies running on natural gas will provide both base and peak demand so that full operational continuity is ensured and important medical services are available to the more than one million people that use or work at these facilities every year. These same individuals and business entities will also benefit as Con Edison customers and ratepayers to the extent this project helps Con Edison avoid either a major substation or system failure during high demand periods, or a costly expansion to the Brownsville substation, or both. The cost of upgrading the Brownsville Substation was estimated by Con Edison to be about $1 billion.

3.2.2 – How would installing this microgrid benefit the utility (e.g. reduce congestion or defer upgrades)? What costs would the utility incur as a result of this project?

Con Edison is currently faced with severe power congestion issues and constrained substations, including the Brownsville 1 and 2 substations which are a short distance away from the proposed microgrid. By lowering demand during normal grid operation by 8+ MW, this project will significantly alleviate strain on the Brownsville substations. The cost of upgrading the Brownsville Substation was estimated by Con Edison to be about $1 billion.

It is not envisioned that Con Edison will incur any costs as a result of this project aside from possible technical study of the proposed interconnections, in which case they would be reimbursed.

3.2.3 – Describe the proposed business model for this project. Include an analysis of strengths, weaknesses, opportunities and threats (SWOT) for the proposed business model.

The Clarkson Avenue microgrid participants are ideal candidates to host and serve as off-takers to the proposed microgrid. As public-sector entities with critical operational requirements, they represent attractive low-risk partners to private entities developing microgrids.

The microgrid participants have expressed interest in a public-private-partnership or “P3” design-build-own-operate-maintain (DBOOM) structure that shifts construction, technical, financial and operational risk to a qualified, financially strong entity with a proven track record. They recognize that the project would not be viable if it was upon them to band together and attract vendors, contractors and a team of engineering firms to design, develop, finance, construct, operate and own the microgrid. An added benefit of the P3-DBOOM approach is that it allows the private entities to monetize the tax related benefits associated with the deployment of certain distributed generation technologies including PV, fuel cells, and cogeneration.

The following “SWOT” analysis identifies the primary strengths, weaknesses, opportunities and threats of this approach:

SWOT ANALYSIS – P3 DESIGN, BUILD, OWN, OPERATE & MAINTAIN BUSINESS MODEL

Internal Strengths

- No upfront capital required
- Large public entities with long-term financial stability, high energy loads and critical operating requirements are attractive microgrid hosts/off-takers
- Immediate savings can accrue to hosts/off-takers
- Procurement can be expedited because no funds need to be budgeted, dispersed

- Scalable for host if it has other sites
- Leverage underutilized resources/assets (roofs, land)
- Financial and technical risk is limited

Weaknesses

- Microgrid hosts/off-takers may trade some benefits for reduced execution, construction, and operations risk
- Some risk remains related to variable fuel costs and technology/system performance
- Contracts can be hard to negotiate due to long-term nature and technical complexity
- Microgrid hosts/off-takers may lack technical and legal experts
- Shortage of interested/capable P3 partners may limit ability to negotiate best deal
- Limited transparency

External Opportunities

- Leverage external expertise, resources, and capital
- For strong projects, may be possible to attract multiple interested private partners and increase competitiveness of procurement
- Ensure operational continuity and resilience in face of extreme weather and other disruptions to the power grid
- Provide critical health, life, and safety services to the community, staff, and broader public
- Private partners assume most of operating and technical risk

Threats

- Hosts/off-takers could forego savings if energy prices fall and they are locked into long-term ESA/PPA contracts
- If technology advances, may not have option to swap out/upgrade system
- Shifting responsibility for critical resilience infrastructure and systems to P3 partner whose long-term business prospects may be relatively uncertain

3.2.4 – Are there any characteristics of the site or technology (including, but not limited to, generation, storage, controls, information technology (IT), automated metering infrastructure (AMI), other) that make this project unique?

This is a unique and highly concentrated cluster of critical health-care, emergency and homeless facilities serving a large diverse urban population. It is also in the heart of the BQDM congestion area and will significantly reduce demand on the Brownsville substation, with benefits that will accrue to the entire Con Edison customer base.

If this project goes forward, it would be one of the largest deployments in an urban setting of fuel cells in the country, which will provide clean, reliable and base loaded resilient energy 24 x 7. The proposed fuel cell array's system architecture and inherently redundant design is such that the manufacturer claims uptime availability of 99.998%.

Project construction will also feature direct boring, a technology similar to that used to directionally drill gas wells in shale formations. Based on Con Edison system constraints, it will not be possible to utilize existing Con Edison feeders to form the microgrid. As a result, and to avoid the alternative of trenching in a dense urban setting at exorbitant costs, direct boring will enable the routing of conduit directly from the primary generation site at Kingsboro Psychiatric Center to both SUNY-DMC and KCH. This proven method is expected to considerably reduce construction permitting, time, labor and costs.

3.2.5 – What makes this project replicable? Scalable?

The proposed P3-DBOOM business model will expedite and simplify the commercial procurement process, the primary generation is supplied by an all-electric Fuel Cell Array that, compared to CHP, produces virtually no emissions and is very simple to install, and thus minimizing permitting and construction related costs. The Fuel Cell Array will be black start enabled and equipped with a module that enables load following and system stability. The microgrid participants all operate multiple sites throughout the state that could benefit from this same

3.2.6 – What is the purpose and need for this project? Why is reliability/resiliency particularly important for this location? What types of disruptive phenomenon (weather, other) will the microgrid be designed for? Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time.

The purpose of this project is to ensure that these critical facilities remain operational during an extreme and highly protracted power grid failure. Thousands of people depend on these facilities daily for in-patient, out-patient, emergency care and mental health services. The microgrid facilities will also support police, fire and first responders as they carry out their duties during disasters and protracted power grid failures.

The microgrid is designed to operate at full load indefinitely as long as natural gas supply is not disrupted. All electrical infrastructure will be underground, and the generating assets, including fuel cells, solar PV, dual fuel emergency backup generators and battery storage are designed to withstand extreme weather.

3.2.7 – Describe the project's overall value proposition to each of its identified customers and stakeholders (including, but not limited, the electricity purchaser, the community, the utility, the suppliers and partners, and NY State).

The microgrid project's value proposition is based in the ability to provide operational continuity during a protracted power grid emergency. More than 1 million people every year are served by the health, medical, emergency and homeless facilities that comprise the Clarkson Avenue Microgrid. Stakeholders include patients, local and regional communities, a homeless shelter, students, the U.S. Army's Reservists Medical Staff, area businesses, and facility employees.

For the microgrid participants, energy savings and long-term supplies of power at fixed costs through a power or energy services purchase agreement (PPA and ESA) provide a hedge against electric cost increases without an upfront investment. Potential revenue from future power market participation represents, at a fundamental level, the value of broader transmission and distribution system efficiency.

Con Edison and its ratepayers stand to benefit through the deferral of an expensive expansion of the Brownsville Substation. Also, the 8MW of behind the meter distributed baseloaded generation will reduce transmission and distribution system losses, including line losses and transformer losses. These system losses are often greatest during periods of peak demand, electric system congestion and high ambient temperatures – three contributing factors that often coincide, further compounding the problem in a sort of “perfect storm” manner. While average losses are in the 6%-7% range, losses during “perfect storm” circumstances can exceed 10%.

3.2.8 – What added revenue streams, savings, and/or costs will this microgrid create for the purchasers of its power?

The Fuel Cell Array and 300kW of solar will provide energy saving to all customers in the microgrid. In general, with the potential enactment of new policies to allow "behind the meter net generation" or "BTM: NG" by the end of 2016, it is hoped that the microgrid will sell ancillary services to the grid and receive new ongoing revenue as a result. The magnitude of these potential revenues is difficult to predict at this stage given the emerging nature of these grid services and markets.

3.2.9 – How does the proposed project promote state policy objectives (e.g. NY REV, RPS)?

The proposed project will enable the efficient and resilient generation of power at a local level. The installation of the Fuel Cell Array and solar panels will promote the objective of generating power in a low carbon manner, highly reliable and resilient manner. The proposed microgrid is in the heart of the BQDM congestion area and the on-site generation will significantly reduce demand on the Brownsville substation. This will benefit both Con Edison and its customer base.

In these ways, the Clarkson Avenue Microgrid value proposition directly benefits multiple stakeholders, helps meet the BQDM initiative and advances the goals of REV, goals that call for, among other things, the creative and targeted deployment of distributed energy resources to improve the efficiency and resilience of the electric grid.

3.2.10 – How would this project promote new technology (including, but not limited to, generation, storage, controls, IT, AMI, other)? What are they?

Technologies included in the proposed microgrid include solar PV, fuel cells, dual-fuel generators, energy storage, microgrid control and IT. In addition to showcasing these advanced energy technologies individually, the project will demonstrate the potential of microgrids to provide a platform for integrating and optimizing a diverse array of systems to lower energy costs, increase resilience and reduce carbon emissions.

Task 3.3 – Commercial Viability – Project Team

3.3.1 – Describe the current status and approach to securing support from local partners such as municipal government? Community groups? Residents?

Additional support for the proposed project has been demonstrated by New York City's Department of Homeless Services, and the Mayor's Office of Sustainability. Project details have been shared with these offices and the Department of Homeless Services, which leases buildings from the Office of Mental Health at Kingsboro, is now a project participant.

3.3.2 – What role will each team member (including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners) play in the development of the project? Construction? Operation?

New York State Office of Mental Health, on behalf of the Clarkson Ave stakeholders, will be the project applicant. Burns Engineering's role will be to oversee the further assessment and follow-on engineering and design of the microgrid as part of Phase 2. Burns Engineering and GE Energy Consulting will continue to provide technical engineering and analysis services. Looking forward to Phase 3, Burns Engineering is interested to provide a design-build-own-operate solution that includes project funding.

3.3.3 – Are public/private partnerships used in this project? If yes, describe this relationship and why it will benefit the project.

A public-private-partnership (P3) is central to this projects commercial viability. This P3 approach will overcome two issues that would otherwise present insurmountable hurdles going forward: project financing and microgrid design, construction, operation and maintenance. It is proposed that one of several qualified and interested private energy firms would develop, finance, design, build, own, operate and maintain. In turn, the public-sector project participants would sign a long-term energy or power purchase agreement with the selected private partner, thus providing a means to recover its investment over 15-20 years.

3.3.4 – Describe the financial strength of the applicant. If the applicant is not the eventual owner or project lead, describe the financial strength of those entities.

It is probable that the applicant, the New York State Office of Mental Health, will not be the eventual owner of the microgrid. It is intended that the microgrid be operated in a public-private-partnership (P3) manner, no owner has been selected at this time.

3.3.5 – For identified Project Team members (including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners), what are their qualifications and performance records?

Burns Engineering – Burns is at the forefront of the design, development and implementation of advanced microgrids and DER. Burns is currently performing the preliminary design of a 100+ MW microgrid for NJ TRANSIT to power transit operations to and from Manhattan to northern New Jersey in the event of a protracted grid failure.

Burns is also currently evaluating a 10-20 MW microgrid for the Port Authority of New York and New Jersey. Previous notable projects include the design and implementation of a microgrid for the Philadelphia Navy Yard, and the engineering and project management for a 16 MW microgrid at Temple University. Burns and its teaming partners have received several U.S. Department of Energy (“DOE”) grants to advance the development and testing of microgrid controller technology, and to deploy and test advanced micro synchrophasors for enhanced grid stability and control.

GE Energy Consulting (GE EC) – GE EC is a core group of leading GE technical and business experts focused on solving the electric power industry’s most pressing challenges with a goal to “pursue and execute engagements that expand the study portfolio and help define the energy industry of the future.” The foundational strength of GE EC lies in the experience and expertise of its employees, a total staff of approximately 100, with most having advanced degrees in engineering disciplines, including more than 25 with doctoral degrees. GE EC is distinguished by having six engineers on staff elevated to the esteemed status of IEEE Fellow, the highest honor bestowed by IEEE.

GE EC has decades of experience conducting detailed engineering assessments in NY State, the Northeast and across the country. Increasing interest in microgrids, driven by storm impacts in the Northeast, has resulted in a number of opportunities with the states of NY, NJ, PA, CT, and MA, individual utilities in the Northeast, and various end-customers and communities. As a precursor and enabler to NY Prize, GE EC was retained by NYSERDA to perform microgrid feasibility studies and develop the technical microgrid functional designs for five designated sites in NY State. Results of this work are found in the NYSERDA final report entitled “Microgrids for Critical Facility Resiliency in New York State,” December 2014.

3.3.6 – Are the contractors and suppliers identified? If yes, who are they, what services will each provide and what is the relationship to the applicant? If no, what types of team members will be required and what is the proposed approach to selecting and contracting?

Equipment vendors have been approached for a range of hardware and software systems, including microgrid control and fuel cells. No decisions have been made to pre-select any technology, though the team has identified best in class and will only procure technology with proven performance record. Similarly, no contractors have been determined. The Team will commence discussions with potential contractors as part of Phase 2. Procuring equipment and construction services will be done through a competitive process at the appropriate time.

3.3.7 – Are the project financiers or investors identified? If yes, who are they and what is their relationship to the applicant? If no, what is the proposed approach to securing proposed financing? Will other members of the Project Team contribute any financial resources?

For Clarkson Avenue, it is intended that the microgrid be owned, operated, and financed in a public-private-partnership (P3). No owner has been selected at this time, however, the potential primary owner and financier could be a company such as NRG, Constellation, Veolia, or Ameresco, all of which have expressed specific interest in the project.

3.3.8 – Are there legal and regulatory advisors on the team? If yes, please identify them and describe their qualifications. If no, what is the proposed approach to enlisting support in this subject area?

At this time, there are no legal and regulatory advisors on the team. It is planned that the organization who will own and operate the microgrid will possess the necessary legal and regulatory qualifications. As mentioned, the possible owners and operators of the microgrid are being considered at this time. NRG, Constellation, Veolia, and Ameresco have all expressed specific interest in this project.

Task 3.4 – Commercial Viability – Creating and Delivering Value

3.4.1 – How were the specific microgrid technologies chosen? Specifically discuss benefits and challenges of employing these technologies.

The microgrid distributed energy resources were chosen based on a number of factors. We started overall system optimizations and initial asset selection, sizing, and configuration by using Lawrence Berkeley's Lab microgrid optimization tool, "DER-CAM". This tool takes a wide range of detailed inputs regarding DER assets, site loads, participant tariffs, site location weather, energy prices, and environmental parameters to optimize the selection and operation of DERs in the microgrid.

DER selection was further refined by considering the specific types of loads, available space, detailed asset performance characteristics and limitations given their intended function (e.g., base or peak generation) in the microgrid. Due to the significant electric base load and availability of land at Kingsboro, the site was determined to be well suited for electric fuel cells. The 8MW of fuel cells can very efficiently and cleanly generate power to support the load of the facilities at Clarkson Ave. The consistency with which they produce power while operating at a rated capacity will greatly reduce the demand on Con Ed's Brownsville substation. Solar PV was selected as an additional resource and sized based on roof area available.

3.4.2 – What assets does the applicant and/or microgrid owner already own that can be leveraged to complete this project?

The Clarkson Avenue Microgrid participants have a combined installed base of emergency generators totaling 17.5 MW of nameplate capacity and a standard operating capacity of 14.4 MW. The preliminary microgrid design calls for 8 MW of base load power to be produced by the fuel cell array, with the backup generators being able to provide load following and meet peak loads so that the facilities can operate at full power.

Of the installed emergency generator capacity, 6 MW will be converted to dual fuel operation to ensure long-term fuel availability.

3.4.3 – How do the design, technology choice, and/or contracts ensure that the system balances generation and load?

Clarkson Avenue will feature 8MW of fuel cells which will be able to offset baseline power usage for all three facilities. Once a utility outage is detected through under voltage and frequency monitoring, the microgrid will island. Each sites emergency generators will come online to comply with code mandated starting times, with the microgrid paralleling to the site emergency distribution system. Upon detecting the presence of the microgrid, the diesel generators will ramp down and turn off based upon demand load.

3.4.4 – What permits and/or special permissions will be required to construct this project? Are they unique or would they be required of any microgrid? Why?

The Project Team does not expect that special permits will be required.

3.4.5 – What is the proposed approach for developing, constructing and operating the project?

The proposed approach is to provide a P3 solution wherein a third party, such as NRG, will finance, build, own, operate, and maintain the microgrid.

3.4.6 – How are benefits of the microgrid passed to the community? Will the community incur any costs? If so, list the additional costs.

The benefits of the microgrid will redound to the community in a number of direct and indirect ways. By helping to lower demand on the Brownsville substations, the likelihood of an outage is reduced, as are increases in electric costs. Ensuring long-term operational continuity of the microgrid's critical health and emergency-care related facilities in the face of a severe, protracted grid failure provides significant benefits to the more than 1 million people who rely on these facilities every year.

3.4.7 – What will be required of the utility to ensure this project creates value for the purchaser of the electricity and the community?

Because all three facilities are on dedicated network transformers or spot networks, there is no connection with the meshed street grid, which significantly reduces the number points that need to be controlled. A low voltage breaker or disconnect switch downstream of each network transformer secondary bus will be required to isolate the microgrid from the grid, in accordance with New York State Standardized Interconnection Requirements.[2] These breakers will be used by the microgrid controller to island the system or reconnect to the main grid. Each point will have instrumentation to allow the microgrid Energy Management System (or Controller) to monitor the voltage, current and frequency at the POI.

Because the microgrid has distributed sources including both rotating machines and inverter based generation, traditional protection schemes based on high fault currents will likely not be applicable when in islanded mode. Coordination of the protection schemes between grid-connected and islanded mode will require relays capable of being remotely switched between multiple modes or set-points.

In addition to Instantaneous/Timed Overcurrent protection (Functions 50P/50G/51P/51G), the microgrid protection scheme will employ some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

3.4.8 – Have the microgrid technologies (including but not limited to: generation, storage, controls) been used or demonstrated before? If yes, describe the circumstances and lessons learned.

All of the technologies incorporated in the proposed microgrid are commercialized and proven. Solid oxide fuel cell and solar PV are established technologies, and retrofitting emergency generators to allow dual fuel operation is a well understood and proven solution to ensure long-term fuel availability.

The Microgrid Control design will incorporate GE's proven U90Plus Microgrid Cost Minimizer to dispatch the DERs, and the D400 RTU/Controller to implement various operational control strategies. GE is currently developing a DoE funded eMCS controller that expands upon the algorithms implemented in the U90Plus and incorporates many of the control functions that now reside in the D400. The eMCS will be tested at NREL in early 2016 and will be applied at a microgrid site on Potsdam, NY. The U90Plus algorithm is being incorporated into the D400 controller, and this solution will be deployed in mid-2016 on a Microgrid at the University of Ontario in Toronto.

Another proven solution that could be utilized is GE's proven C90Plus Fast Load Shed Controller. The C90Plus provides adaptive load shedding for loss of generation and/or a utility tie to trip non-critical load. The IEDs/relays communicate real-time load and generation values as well as status to the C90Plus via IEC 61850 GOOSE messaging. The C90Plus evaluates this information and will issue a fast trip GOOSE message to the IEDs/relays to trip non-critical loads to assure a generation-load balance. The tripping of the load breakers is initiated in less than 20ms from detection of the triggering event. This compares to 200ms to 400ms for conventional load shedding schemes. This solution was recently

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[2] http://www3.dps.ny.gov/W/PSCWeb.nsf/All/DCF68EFCA391AD6085257687006F396B?OpenDocument

successfully deployed and demonstrated at the Portsmouth Naval Shipyard under a DoD Environmental Security Technology Certification Program (ESTCP) contract.

3.4.9 – Describe the operational scheme (including, but not limited to, technical, financial, transactional and decision making responsibilities) that will be used to ensure this project operates as expected.

All three facilities, KPC, KCHC and SUNY-DMC, currently receive power via several dedicated network transformers or spot networks of Con Edison's 27 kV feeders. None of the facilities are powered directly off the street network, which significantly reduces the number of interconnection points with the grid. The spot networks are designed to N-2 standard (meaning loss of two feeders or transformers would not interrupt load), and all construction is underground and designed to submersible. This is an extremely reliable design that is *likely* only compromised by a transmission system failure, substation failure, or a network collapse.

Normal Conditions

Under normal condition the microgrid facilities will be served by Con Edison's 27-kV system, as well as the Fuel Cell located at KPC and PV generation at KPC and SUNY DMC. The new tie cable shown in Figure 2-2 may or may not be connected during blue sky days. These decisions will be made by the microgrid controller, which will be able to utilize distributed assets based upon the economic market.

As the coincident normal load for these three facilities is typically over 10MW, the fuel cell generation will be consistently loaded at rated capacity.

Emergency Conditions

When power is lost to the facilities due to, for example, a catastrophic event on the bulk power system, loads in all the facilities will be unserved. The microgrid controller which is monitoring the points of interconnection (POIs) with the main grid will sense loss of voltage or frequency and the DERs (Fuel Cell and Dual Fuel units) will go off-line (in accordance with anti-islanding protection procedures). Interconnection points with the utility (and between the facilities if the tie line is active) will open and the converted dual fuel and existing diesel backup generators at all three locations will start up to supply facility emergency life safety loads. The dual fuel generators will start using diesel as the pilot fuel to ignite the natural gas, while still maintaining NFPA 110 starting requirements.

Once the facilities are isolated from the utility system, the Fuel Cell units will restart and synchronize with the online backup generation (5-10 minutes). When the generation is stabilized, the microgrid tie-line is closed in and load at all three microgrid locations can be sequentially transferred from the backup generators to the Fuel Cell and Dual Fuel units. Once the island is stable and active, PV would reconnect and begin generating. During islanded operation, the microgrid controller would actively monitor voltage and frequency in the island. Loads on some breakers could be shed and some backup generation might remain online or be brought online to maintain stable operation. Diesel generators will then be safely shut down and load will be transferred back to the microgrid system. This enables a reduction of diesel generator run time usage and helps alleviate any issues or reliance on fuel delivery trucks during an emergency.

In cases when the grid is stressed but there is no forced outage, "seamless" transition to microgrid mode is possible. In this scenario the Fuel Cell and Dual Fuel units would remain online during the transition, and the microgrid controller would shed load quickly or bring backup generation online to maintain balance in the island.

3.4.10 – How does the project owner plan to charge the purchasers of electricity services? How will the purchasers' use be metered?

The project owner would enter into long-term power and/or energy services agreements with the various microgrid customers wherein the price per kW and the price for thermal energy would be established and agreed to by all parties. Energy usage at individual sites would all be recorded by revenue grade meters.

3.4.11 – Are there business/commercialization and replication plans appropriate for the type of project?

Yes, the project's proposed P3 business and commercialization plans are appropriate for this project. Long-term power and/or purchase agreements between private parties and governmental/ institutional/non-profit entities are a proven and widely used deal structure to implement large energy infrastructure projects.

3.4.12 – How significant are the barriers to market entry microgrid participants?

Microgrid participants in the U.S. face significant barriers from the constantly changing and evolving markets and regulatory environment between different states and between different utility service territories. Also, the microgrid business model for recovering costs for the different entities involved in the project is another challenging aspect of microgrid project development and commercial execution. Microgrid design engineers and developers also face challenges when dealing with a built environment and existing infrastructure, as compared to a new building or campus that can be more easily and economically set up for islanding operation.

The interdisciplinary nature of microgrid design involving electrical, mechanical, financial, legal, and regulatory domains is another challenge for market entry participants. As discussed above in Task 3.3, a third party could address this challenge through a combination of in-house expertise and the selection of subject matter experts, such as Burns Engineering and GE EC. A single entity with a proven track record and adequate financial strength can finance, build, own, operate, and maintain the assets as a system to optimize performance and reduce risk and costs to microgrid customer participants.

3.4.13 – Does the proposer demonstrate a clear understanding of the steps required to overcome these barriers?

Burns Engineering has a comprehensive understanding of the use of P3 for energy projects and has participated in several as both owner's engineer and engineer of record. In particular, Burns has led the multi-year planning and implementation of a microgrid at the Philadelphia Navy Yard and developed a number of P3 project structures to fund the construction and facilitate the operation and ownership of distributed generation resources central to the microgrid.

3.4.14 – Has the market been identified and characterized?

The market of qualified private entities with the experience and track record of successfully deploying large energy assets and infrastructure have been identified and it includes but is not limited to large national or international entities such as NRG, Constellation, Siemens, Veolia and Ameresco.

Task 3.5 – Financial Viability

3.5.1 – What are the categories and relative magnitudes of the revenue streams and/or savings that will flow to the microgrid owner? Will they be fixed or variable?

The principal revenue streams for the proposed microgrid would be derived mostly from base-load electric sales, with a considerably smaller amount of electric sales from the solar PV systems. Sales of electricity from 8 MW of base-loaded fuel cells together with 300 kW of PV will earn gross annual revenues of approximately $9 million. This amounts to a savings or roughly $500,000 - $1 million/year for the off taker participants. It is expected that the cost of power would be fixed for the first 5-7 years after which there could be minor adjustments up or down based on the cost of long-term natural gas contracts. Additional revenues are foreseen based on participation in demand response and NYISO energy and ancillary services markets.

3.5.2 – What other incentives will be required or preferred for this project to proceed? How does the timing of those incentives affect the development and deployment of this project?

Incentives to deploy solar PV, CHP and fuel cells would be required to buy down the initial cost of these technologies. Other incentives required or preferred will depend in part on the magnitude of the NY Prize funding received in future stages. The Project Team believes that the NY Prize Stage 2 funding, preferably without a cost share requirement, will be particularly important for communities and their partners to move forward with the microgrid development process. Absent this funding from NYSERDA, communities will most likely be challenged to secure additional funds and proceed to a final, buildable project design.

A number of federal and state-level incentives, subject to funding availability and eligibility and changes in incentive levels and structures, will contribute to the overall financial viability of the project:

- Federal Investment Tax Credit
    - 30% for Solar PV (extended at 30% through 12/31/2019 and gradually stepping down each year thereafter)
    - 10% for CHP (currently set to expire on 12/31/2016)
- NY-SUN Incentive for Small Nonresidential Applications – NY PON 3082
    - $0.35/Watt for first 50 kW, $0.30/Watt for each additional up to 200 kW total (Block 4, Long Island Nonresidential)

Through NY State’s Net Metering Law and the LIPA Tariff for Electric Service, customers with solar PV systems are entitled to net metering. When the customer’s solar system generates more electricity than consumed, excess electricity is returned to the system, and the customer will be billed only for the net consumption at the end of each month.

3.5.3 – What are the categories and relative magnitudes of the capital and operating costs that will be incurred by the microgrid owner? Will they be fixed or variable?

The capital cost of the proposed microgrid is estimated to be $50 million before rebates and incentives. Operating costs will be a combination of fixed and variable and are estimated to be in the range of $3 Million with most of the cost related to fuel. Fixed O&M costs are currently estimated at $16,000 per year.

The fully installed cost estimates (+/-30%) and engineering life span for all the capital equipment is shown in the below table:

Capital Component	Installed Cost ($ in millions)	Component Lifespan (round to nearest year)	Description of Component
8 MW Fuel Cell	$0	20	PPA Agreement, costs included in O&M Section (See Question 14)
Dual Fuel Generators at Kingsboro (1MW)	$0.06	30	Cost for converting (1) diesel generator sets to dual fuel generator
Dual Fuel Generators at Kings CHC (2MW)	$0.06	30	Cost for converting (1) diesel generator sets to dual fuel generator
Dual Fuel Generators at SUNY (4.5MW)	$0.24	30	Cost for converting (4) diesel generator sets to dual fuel generator
27kV Switchgear	$1.5	30	Switchgear to connect Generator to distribution voltage
Transformers	$1.5	30	Transformers to connect to existing system voltages
LV Paralleling Switchgear	$2	30	Equipment to connect generators to existing distribution busses
300kW Solar Panel/Storage	$0.80	20	Solar Panels at Kingsboro
Cabling	$2	30	Connecting campuses, including direct bores
Communication Backbone	$1.5	30	Microgrid Controllers
Subtotal - Capital Costs	**$9.66**		
Initial Planning & Design	$2.5		Project Design, Permitting, Financing
Total	**$12.16**		

3.5.4 – How does the business model for this project ensure that it will be profitable?

The P3 business model will utilize long-term power purchase and / or energy service agreements with the participant off takers that will incorporate energy adjustment and natural gas pass through clauses to ensure that the 3rd party profits are protected if gas prices increase. For electric commodity, the agreement will allow the 3rd party to increase electric rates as the utility rates increase, but only to some agreed to percentage of the utility's cost per kWh, thus ensuring savings for the microgrid participant off takers. This upside for the 3rd party will provide additional revenue and help protect against unforeseen circumstances and costs.

The P3 business model also lowers the total amount of capital that has to be recovered because the private entity is able to obtain tax credits and use accelerated depreciation on certain assets. This has the direct effect of lower project risk and enhancing profitability. Without a private firm's involvement, the value of those tax related benefits would be lost.

3.5.5 – Describe the financing structure for this project during development, construction and operation.

The financing structure will be similar to other construction projects wherein a construction loan is used to fund construction costs which is then recovered as part of the long-term offtake agreements.

Task 3.6 – Legal Viability

3.6.1 – Describe the proposed project ownership structure and Project Team members that will have a stake in the ownership.

The project ownership structure will be based on having a qualified private energy company with proven technical capabilities and financial wherewithal serving as the primary owner of the microgrid as well as the operator. Additional ownership may be held by a key partners such as a specialty equipment vendor and the lead technical services/engineering firm. For the Clarkson Avenue Microgrid, the primary owner could be a company such as NRG, Constellation, Veolia, or Ameresco, all firms that have expressed interest in the project. The key vendor partner might be Bloom Energy whose fuel cells will be the primary source of baseload electric and whose business model is to own, operate and maintain their equipment. The lead technical firm could be Burns Engineering, as the firm is interested in creating ownership stakes in design-build microgrids.

3.6.2 – Has the project owner been identified? If yes, who is it and what is the relationship to the applicant? If no, what is the proposed approach to securing the project owner?

For the Clarkson Avenue Microgrid, the potential primary owner could be a company such as NRG, Constellation, Veolia, or Ameresco, all of which have expressed specific interest in the project.

3.6.3 – Does the project owner (or owners) own the site(s) where microgrid equipment/systems are to be installed? If not, what is the plan to secure access to that/those site(s)?

The Clarkson Avenue Microgrid will utilize existing land and roof space. All of the participant offtakers own their properties. The owner of the microgrid would be a private third-party entity such as NRG, Constellation, Veolia, or Ameresco, all firms that have expressed interest in the project. Since it is anticipated that the primary generation assets would be located on Kingsboro Psychiatric Center's (KPC) property, the microgrid owner would pay a small amount of rent to compensate KPC for use of their property. KPC already expressed interest in such an arrangement.

3.6.4 – What is the approach to protecting the privacy rights of the microgrid's customers?

P3 energy projects that include the sale of energy commodities from the private party to the public host or offtaker are common place and viewed as a creative means to accelerate the penetration of energy efficiency and distributed generation projects. Private firms that use this business model and implement these projects are accustomed to ensuring the privacy of their public hosts.

3.6.5 – Describe any known, anticipated, or potential regulatory hurdles, as well as their implications that will need to be evaluated and resolved for this project to proceed. What is the plan to address them?

If Con Ed is part of a special purpose entity that owns and operates the microgrid, certain regulatory concerns regarding franchise limitations are diminished while others that restrict utility ownership of generation become problematic. If a new line is built without Con Ed's involvement, the microgrid would need regulatory approval to cross public rights of way. If Con Ed is part of the microgrid, the following issues arise: restrictions on utility ownership of generation; ability of microgrid ownership entity to recover fixed costs for infrastructure from direct and indirect beneficiaries; ability of microgrid ownership entity to act as DR aggregator for wholesale markets; valuation of locational benefit of microgrid DERs (LMP+D).

Section 4 – Microgrid Benefit-Cost Analysis

Task 4.0 – Benefit-Cost Analysis Summary Report

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, a Project Team led by the New York State Office of Mental Health has proposed development of the Clarkson Avenue Community Microgrid Project in Brooklyn, New York. This project would serve the SUNY Downstate Medical Center hospital, the Kings County Hospital Center (CHC), the Kingsboro Psychiatric Center (PC), and the Kingsboro Homeless Shelter.

The proposed microgrid project would be powered primarily by a new 8 MW fuel cell generator as well as a new 0.3 MW solar array. The microgrid would also connect six existing dual fuel generators with a combined nameplate capacity of 6 MW that are currently used to provide emergency backup power to the facilities to be supported by the microgrid project. The energy resources would be located at the three critical facility sites, with the minimum capacity required for each facility at each site. The system as designed would have sufficient generating capacity to meet about 60 percent of average demand for electricity from the supported facilities during normal operations, as well as 100 percent of supported facilities' demand during a major outage. Project consultants also indicate that the system would have the capability of providing ancillary services 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.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. Of note, the model analyzes a discrete operating scenario specified by the user; it does not identify an optimal project design or operating strategy.

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

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[3] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance

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 three scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[4]

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that even if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's benefits would exceed its costs by roughly 20 percent.

Since the Scenario 1 results suggest a benefit-cost ratio greater than one, this report does not provide 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.

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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.]

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

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.9 DAYS/YEAR
Net Benefits - Present Value	$22,800,000	Not Evaluated
Benefit-Cost Ratio	1.2	Not Evaluated
Internal Rate of Return	14.6%	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)

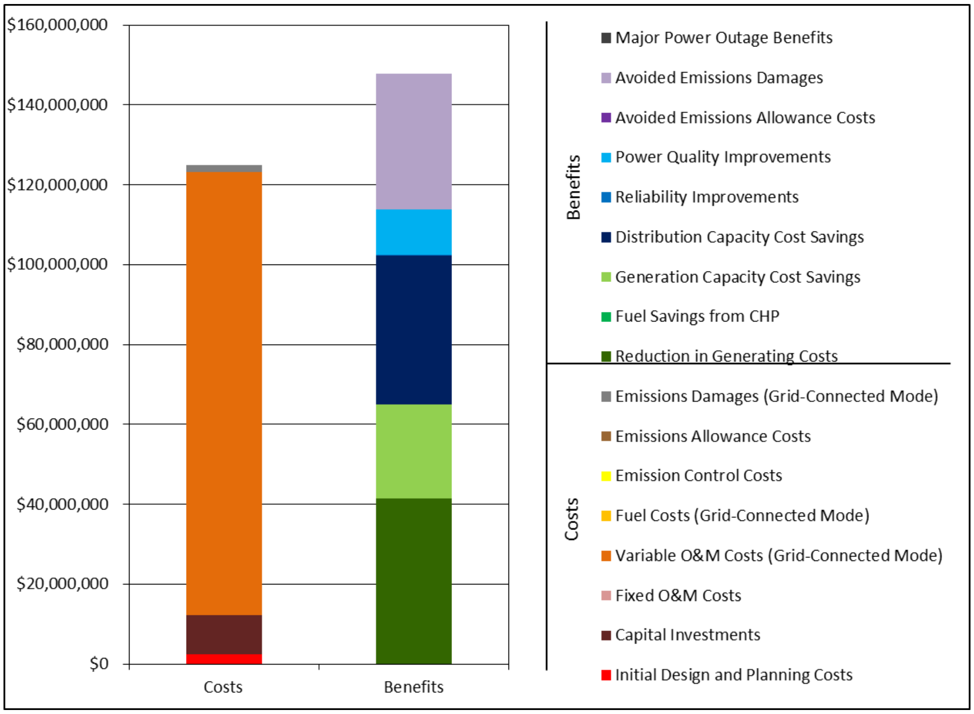

Table 2 – Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$2,500,000	$221,000
Capital Investments	$9,660,000	$738,000
Fixed O&M	$181,000	$16,000
Variable O&M (Grid-Connected Mode)	$111,000,000	$9,790,000
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,700,000	$150,000
Total Costs	**$125,000,000**	
Benefits		
Reduction in Generating Costs	$41,500,000	$3,660,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$23,500,000	$2,070,000
Distribution Capacity Cost Savings	$37,300,000	$3,290,000
Reliability Improvements	$236,000	$20,800
Power Quality Improvements	$11,300,000	$998,000
Avoided Emissions Allowance Costs	$22,800	$2,010
Avoided Emissions Damages	$33,900,000	$2,210,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$148,000,000**	
Net Benefits	**$22,800,000**	
Benefit/Cost Ratio	**1.2**	
Internal Rate of Return	**14.6%**	

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 $2.5 million, which includes the costs of project design, obtaining permits, and securing financing. The present value of the project’s capital costs is estimated at approximately $9.7 million, including costs associated with developing the 0.3 MW solar array and storage; converting existing diesel generators to dual fuel use; switches, transformers, and other equipment to connect the microgrid’s DERs to existing distribution networks; cabling; and microgrid controllers. These costs do not include the capital costs of developing the 8 MW fuel cell generator, as those costs are incorporated into a power purchase agreement (PPA), which the model treats as part of variable operation and maintenance (O&M) costs (described below).

Fixed O&M costs for the entire system, which include software licensing as well as miscellaneous O&M for the solar array and storage, would be approximately $16,000 per year. The present value of these O&M costs over a 20-year operating period is approximately $181,000.

Variable Costs

The BCA's analysis of variable costs considers the costs of any fuel required to run the microgrid's distributed energy resources, as well as any variable O&M costs, and the social costs of environmental damages associated with pollutant emissions from the microgrid's DERs. The two new DERs incorporated into the Clarkson Avenue microgrid are the 8 MW fuel cell generator and the 0.3 MW solar array. Fuel costs for the fuel cell generator are incorporated into the generator's PPA, and the solar array does not consume fuel; accordingly, the analysis does not estimate any fuel costs for the microgrid.

The PPA for the 8 MW fuel cell generator includes a delivered price for all electricity produced by the generator of $147 per MWh. In PPAs such as this, the delivered price is meant to cover all of the costs associated with developing and operating a generator (including capital costs, O&M, and fuel costs), as well as any return on investment (ROI) that the operator expects to earn. Because this price includes both the actual costs of developing and operating the generator and the operator's ROI, it likely overestimates the true costs (i.e., the value of resources consumed) associated with the fuel cell generator. For purposes of this analysis, the model considers the PPA delivered electricity price to be a variable O&M cost of the microgrid and estimates the present value of this cost, based on expected generation of the microgrid's DERs, to be about $111 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the microgrid's DERs, based on the operating scenario and emissions rates provided by the Project Team and the understanding that none of the system's generators would be subject to emissions allowance requirements. Based on the emissions rates associated with the fuel cell generator, the analysis estimates the damages attributable to the emissions from the microgrid's DERs at approximately $150,000 annually, with a present value of about $1.7 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 $41.5 million. This reduction in demand for electricity from bulk energy suppliers would also avoid emissions of CO2, SO2, NOx, and particulate matter, yielding avoided emissions allowance costs with a present value of about $22,800 and avoided emissions damages with a present value of approximately $33.9 million.

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. Based on the application of appropriate availability factors for each DER, the Project Team estimates the impact of the microgrid on generating capacity requirements to be approximately 14.1 MW per year. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $23.5 million over a 20-year operating period. Similarly, the Project Team estimates that the microgrid project would reduce the need for local distribution capacity by approximately 8.3 MW per year, yielding annual benefits of approximately $3.3 million. Over a 20-year period, the present value of these benefits is approximately $37.3 million.

The Project Team has indicated that the proposed microgrid would be designed to provide real power support, 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 market for ancillary services is 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 this service.

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 $20,800 per year, with a present value of $236,000 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:

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) - 181.2 minutes.[5]

The estimate takes into account the number of 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. 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. 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.

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. The Clarkson Avenue Project Team estimates that the microgrid would help the facilities it serves avoid five power quality events per year. The model estimates the present value of this benefit to be approximately $11.3 million over a 20-year operating period. In reality, some customers for whom power quality is important (e.g., hospitals) may already have systems in place to protect against voltage sags, swells, and momentary outages. If this is the case, the BCA may overstate the power quality benefits the project would provide.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 1.2; i.e., the estimate of project benefits exceeds costs by about 20 percent. Accordingly, the analysis does not consider the potential for 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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[5] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Consolidated Edison.

Task 4.1 – Facility List and Customer Description

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (kWh)	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
SUNY (Downstate Medical Center)	Large (>50 annual MWh)	Hospital / Teaching Institution	Health Infrastructure	46,885.596	7.68	100%	24
Kings County Hospital	Large (>50 MWh)	Hospital – Multi Building	Health Infrastructure	57,366.200	10.40	100%	24
Kingsboro	Large (>50 annual MWh)	Hospital Outpatient Health-Multi Building	Health Infrastructure	6,008.800	1.28	100%	24
Kingsboro Homeless Shelter	Large (>50 annual MWh)	Homeless shelter	Residential	585	0.12	100%	24

Task 4.2 – Characterization of Proposed Distributed Energy Resources

Distributed Energy Resource Name	Facility Name	Energy Source	Name-plate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
8 MW Fuel Cell	Kingsboro and all three	Natural Gas	8	66576	192	6.56	Mbtu/ MWH
Backup Generator G-22	Kingsboro PC, Building 22, Power House	Dual Fuel	1	0	11.56	20.4	Mbtu/ MWH
300 kW Solar Panel	Kingsboro	SOLAR/ST OARAGE	.3	657	1.8	N/A	N/A
Backup Generator Genset No.2	Kings CHC Building R	Dual Fuel	2	0	42	8.17	Mbtu/ MWH
SUNY UHB-1	SUNY	Dual Fuel	0.75	0	18	9.05	Mbtu/ MWH
SUNY *UHB 2*	*SUNY*	Dual Fuel	0.75	0	18	9.05	Mbtu/ MWH
SUNY *UHB 3*	*SUNY*	Dual Fuel	0.75	0	18	9.05	Mbtu/ MWH
SUNY *UHB 4*	*SUNY*	Dual Fuel	0.75	0	18	9.05	Mbtu/ MWH

Task 4.3 – Capacity Impact and Ancillary Services

The following resources would be available for peak load support.

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does distributed energy resource currently provide peak load support?
Fuel Cell	Kingsboro and all three	8	☐ Yes
Backup Generator G-22	Kingsboro PC, Building 22, Power House	1	☐ Yes
300kW Solar Panel/Storage	Kingsboro	0.108	☐ Yes
Backup Generator Genset No.2	Kings CHC Building R	2	☐ Yes
SUNY UHB-1	SUNY	0.75	☐ Yes
SUNY UHB-2	SUNY	0.75	☐ Yes
SUNY UHB-3	SUNY	0.75	☐ Yes
SUNY UHB-4	SUNY	0.75	☐ Yes

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently
Kingsboro	11.3	0.9
Kings CHC	12	0.3
SUNY	4.5	0

The microgrid operation will relieve the local distribution network by the kW generated capacity of the microgrid. The kW power offset will allow the utility and the system to provide more power to other energy consumers. If applicable, Con Ed’s engineering team will provide a value of what this capacity is worth in system avoided costs for the increased power availability.

The microgrid DER would be available for real (power) and reactive (voltage) local utility support, as well as black start or system restoration support as described in 2.3.6 and 2.5.2.

No emission allowances will be purchased for the operation of the DER. For regulated NOx and Particulate Matter emissions, the generator engines meet the required limit. Estimated emission rates for the equipment are in the following table. These rates are weighted averages for all DER in the microgrid.

Emissions Type	Emissions per MWh	Unit
CO_2	0.00667	Metric tons/MWh
SO_2	0	N/A
NO_x	0.00018	Metric tons/MWh
PM	0	N/A

Task 4.4 – Project Costs

The fully installed capital cost of the proposed microgrid is estimated to be approximately $5.9 million before rebates and incentives, plus a $1.5 million cost estimate for initial planning/design. Operating costs will be a combination of fixed and variable and are estimated to be in the range of $5,330,000, with most of the costs related to variable O&M. Fixed O&M costs are currently estimated at $10,000 per year. The fully installed costs (+/- 30% estimates) and engineering lifespan for all the capital equipment is shown in the below table:

Capital Component	Installed Cost ($ in millions)	Component Lifespan (round to nearest year)	Description of Component
8 MW Fuel Cell	$0	20	PPA Agreement, costs included in O&M Section (See Question 14)
Dual Fuel Generators at Kingsboro (1MW)	$0.06	30	Cost for converting (1) diesel generator sets to dual fuel generator
Dual Fuel Generators at KCHC (2MW)	$0.06	30	Cost for converting (1) diesel generator sets to dual fuel generator
Dual Fuel Generators at SUNY (4.5MW)	$0.24	30	Cost for converting (4) diesel generator sets to dual fuel generator
27kV Switchgear	$1.5	30	Switchgear to connect Generator to distribution voltage
Transformers	$1.5	30	Transformers to connect to existing system voltages
LV Paralleling Switchgear	$2	30	Equipment to connect generators to existing distribution busses
300kW Solar Panel/Storage	$0.80	20	Solar Panels at Kingsboro
Cabling	$2	30	Connecting campuses, including direct bores
Communication Backbone	$1.5	30	Microgrid Controllers
Subtotal - Capital Costs	**$9.66**		
Initial Planning & Design	$2.5		Project Design, Permitting, Financing
Total	**$12.16**		

All of the new fuel-based DER will use natural gas. The gas supply should be considered unlimited for the expected design basis events. Fuel consumption is listed in the below table.

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
Fuel Cell	Kingsboro and all three	Indefinitely	58,800	scfh
Backup Generator G-22	Kingsboro PC, Building 22, Power House	14 Days	96	Gallons
Solar Panel	Kingsboro	Indefinitely		Choose an item.
Backup Generator Genset No.2	Kings CHC Building R	14 Days	96	Gallons
SUNY UHB-1	SUNY	14 Days	96	Gallons
SUNY *UHB 2*	*SUNY*	14 Days	96	Gallons
SUNY *UHB 3*	*SUNY*	14 Days	96	Gallons
SUNY *UHB 4*	*SUNY*	14 Days	96	Gallons

Task 4.5 – Costs to Maintain Service during a Power Outage

Existing Backup Generation Capabilities:

Facility Name	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		
Kingsboro PC, Building 1	*Diesel*	*0.800*	*29.0*	*5.57*	*152.62*	*MMBtu/ Day*	*2*	*25*
Kingsboro PC, Building 2	*Diesel*	*0.800*	*34.9*	*6.71*	*152.62*	*MMBtu/ Day*	*2*	*25*
Kingsboro PC, Building 22, Power House	*Diesel*	*1.000*	*48.1*	*11.56*	*235.96*	*MMBtu/ Day*	*2*	*30*
Kings CHC, Building T	*Diesel*	*0.150*	*100*	*3.6*	*32*	*MMBtu/ Day*	*2*	*25*
Kings CHC, Building R	*Diesel*	*1.75*	*100*	*42*	*343*	*MMBtu/ Day*	*2*	*30*
Kings CHC, Building ABC	*Diesel*	*0.750*	*100*	*18*	*165*	*MMBtu/ Day*	*2*	*25*
Kings CHC, Building S	*Diesel*	*2.000*	*100*	*48*	*441*	*MMBtu/ Day*	*2*	*30*
Kings CHC, Building E	*Diesel*	*0.750*	*100*	*18*	*165*	*MMBtu/ Day*	*2*	*25*
Kings CHC, Building Z	*Diesel*	*0.500*	*100*	*12*	*112*	*MMBtu/ Day*	*2*	*25*
Kings CHC, Building ABC, Z ę F	*Diesel*	*0.500*	*100*	*12*	*112*	*MMBtu/ Day*	*2*	*25*
Kings CHC Building D, Roof	*Diesel*	*2.0*	*100*	*48*	*441*	*MMBtu/ Day*	*2*	*30*
SUNY	*Diesel*	*0.750*	*80*	*18*	*163*	*MMBtu/ Day*	*2*	*30*
SUNY	*Diesel*	*0.750*	*80*	*18*	*163*	*MMBtu/ Day*	*2*	*30*
SUNY	*Diesel*	*0.750*	*80*	*18*	*163*	*MMBtu/ Day*	*2*	*30*
SUNY	*Diesel*	*0.750*	*0*	*18*	*163*	*MMBtu/ Day*	*2*	*30*
SUNY	*Diesel*	*1*	*80*	*24*	*235*	*MMBtu/ Day*	*2*	*30*
SUNY	*Diesel*	*0.5*	*80*	*12*	*112*	*MMBtu/ Day*	*2*	*30*

Cost of Maintaining Service while Operating on Backup Power:

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Kingsboro Homeless Shelter	*One-Time Measures*	Relocating to nearest homeless shelter	5000	$	Required in summer or winter to ensure comfort levels of inhabitants

Cost of Maintaining Service while Backup Power is Not Available:

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Kingsboro	*One Time Measure*	*Hooking up additional portable generator*	2500	$	Year Round
Kingsboro	*On Going Measure*	*Renting additional portable generator*	6000	$/day	Year Round
Kings County	*One Time Measure*	*Hooking up additional portable generator*	2500	$	Year Round
Kings County	*On Going Measure*	*Renting additional portable generator*	35000	$/day	Year Round
Kingsboro Homeless Shelter	*One Time Measure*	*Hooking up additional portable generator*	2500	$	Year Round
Kingsboro Homeless Shelter	*On Going Measure*	*Renting additional portable generator*	650	$/day	Year Round
SUNY	*One Time Measure*	*Hooking up additional portable generator*	2500	$	Year Round
SUNY	*On Going Measure*	*Renting additional portable generator*	20000	$/day	Year Round

Task 4.6 – Services Supported by the Microgrid

Combined, Kings County Hospital (KCH), SUNY Downstate Medical Center (SUNY-DMC) and Kingsboro Psychiatric Center (KPC), provide a complete range of health, medical and emergency services to more than a million people in Brooklyn and the other boroughs.

KCH, the largest municipal hospital in New York City, is a Level I Trauma Center serving 2.6 million residents of Brooklyn and Staten Island. It is the official training site for the United States Army Reservists Medical Staff prior to their deployment. Together with SUNY-DMC, the two emergency centers have almost 4,000 visits per week. And with more than 1,500 patient beds, in- and out-patient visits total more than 17,000 per week, or almost 900,000 per year.

Kingsboro Psychiatric Center houses 175 patients, and the Kingsboro Homeless shelter has more than 400 beds for men with substance abuse problems.

Lastly, roughly 1,600 medical students are enrolled at SUNY DMC, and more than 20,000 people are employed at these facilities.

Estimated percent loss in the facility's ability to provide services during a power outage:

Facility Name	Percent Loss in Services When Using Backup Gen
Kingsboro Psychiatric Center	0
Kings County Hospital Block	0
SUNY Downstate	0
Kingsboro Homeless Shelter	50

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
Kingsboro Psychiatric Center	100
Kings County Hospital Block	100
SUNY Downstate	100
Kingsboro Homeless Shelter	90

Section 5 – Feasibility Study Results

Introduction

The conceptualized microgrid at Clarkson Ave would provide power resilience and reliability to Kings County Hospital (KCH), State University of New York Downstate Medical Center (SUNY DMC), and Kingsboro Psychiatric Center (KPC). This very large and unique cluster of health and medical emergency related facilities has provided over time a complete range of health, medical, and emergency services to millions of people in Brooklyn and the surrounding metropolitan area. KCH, the largest municipal hospital in New York City, is a Level 1 Trauma Center serving 2.6 million residents of Brooklyn and Staten Island. It is the official training site for the United State Army Reservist Medical Staff prior to their deployment. Together with SUNY-DMC, the two emergency centers have almost 4,000 visits per week. And with more than 1,500 patient beds, in- and out-patient visits total more than 17,000 per week, or almost 900,000 per year. Kingsboro Psychiatric Center houses 175 patients, and the Kingsboro Homeless shelter has more than 400 beds for men with substance abuse problems. Lastly, roughly 1,600 medical students are enrolled at SUNY DMC, and more than 20,000 people are employed at these facilities.

The microgrid is designed to provide significantly enhanced power reliability and resilience based on the use of proven technologies such as fuel cells, solar PV, battery and dual fuel generators. Available land, open rooftops and very favorable constructability make it possible to cost-effectively deploy a diverse array of no/low carbon distributed energy resources. These factors together with a clear, concentrated need for enhanced resilience help to make the proposed Clarkson Avenue microgrid a compelling “public purpose” microgrid that will yield day-to-day economic and environmental benefits when the sun is shining, and enable critical benefits and services when the grid is down.

Currently, each facility in the proposed microgrid has a dedicated feeder from Con Ed. The interconnection of the microgrid will be made of entirely new cable and breakers however the sites benefit from being located right next to each other. Once connected to each of the three facilities, the existing distribution of the facility will be utilized.

The proposed Clarkson Avenue microgrid includes 6MW of existing diesel generators that are being converted to dual fuel, 8MW of fuel cells, and 300kW of solar panels. The fuel cell, solar panels, and 1MW of dual fuel generation will be at Kingsboro. 2MW of dual fuel generation will be at Kings County and the rest of the dual fuel generation will be at SUNY Downstate.

Under normal condition the microgrid facilities will be served by Con Edison’s 27-kV system, as well as the Fuel Cell Array (FCA) located at KPC and PV generation at KPC and SUNY DMC. The tie cable may or may not be connected during blue sky days. These decisions will be made by the microgrid controller, which will be able to utilize distributed assets based upon the economic market. As the coincident normal load for these three facilities is typically over 10MW, the fuel cell generation will be consistently loaded at rated capacity. During emergency conditions, once the DERs restart and stabilize, the microgrid will be able to meet the load of the microgrid and the controller will decide if load needs to be shed and which backup generators should be brought online to maintain stable operation.

The DBOOM business model proposed has the benefit of shifting capital requirements as well as general performance and operational risk to third parties whose go-to-market strategies include entering into long term power purchase agreements with qualified off-takers. This enhances the project’s overall appeal and financial feasibility to the Clarkson Avenue and other microgrid participants.

Project Update – Potential CHP and BQDM-Incentivized Fuel Cell Projects

The Project Team evaluated both CHP and fuel cells at a preliminary level and determined that space constraints would likely significantly limit the scale of these installations at both SUNY and Kings County Hospital, but that Kingsboro had considerable available land on which CHP and fuel cells could be deployed. The challenge, as explained in the body of this report, is that the bulk of the thermal and electric load is from SUNY and Kings County Hospital. This preliminary conclusion led the Team to develop a configuration based on siting electric generation resources on the Kingsboro campus and supplying electricity to all three sites. But because it was also concluded that a large CHP system located on Kingsboro campus could not cost-effectively supply thermal energy to SUNY and KCH, the Team instead determined that 8 MW of electric-only fuel cells would be the best option to meet the microgrid's base electric load.

However, during the course of the Stage 1 study, all of the microgrid participants were contacted directly by Con Edison and Bloom Energy to explore the deployment of fuel cells on their respective campuses based on available incentives from the BQDM program. In addition, Kings County Hospital began exploring the potential to install CHP. These efforts, independent of but related to the Stage 1 study, have since determined that SUNY is not a viable location for any DER deployment, and that a 2.7 MW fuel cell deployment at Kings County *may* be possible, though constructability issues and space constraints could increase project cost past the point of economic feasibility. Regarding CHP, late in the Stage 1 study, KCH determined that a 1.6 MW CHP system was worth pursuing and has since obtained proposals for a turn-key installation. This project would leverage approximately $3 million in NYSERDA incentives (KCH expects approval from NYSERDA shortly), and if implemented, positively impact the overall cost-benefit ratio of the microgrid.

These projects, should they be proved feasible and go forward, will leverage other significant funding sources besides the NY Prize program and further enhance the economic viability of the microgrid project.

Conclusion and Recommendations

We offer the following conclusions and recommendations for proceeding with the Clarkson Avenue project and promoting other microgrid projects:

Conclusions

1. *A Clarkson Avenue microgrid would provide significant economic, environmental and societal benefits.* These benefits would accrue to the millions of people directly and indirectly served by the Clarkson Avenue health and medical complex, as well emergency personnel, students at SUNY Downstate, homeless people, local businesses and the City of New York.
2. *The Clarkson Avenue community microgrid is technically feasible, but will require government subsidies and/or other incentives to attract private funding.* Incentives could include NYSERDA grants, favorable gas tariffs, and/or credits for DER generation or capacity. Depending on the status of potential BQDM and NYSERDA incentivized projects described above, the overall financial viability of the microgrid will be significantly improved.
3. *Microgrid project design and development is complex and costly.* The costs to obtain, compile and analyze data from multiple facilities, and design the DERs and controls,

and develop and implement a project, can be relatively high in relation to the project size. Government funding is critical for providing early stage capital to perform these tasks, and develop projects to the point where they can attract private project financing.

4. *Energy storage and efficiency provides stability for microgrids and reduces peak demand charges*. A battery storage system can provide stability for the microgrid when operating in island mode, and can help reduce peak demand charges for facilities with uneven loads during blue-sky days.
5. *Public-private-partnerships are a viable and important business model for microgrids*. Specifically, P3 structures such as design-build-own-operate and maintain or "DBOOM" can accelerate the deployment of microgrids because they shift financial and operational risk away from government and local entities that lack the capital as well as the required technical and operational expertise.
6. *Microgrids will benefit utility partners.* Microgrids will benefit electric utilities by:
    a. Reducing the need for peak power facilities and/or new transmission and distribution infrastructure
    b. Enhancing power reliability and resilience for utility customers. The Clarkson Avenue microgrid is a compelling example of this because it will significantly reduce peak demand on the overloaded Brownsville substation. Also, gas-fired DERs provide additional demand for gas distribution and supply companies.
    c. Providing electricity market services related to grid stability and power quality in the form of capacity, synchronous reserve and fast frequency regulation.

Recommendations

1. *The Clarkson Avenue project should proceed with design, development and financing, subject to support from NYSERDA*. The project should proceed with project design, development and financing activities. These should include finalizing conceptual project design, completing detailed design and permitting, securing agreements with customers, arranging fuel supply contracts, obtaining construction bids and selecting an EPC contractor, refining financial modeling and projections, identifying a project lender and/or investor, and completing project documentation and due diligence.
2. *NYSERDA should continue to promote microgrids*. NYSERDA should continue to provide financial incentives and technical support for development of microgrids.
3. *NYSERDA should consider microgrid energy or capacity credits*. NYSERDA should consider providing such credits and/or capacity payments ("MECs" or "MCAPs"), similar to RECs for renewable energy sources, to provide financial incentives for DERs that are not eligible for RECs under the RPS. The MECs or MCAPs would be justified in light of the financial, societal and environmental benefits provided by microgrids.
4. *Utilities should do more to help facilitate development of microgrids*. Gas and electric utilities should evaluate new incentives for microgrids to reflect their financial, societal, system and environmental benefits. Electric utilities should also expedite hardening of local distribution systems to support microgrids, and facilitate interconnection policies to streamline deployment of DERs. Gas utilities should offer favorable microgrid gas supply tariffs, and prioritize infrastructure improvements needed to serve microgrids.
5. *Continue development of analytical tools*. Government entities should continue development of analytical tools for analyzing microgrids, such as DER-CAM.