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Notice

City of Long Beach Community Microgrid

August 12, 2016

Microgrid Feasibility Study

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

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Project Summary

Long Beach was devastated by Superstorm Sandy, which caused estimated damages of $200 million to city facilities and infrastructure and total damages to all of Long Beach likely exceeding $1 billion. Vital services (including utilities, water, and sewage systems) were left without power for an extended period.

Although Long Beach has made tremendous progress in its recovery, the community and city's infrastructure remain vulnerable to future storms, as almost the entire city is within a FEMA Special Flood Hazard Area. Community microgrids can increase system reliability and resilience, strengthening infrastructure and protecting against damage from future storms or other major disruptive events. The Long Beach microgrid will be designed to promote clean and efficient localized electrical generation, enable the city to sustain vital operations and emergency services in the event of power disruptions, and reliably serve critical facilities in Long Beach, including City Hall, Police and Fire Department Headquarters, water/wastewater treatment plants, and U.S. HUD-subsidized affordable housing.

This study will evaluate the feasibility of deploying an optimized mix of clean and efficient distributed energy resources (solar, storage, combined heat and power, etc.), emergency power and demand management solutions, and a microgrid control system and management technology platform to aggregate, coordinate, and optimize local resources and loads during normal and islanded operation. Project partners include NRG Energy, Inc. ("NRG"), the City of Long Beach, the Long Beach Housing Authority ("LBHA"), the MTA Long Island Rail Road ("LIRR"), and PSEG Long Island ("PSEG-LI").

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. As additional visibility is gained into electrical demand, infrastructure challenges, and isolation challenges for islanded operation, the final determination of what facilities can be practically served will be made. Facilities included in the proposed microgrid are shown in the following table, as listed in the Community Asset Inventory in the Long Beach NY Rising Community Reconstruction Plan from March 2014.

Asset	Risk Area	Critical Facility	Community Value	Socially Vulnerable Populations
City Hall, Police Station	High	Yes, FEMA	High	No
Water Pollution Control Plant	High	Yes, locally significant	High	No
Water Purification Plant	Extreme	Yes, locally significant	High	No
MTA Long Island Rail Road Long Beach Station	High	No, locally significant	High	No
Channel Park Homes (LBHA)	High	No	Medium	Yes
Michael Valente Apartments senior/disabled housing (LBHA)	High	Yes, FEMA	High	Yes
Long Beach Ice Arena and Recreation Center	Extreme	No	Medium	No
Magnolia Senior Community Center	High	No	Medium	Yes

Source: Long Beach NY Rising Community Reconstruction Plan, March 2014.

The map below shows facilities included in the proposed microgrid.

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

In microgrid applications depending on the types of loads, natural gas engines are typically preferable to diesel engines provided that there is an existing natural gas distribution network. In addition, natural gas supply in general has proven to be highly reliable, with limited or no interruptions even during severe weather events.

In most cases, existing diesel storage systems are sized to enable diesel engine operations for a day or two during short-term grid outages. So, one of the factors against selection of diesel engines is the availability of adequate storage to ensure uninterrupted operation of the microgrid for a period of at least two weeks.

Accordingly, a variety of non-diesel generation systems are being assessed as primary power sources for the microgrid. Based on preliminary facility and energy usage assessments, electric demand is estimated to range from a base-load of 600 kW to a peak of 1,400 kW. A combination of fuel cells, small CHP, rooftop solar PV, and energy storage are contemplated to provide resilient and reliable sources of power to serve the microgrid load in an islanded condition. Fuel cells and CHP perform best technically and economically when base loaded, while the combination of solar PV, battery storage and existing backup generation are more suited to load following and peak reduction. These performance characteristics are being 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;

As mentioned, a variety of distributed energy resources are being evaluated at a conceptual level to provide diverse, integrated and resilient power to the Long Beach microgrid. Presented below are initial considerations and applications:

Combined Heat and Power (CHP) or Cogeneration

CHP is thought to have limited application in the Long Beach microgrid as it requires a consistent thermal/heat sink. The Waste Water Treatment Plant (WWTP) has anaerobic digesters that require heat to keep the temperature at or near 100 deg. F. Based on the average treatment rates of the WWTP, and depending on the efficiency of the plant's digestion process and solids destruction rate, digester or "biogas" would be able to fuel less than 100 kW using rules of thumb and best engineering estimates. However, the available biogas could be supplemented with natural gas to increase output. Biogas typically requires treatment to remove impurities and moisture before use in a combustion process, which can add considerable cost to any biogas-fueled CHP project. So, though digester gas may be "free", the cost to clean it to certain standards often extends the payback period beyond acceptable lengths, especially with smaller projects that lack economies of scale.

The Long Beach Recreation Center pool is heated year round, and there is a domestic hot water requirement for showers and wash rooms. Combined, CHP potential at the Recreation Center is estimated to be 75 kW – 100 kW. The City of Long Beach has expressed particular interest in efficient cogeneration opportunities and would like to further evaluate during the detailed design phase of the project.

Solar PV

The estimated rooftop capacity of the Ice Arena/Recreation Center and the Long Beach Housing Authority's Channel Park Homes is 250 kW. An additional 150 kW – 200 kW of solar is estimated to be possible in the form of a shade canopy over the parking lot between City Hall and the Channel Park Homes. The estimates are 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. During the detailed design phase of the project, the project team will determine the potential for additional solar PV at the MTA LIRR Long Beach Station and the incorporation of new or existing solar PV, such as the current project at the Long Beach Martin Luther King Center at 615 Riverside Blvd.

Battery Storage

The role of potential battery storage in the Long Beach 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. Available space to locate batteries may be limited, particularly if actual generation systems are given priority.

Fuel Cells

The Long Beach 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 some economies of scale with a fuel cell deployment, facilities with the largest and most consistent loads are being considered as potential host sites, specifically the water purification and sewage treatment plants. The Ice Arena and Recreation Center lack available space, as does City Hall and the Channel Park Homes.

Wind Power

Small-scale wind power, most likely building mounted, has limited application in the Long Beach microgrid due to the relatively limited siting options and low power output. Other concerns are related to permitting (e.g., noise, aesthetics, and concerns for birdlife) and indicate a low likelihood of wind suitability.

Backup Generators

The installed capacity of backup generation within the proposed microgrid exceeds 1 MW and includes the following: 660 kW at the Water Purification Plant (new replacement generator awaiting installation), 400 kW at the Sewage Treatment Plant, and 100 kW at City Hall including the Police and Fire Department Headquarters. Two potable water wells have been tied to the Water Purification Plant generator, so these active wells and the water treatment facility would remain operational in the event of a major outage while the 660 kW backup is available.

Depending on the nature and duration of the events or circumstances causing the prolonged islanded condition, it is expected that in most instances the already installed backup generation would serve to provide both 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 project team is considering 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 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. The transfer switch will likely be at PSEG-LI distribution voltage to minimize voltage drops across the system, and ensure that existing manhole and distribution systems can be utilized.

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 MG 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 MG 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 (BESS), 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 Long Beach microgrid design will include power and communication equipment necessary to separate from the grid. 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;

The Long Beach microgrid will serve several critical facilities including the Police and Fire Headquarters located at City Hall, and the City of Long Beach's water purification and sewage treatment plants. In addition, the Recreation Center and Ice Arena, which together serve as points of distribution and a base for first responders and rescue teams, will be included in this microgrid. Resources will be allocated and dispatched to ensure that manufacturer required service and maintenance will not negatively impact operations or safety.

- 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;

The 2013 New York State Department of Public Service ("DPS") data 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.

Long Beach History of Extreme Weather and Major Outage

The City of Long Beach has been devastated by several severe storms over the past five years. Of particular note was Superstorm Sandy, which caused an estimated $200 million worth of damage to municipal facilities and total property damage to the entire community likely exceeding $1 billion. In the aftermath of Sandy, multiple essential city facilities, including utilities, water, and sewage systems, were left without power for an extended period of less than two weeks.

While no one municipal facility is more critical than another, certain facilities serve more vulnerable populations and thus require reliable power in times of natural disasters. Storms like

Sandy pose an enormous threat to those living in the Long Beach Housing Authority (LBHA) Channel Park Homes and Michael Valente Apartments, as well as the Park Avenue Extended Care nursing home and rehabilitation facility. Additionally, City Hall, which houses Police and Fire Department Headquarters, is listed as a FEMA Critical Facility.

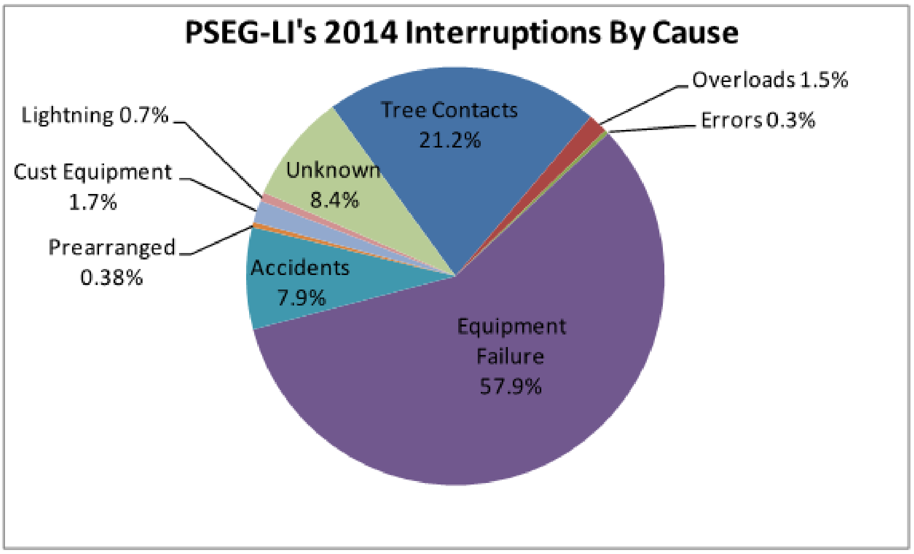
Superstorm Sandy left the City of Long Beach without power for an extended period. The City also experienced flooding due to Hurricane Irene and Tropical Storm Lee, both in 2011. The following storms have all had flooding impacts on the City of Long Beach:

- 1938 Hurricane
- 1960 Hurricane Donna
- 1962 Nor'easter
- 1971 Tropical Storm Doria
- 1976 Hurricane Belle
- 1979 Hurricane Davis
- 1983 Tropical Storm Dean
- 1985 Hurricane Gloria
- 1991 Hurricane Bob
- 1992 Nor'easter
- 1996 Hurricane Bertha
- 2013 Tropical Storm Andrea
- 2016 Nor'easter (Winter Storm Jonas)

PSEG-LI Reliability Information

Performance Metric	2010	2011	2012	2013	2014	Current RPM Target	5-Year Average
Frequency (SAIFI)	0.73	0.75	0.67	0.71	0.72	0.90	0.72
Duration (CAIDI)	1.11	1.14	1.26	1.13	1.36	1.40	1.20

As is common to most utilities, a majority of faults and loss of power events were the direct consequence of natural events, but also a large percentage due to equipment failures. As a result of these critical losses, and performance during Sandy, PSEG-LI was recently awarded over $730 million from FEMA to harden their infrastructure.



- 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 & 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 project team has begun considering design options for this capability. Important information has been requested from both the utilities and facilities, which will provide details on in-place networks and protocols that possibly could be leveraged in support of this requirement (e.g. leveraged 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, the project team will move to select platform and protocol compatible monitoring services as well as security services to satisfy the cyber security protection functions.

The project team will evaluate 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. Given previous experience with underground fiber cables that were damaged by salt water exposure during and after Superstorm Sandy, care will be taken to ensure that the cable technology selected for the microgrid will be resistant to salt water. 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 proposed microgrid will serve up to ten (10) facilities, all but one of which belong to fire, police, city government, public housing, sewage treatment, and water supply. This presents a wide diversity of critical facilities and customers and thus the possible benefit of complimentary loads for maximum utilization and capacity factor.

- 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;

Historically, the Long Beach barrier island has faced damaging winds, repetitive flooding, and storm surge. Long Beach was devastated by Superstorm Sandy in October 2012 (and to a lesser extent by Hurricane Irene in August 2011). Sandy damaged much of the City's infrastructure, including the sewer and water lines, wells, pumping/lift stations, roads, electrical systems, etc. The Water Pollution Control Plant was out of service for 7 days, and the Water Purification Plant was shut down for about 2 weeks. Nearly all of Long Beach's housing, including public and senior housing, was damaged by Sandy. Although Long Beach has made significant progress in its recovery, the community and City's infrastructure remain vulnerable to future storms, as almost the entire City is located within a Federal Emergency Management Agency (FEMA) Special Flood Hazard Area.

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. On-site power generation mitigates the risk of excess load on underground wires. If available, the team will also consider the utilization of underground distribution as much as possible in order to mitigate the risk of power cuts due to high winds, flooding 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 will consider all opportunities to incorporate renewable resources into the generation mix for the Long Beach microgrid. The project's functional design will be 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;

The energy efficiency of the system will be based on the choice of new equipment and devices that will be included in the Long Beach microgrid. The designed microgrid will also include demand response functionalities for scheduling and control of demand response resources 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 delivers 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, cash rebates, tax credits, and such.

Demand response, on the other hand, implies a change in operations and consumption behavior. This study will consider 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. Curtailable load is the load that can immediately be shed or dropped, similar to interruptible load of traditional demand-side management programs. Discretionary load is akin to more recent demand response programs. However, the main signal to activate demand response action is the microgrid's own assessment of self-supply availability instead of a utility's price or event signal.

This study will consider 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 design 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 project 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 streams 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 in Nassau and Suffolk Counties, especially for storm-prone communities on the North and South Shores.

The microgrid feasibility and design processes could serve to inform a strategy for hardening transportation infrastructure across the MTA's LIRR network, and a flexible and scalable design could potentially support nearby customers, such as Long Beach Plaza (supermarket, pharmacy), other community services in the City's central business district, and facilities that may result from the longer-term waterfront redevelopment initiative.

- 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 project 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 Long Beach microgrid will be expected to result in valuable experience and tangible benefits related to the effective integration of clean and efficient DER and development of new business models with multi-party engagement (utility, community, customer, and competitive solutions providers). It will be designed to strengthen critical infrastructure against future storms and advance resiliency recommendations in the Long Beach NY Rising Community Reconstruction Plan. Damages from Superstorm Sandy have been estimated at $200 million for City facilities and infrastructure, with total damages to all of Long Beach likely exceeding $1 billion. The proposed microgrid will contribute to building a more resilient, sustainable, and prosperous Long Beach that can minimize the social and economic impacts, both to participating facilities and residents in the broader community that rely on vital services provided by the City, of power disruptions due to future storms and other emergency events.

- 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 New York State's Reforming of Energy Vision (REV) policy initiative.

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 demand response programs and also NYISO's energy, capacity, and/or ancillary services 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 Long Beach microgrid will provide power for a number of critical and community support facilities using primarily existing utility infrastructure. The Long Beach microgrid will connect the Municipal Building (houses City Hall, Police and Fire Department Headquarters), the Waste Water Treatment Plant, the Water Purification Plant, the Channel Park Homes and Michael Valente Senior Apartments (Long Beach Housing Authority), and the Ice Arena and Recreation Center.

In order to leverage the existing electric distribution system, a decision was made to expand the scope of the Long Beach microgrid to include additional commercial and residential establishments located on the same feeders as the critical loads. Since these loads are clustered in the same feeders as the designated critical facilities, it was determined that it would be relatively straightforward to connect them to the microgrid circuit, and supply them with power in the event of an outage to the main grid. To accomplish this, it would also be unnecessary to isolate these facilities from the main grid and other local critical loads in the event of an outage.

The proposed Long Beach microgrid includes an existing 660 kW diesel unit converted to operate as a dual fuel unit, a 100 kW CHP unit, a 500 kW Fuel Cell stack, and a 250 kW natural gas engine. Renewable resources include 150 kW of solar PV at the Channel Park Homes and 150 kW of solar PV at the Ice Arena. Each of these solar systems will be supplemented with a 50 kW battery energy storage system.

A 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, including location of the distributed energy resources (DER) and utility interconnection points. Identify new and existing infrastructure that will be a part of the microgrid.

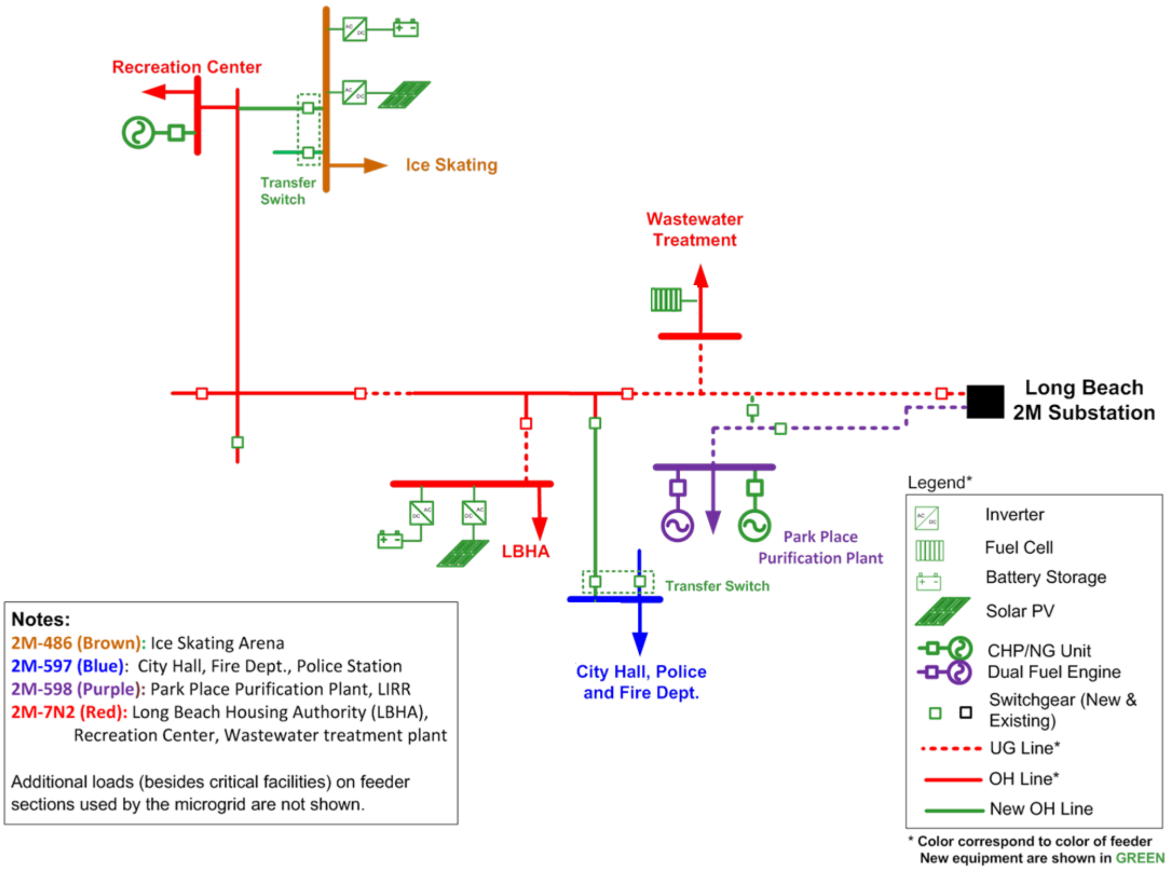
Figure 2-1 shows a simplified layout of the Long Beach microgrid and electrical interconnection of microgrid facilities. The existing underground and overhead lines are shown in different colors to identify sections of existing electrical infrastructure that the microgrid will utilize. Sections of feeders 2M-598 (shown in brown) and 2M-7N2 (shown in red) will be disconnected from the rest of the system by switches and used to form the microgrid. The Ice Arena and Municipal Building (City Hall, Police and Fire Department Headquarters) are on different feeders, which are not shown on the layout. These facilities will connect to the microgrid using transfer switches. In addition to the critical facilities identified in the figure, there are other customers, such as the Magnolia Senior Community Center, served off sections of the existing feeder that the microgrid will use. These customers will continue to receive service from the microgrid in islanded mode as well. The additional load for these customers has been aggregated and included in the load and supply analysis in this task.

Simplified Layout of Long Beach Microgrid Showing Facilities and Routing of Electrical Connections

Figure 2-1

Figure 2-2 below shows a simplified one-line diagram with the location of the distributed energy resources (DER) and the utility interconnection points. New equipment is shown in green. The major additions, besides DER, are the 15-kV class overhead lines connecting the Municipal

Building to the microgrid and the accompanying transformers and switchgear. Some of the existing switches (identified in the figure in red) require upgrade to automation capability.



Long Beach 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.

The facilities that are part of Long Beach microgrid currently receive grid power via four different feeders, out of the Long Beach 2M Substation. The feeders originate as underground feeders and transition to overhead along their route. There is very little vegetation in the area, but the infrastructure is subject to significant damage from ocean and bay storm surge and storm water flooding. Almost the entire city is located within a FEMA regulated floodplain, demonstrating the high degree of flood risk.

Normal Conditions

Under normal conditions, the microgrid facilities will be served by the PSEG-LI distribution system via circuits 2M-486, 2M-597, 2M-598 and 2M-7N2. The additional generation installed for microgrid (shown in green on Figure 2-2) will continue to operate during normal conditions, reducing the peak demand and energy cost of the facilities. In the event of an outage, the newly installed automated switches may also be used to reduce the impact and speed up the restoration efforts.

Emergency Conditions

When power is lost to all of the facilities due to, for example, a catastrophic event on the bulk power system or failure of the 2M substation, loads in all facilities will be unserved. The microgrid controller, which is monitoring the points of facility interconnection (POIs) with the main grid and the switchgear that form the boundary of the microgrid, will sense loss of voltage and frequency, and the CHP generation and other inverter-based generation (solar PV, battery, fuel cells) will go off-line in accordance with anti-islanding protection procedures. Normally-closed switchgear at the boundary of microgrid (shown in Figure 2-2) will open to disconnect sections of feeders from the main grid. The diesel backup generators at the Water Purification Plant, Waste Water Treatment Plant, and Municipal Building will start up quickly to supply the facility loads. Once all the facilities are isolated from the main grid, the CHP generators will restart, and natural gas engines will startup and synchronize with the online backup generation (5-10 minutes). When the CHP generation and natural gas engines are stabilized, the normally open switches on the dedicated overhead line connecting the Municipal Building to the microgrid are closed in, and the islanded microgrid is formed. Some microgrid load can be sequentially transferred to the CHP and natural gas generators, and the facilities without backup generation are brought online. Once the island is stable and active, other inverter-based generation (solar PV, battery, and fuel cells) would reconnect and begin generating. During islanded operation, the microgrid controller would actively monitor voltage and frequency in the island. Loads on some facility breakers could be shed, and some backup generation might remain online or be brought online to maintain stable operation.

In cases when the grid is stressed but there is no forced outage, "seamless" transition to microgrid mode is possible. In this scenario, the CHP generators and fuel cells 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 and CHP Units will be running at close to full capacity in most days during on-peak periods subject to their ramp up and down constraints. Power will be imported from the grid to make up any shortfall over the load cycle. In islanded mode, the CHP Unit will modulate output to match the electrical demand of the island. Whenever demand exceeds CHP generation capacity, curtailable load will be shed and/or backup generation will be brought online to fill the gap. The backup generation at the Waste Water Treatment Plant, the Water Purification Plant and the Municipal Building have 6,900 gallons combined capacity of diesel fuel storage.

In islanded mode, the identified facility electrical loads will be met by the microgrid generation. In addition to the original critical loads identified earlier, the microgrid electrical load includes the load of additional non-critical facilities on the electrical feeders that form the microgrid network. The size of aggregate additional loads is estimated. It was decided that it will be less costly to include these loads in the emergency microgrid load than to separate them from the microgrid network.

In grid-parallel mode, each facility will be on its own and either be fed by its on-site facility DER or purchase power from the grid.

During an emergency, a portion of the microgrid load equivalent to about 5% of peak load of the facilities (about 80 kW) will be curtailed. These demand-side resources will also be available during normal blue sky days for participation in the utility or NYISO demand response programs.

The only thermal load included in the microgrid is the heating load of the Ice Arena and Recreation Center. The recovered thermal energy from the 100 kW CHP, to be installed in the Ice Arena and Recreation Center, will provide the energy to meet the thermal load of this facility.

The facility annual energy and peak demand are provided in the following tables.

Monthly Microgrid Electrical Load
Table 2-1

	Energy (kWh)	Peak (kW)
January	711,593	1,462
February	666,297	1,517
March	644,301	1,333
April	603,646	1,314
May	524,293	1,066
June	641,159	1,453
July	706,034	1,520
August	766,172	1,646
September	576,357	1,220
October	582,641	1,241
November	547,110	1,177
December	696,221	1,484
Annual	7,665,824	1,646

Monthly Microgrid Thermal Load
Table 2-2

	Energy (kWh)	Peak (kW)
January	94,018	152
February	101,049	180
March	101,049	163
April	111,600	186
May	68,856	111
June	59,885	100
July	37,543	61
August	17,322	28
September	17,892	30
October	31,613	51
November	67,816	113
December	61,806	100
Annual	770,449	186

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 sources of data are the electric and fuel billing statements. The monthly energy information was used and applied to various 12 x 24 load profiles from Lawrence Berkeley Lab's Distributed Energy Resources Customer Adoption Model (DER-CAM) for appropriate facility types in order to develop the individual 12 x 24 facility load profiles, and then aggregated into the total microgrid load.

Due to lack of available data, a simple thermal load profile was assumed throughout the week, with similar load levels during weekday and weekends.

The Long Beach microgrid's 12 x 24 electrical and thermal load profiles in tabular and graphical forms are provided in the following tables and charts.

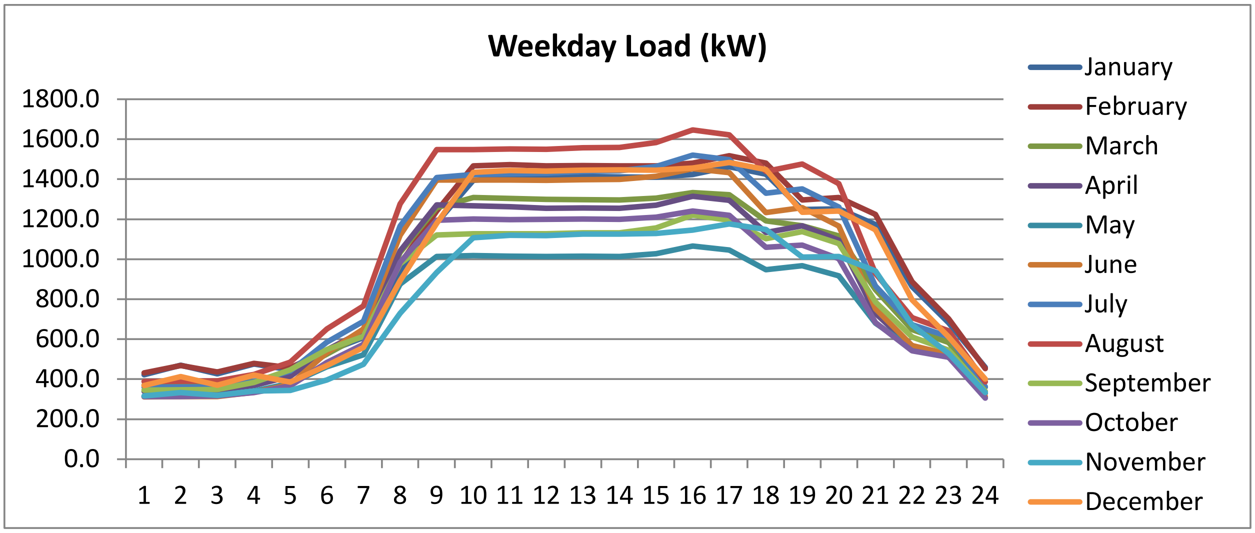
Microgrid 12x24 Electrical Load

Table 2-3

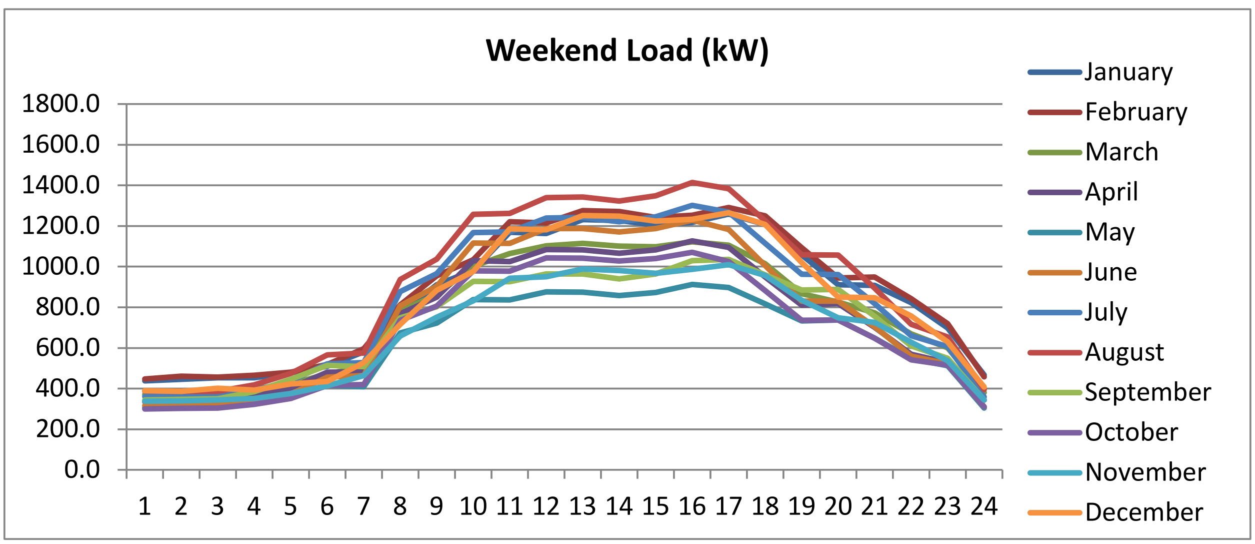
Day-type	month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
week	January	421	470	426	476	447	537	608	934	1182	1394	1409	1404	1412	1412	1410	1424	1462	1426	1249	1251	1172	863	682	460
week	February	432	468	436	478	457	542	629	975	1241	1466	1472	1467	1468	1467	1466	1480	1517	1481	1297	1309	1223	888	702	452
week	March	369	369	377	387	427	525	626	1034	1257	1308	1304	1299	1298	1297	1306	1333	1323	1192	1168	1116	848	648	583	360
week	April	339	342	345	369	414	547	642	1041	1272	1267	1262	1255	1256	1255	1270	1314	1295	1134	1167	1094	729	560	516	330
week	May	315	317	319	340	379	463	522	876	1014	1018	1015	1013	1014	1013	1027	1066	1045	947	967	917	680	555	516	308
week	June	312	313	314	334	374	532	651	1119	1395	1395	1396	1394	1398	1398	1414	1453	1433	1233	1258	1166	752	568	525	313
week	July	361	360	360	387	440	585	690	1165	1408	1423	1427	1430	1439	1441	1464	1520	1497	1330	1351	1261	866	672	612	362
week	August	388	390	392	424	486	650	767	1275	1548	1549	1551	1550	1557	1558	1583	1646	1622	1439	1476	1377	929	708	642	387
week	September	346	347	348	383	447	549	614	976	1122	1127	1127	1126	1132	1132	1156	1220	1194	1103	1138	1077	786	612	545	340
week	October	313	314	316	333	366	484	574	984	1195	1201	1198	1199	1200	1199	1210	1241	1219	1060	1071	1002	684	542	510	305
week	November	317	332	320	341	344	396	475	730	934	1107	1120	1117	1125	1126	1129	1146	1177	1149	1010	1013	941	670	528	333
week	December	369	412	371	421	385	468	559	892	1179	1435	1444	1441	1445	1446	1445	1455	1484	1448	1235	1241	1148	796	611	401
weekend	January	439	446	454	454	477	509	581	770	911	981	1169	1162	1231	1227	1204	1218	1258	1208	1058	911	908	823	698	466
weekend	February	447	460	457	465	481	519	597	812	955	1034	1221	1214	1276	1271	1242	1253	1292	1249	1093	944	950	842	720	458
weekend	March	371	379	380	398	422	473	507	782	863	1003	1064	1103	1115	1101	1098	1122	1105	1014	867	825	773	669	600	380
weekend	April	334	337	340	364	404	481	483	768	850	1029	1026	1084	1083	1066	1082	1127	1094	949	811	818	701	568	528	344
weekend	May	308	309	312	334	369	415	410	674	722	838	837	875	875	858	872	912	898	816	733	738	648	547	513	304
weekend	June	317	319	321	340	373	457	463	807	903	1116	1115	1187	1188	1171	1188	1228	1184	1005	831	830	704	559	522	311
weekend	July	361	362	363	391	438	522	528	877	966	1168	1171	1239	1241	1221	1245	1301	1267	1114	963	960	819	659	607	359
weekend	August	388	387	387	419	474	567	574	937	1036	1257	1262	1340	1343	1323	1349	1413	1383	1225	1059	1056	894	716	654	396
weekend	September	344	347	350	386	445	515	508	749	802	928	926	964	964	940	964	1029	1035	959	885	889	756	610	549	344
weekend	October	301	303	305	322	351	415	421	736	806	979	978	1043	1042	1028	1040	1070	1024	882	736	738	648	542	515	310
weekend	November	337	340	344	351	376	414	465	659	751	832	942	951	988	981	967	987	1010	956	835	748	726	628	538	344
weekend	December	389	386	401	393	423	436	528	717	883	976	1186	1181	1251	1248	1224	1234	1265	1206	1020	851	847	757	629	408

Microgrid 12x24 Heating Load
Table 2-4

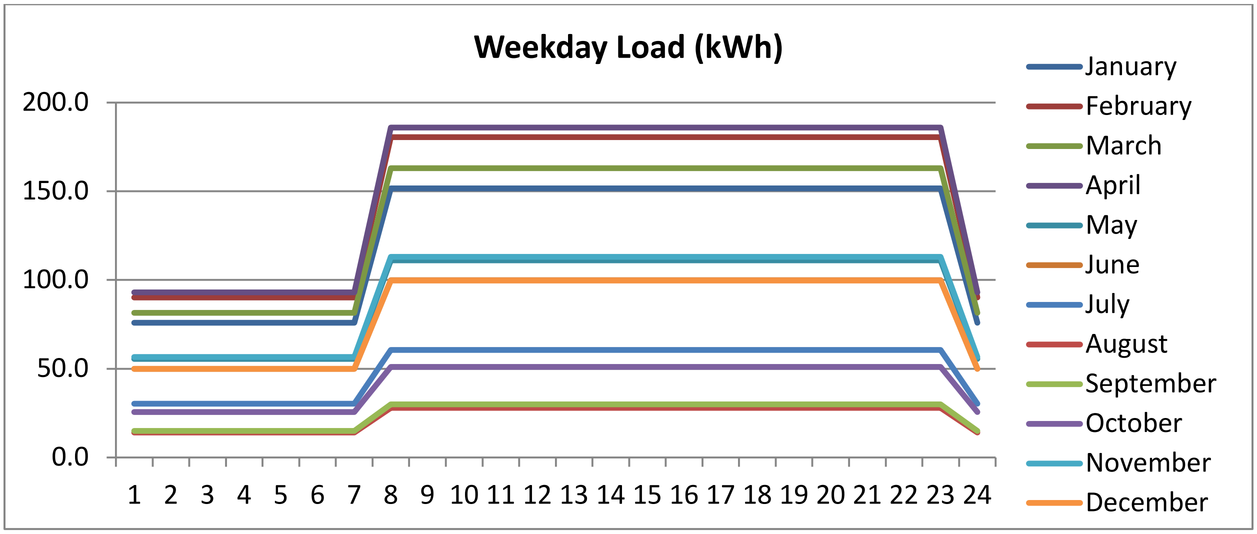
Day-type	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
week	January	76	76	76	76	76	76	76	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	76
week	February	90	90	90	90	90	90	90	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	90
week	March	81	81	81	81	81	81	81	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	81
week	April	93	93	93	93	93	93	93	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	93
week	May	56	56	56	56	56	56	56	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	56
week	June	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50
week	July	30	30	30	30	30	30	30	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	30
week	August	14	14	14	14	14	14	14	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	14
week	September	15	15	15	15	15	15	15	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	15
week	October	25	25	25	25	25	25	25	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	25
week	November	57	57	57	57	57	57	57	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	57
week	December	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50
weekend	January	76	76	76	76	76	76	76	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	76
weekend	February	90	90	90	90	90	90	90	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	90
weekend	March	81	81	81	81	81	81	81	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	81
weekend	April	93	93	93	93	93	93	93	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	93
weekend	May	56	56	56	56	56	56	56	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	56
weekend	June	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50
weekend	July	30	30	30	30	30	30	30	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	30
weekend	August	14	14	14	14	14	14	14	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	14
weekend	September	15	15	15	15	15	15	15	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	15
weekend	October	25	25	25	25	25	25	25	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	25
weekend	November	57	57	57	57	57	57	57	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	57
weekend	December	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50



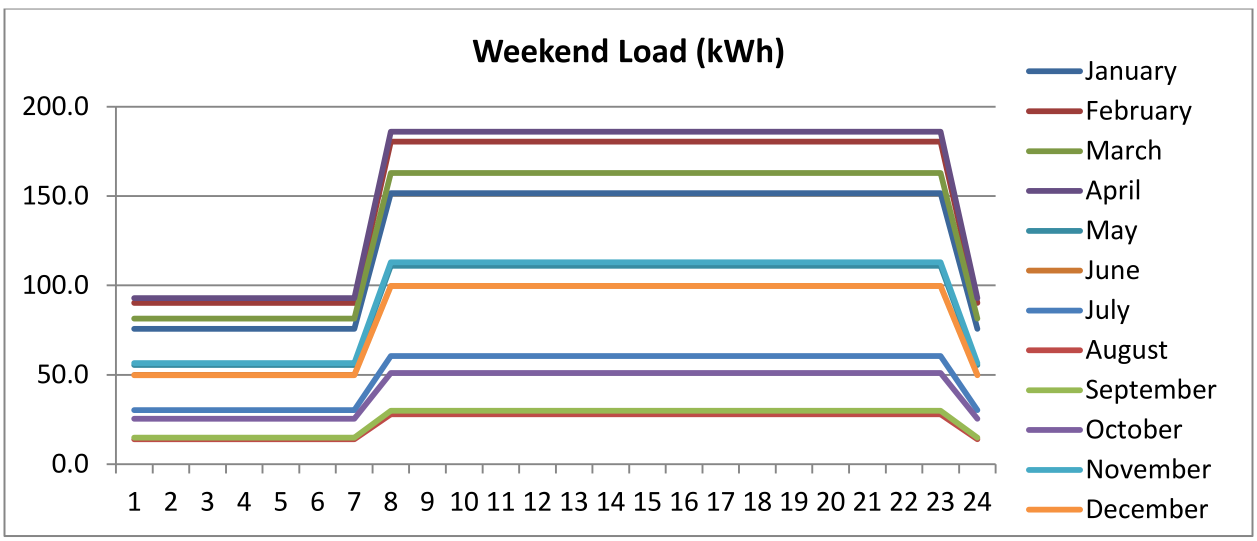
Microgrid Weekday Electrical Load
Figure 2-3



Microgrid Weekend Electrical Load
Figure 2-4



Microgrid Weekday Thermal Load
Figure 2-5



Microgrid Weekend Thermal Load
Figure 2-6

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 listed in the following table (Table 2-5). The load sizes are based on 12 months of electric and fuel billing statements.

As can be seen, the microgrid load includes the extra feeder load, which was estimated based on the available information on the utility feeders serving the critical facilities.

The only thermal load included in the microgrid is the thermal load of the Ice Arena and Recreation Center.

The microgrid generation includes a 660 kW dual fuel engine, a 100 kW CHP unit, a 500 kW Fuel Cell stack, and a 250 kW natural gas engine. In addition, there is 300 kW of solar PV and 100 kW of battery storage distributed between two locations. There is also 550 kW of backup diesel generators (100 kW + 450 kW), but these not expected to be integrated into the microgrid control system at this point. In addition, there is about 80 kW of controllable load.

Hence, the total available nameplate capacity in the system is 2,540 kW. Table 2-5 below indicates that the sum of the microgrid facility non-coincident peak loads is 1,898 kW. However, after the development of 12 x 24 load profiles, the aggregate load's coincident load is 1,646 kW, which occurs in August, as shown in Table 2-1.

As a result, during an emergency, the surplus capacity in the microgrid is 894 kW (2,540 – 1,646). However, this amount of redundant generation falls slightly short of the largest generation resource, which is the 660 kW dual fuel engine; thus, in the event of an outage of the largest resource, the microgrid may need additional resources. However, the cost of additional supply side or demand side reserves has to be weighed against the risk associated with additional contingencies.

Microgrid Electrical and Thermal Load Sources
Table 2-5

		Electrical Load			**Thermal Load**		
	Facility	**Usage (kWh/year)**	**Peak Demand (kW)**	**LF (%)**	**Usage (kWh/year)**	**Peak Demand (kW)**	**LF (%)**
1	City Hall, Police and Fire Department	992,100	322.60	35.11%			
2	Water Pollution Control Plant	987,720	183.86	61.33%			
3	Park Place Water Purification Plant	1,463,700	258.87	64.55%			
4	Channel Park Homes (LBHA)	1,207,040	323.42	42.60%			
5	Ice Arena and Recreation Center	1,359,680	405.83	38.25%	770,449	186.00	47.29%
6	MTA LIRR Long Beach Station	332,760	119.54	31.78%			
7	Additional Feeder Load	1,322,824	284.00	53.17%			
		7,665,824	1,898	46.10%			

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:

Proposed Microgrid Generation Resources
Table 2-6

DER Type	Facility Name	Energy Source	Name plate Capacity (MW)	Avg. Annual Production Normal (MWh)	Avg. Daily Production Emergency (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
New CHP NG Generator	Long Beach Ice Arena and Recreation Center	Natural Gas	.100	768.252	2.4	12.85	MMBtu/ MWh
New 500 kW Fuel Cell	Sited at WWTP to serve City Hall, Police/Fire HQ, LIRR Station, and WWTP	Natural Gas	.500	3,157.98	12	7.26	MMBtu/ MWh
New 250 kW NG Genset	Park Place Water Purification Plant	Natural Gas	.250	788.4	6	12.18	MMBtu/ MWh
Existing 660 Dual Fuel Unit	Park Place Water Purification Plant	Diesel/ Natural Gas	.660	1,130.04	15.84	8.15	MMBtu/ MWh
New Solar PV	Channel Park Homes (LBHA)	Solar	.150	550.128	1.5072	0	N/A
New Battery	Channel Park Homes (LBHA)	Solar	.050	23.3	0.06384	0	N/A
New Solar PV	Ice Arena	Solar	.150	550.128	1.5072	0	N/A
New Battery	Ice Arena	Solar	.050	23.3	0.06384	0	N/A

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 2-6. The new 100 kW CHP unit will be located in the Ice Arena. A 500 kW Fuel Cell will be installed at the Waste Water Treatment Plant (it is shown in Figure 2-2 at the WWTP) to serve the Municipal Building (City Hall and Police/Fire HQ), LIRR Station, and WWTP. The Channel Park Homes and Ice Arena will each have 150 kW of Solar PV and 50 kW of Battery Storage. There is an existing 660 kW dual fuel generator at the Water Purification Plant. Additionally, a new 250 kW natural gas generator is planned at the Water Purification Plant to handle peak demand loads. The CHP unit, existing dual fuel unit, natural gas genset, and inverter-based generation (Solar PV, Battery, and Fuel Cell) are shown on each facility's load bus on the one-line diagram in Figure 2-2. The details of the in-plant wiring are omitted at this point.

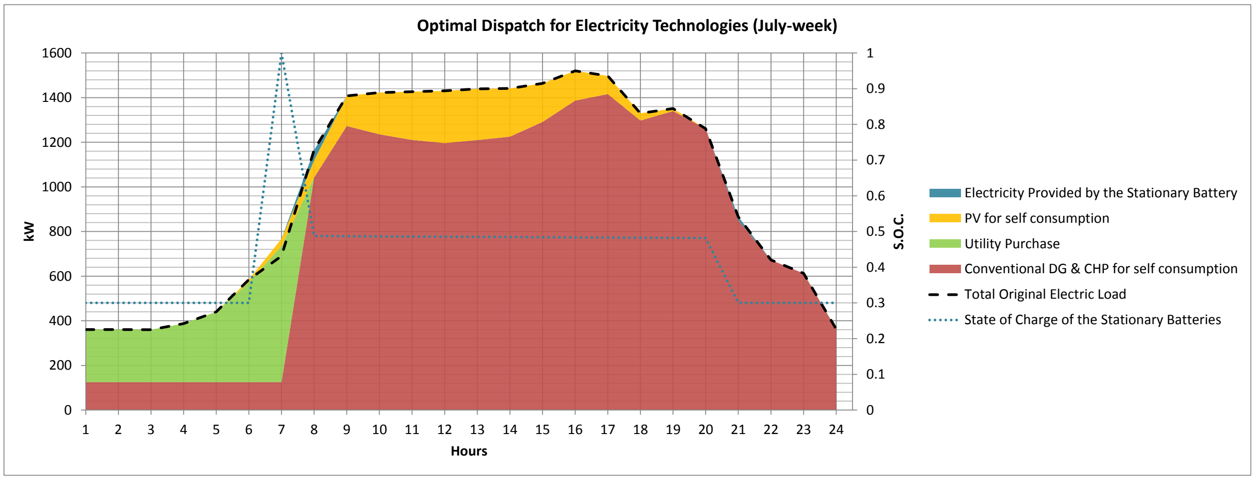
2.3.3 – Provide a written description of the adequacy of the DERs and thermal generation resources to continuously meet electrical and thermal demand in the microgrid.

The DER-CAM model takes into consideration the 12 month x 24 daily average electrical and thermal profiles of the aggregate loads of the microgrid facilities.

Figure 2-7 provides a view of the "theoretical" load and supply balance over a weekday of operation on a normal day in the month of July. The DER-CAM model dispatches all the generation resources based on the comparative economics of on-site generation versus purchase from the utility. As can be seen, power is purchased from the utility during off-peak hours (there is a demand charge during on-peak hours).

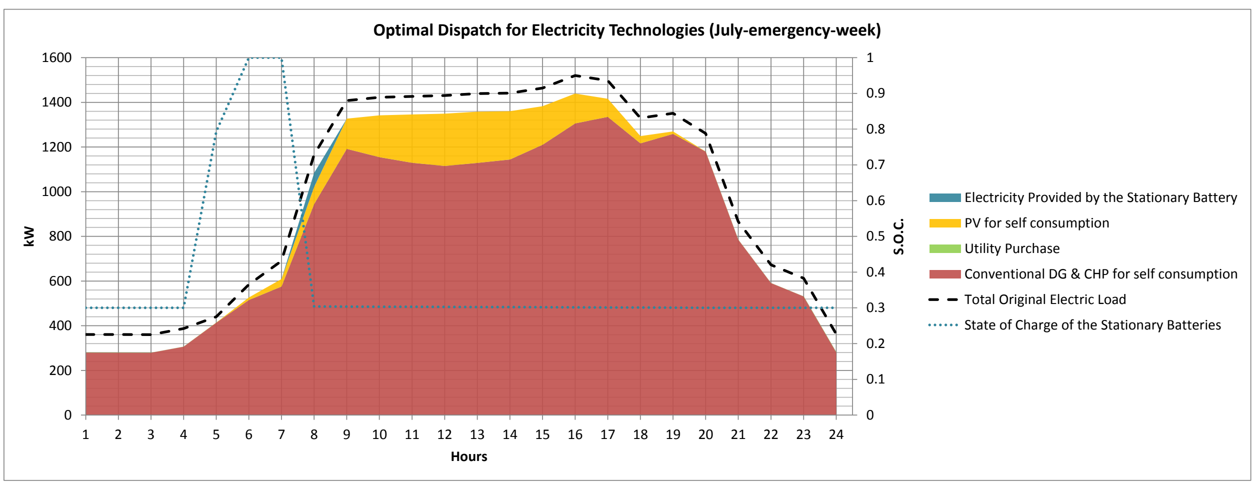
The project team is working with Lawrence Berkeley National Laboratory (LBNL), the provider of the DER-CAM model to improve the operation of the Fuel Cell by providing the option of "must run" operation. The dispatch profile shown is based on purely economic considerations.

The solar energy (based on the solar irradiance profile of nearby ISLIP airport) is available during on-peak hours. The energy storage charging and dispatch is shown, but its sizing and operational parameters need to be improved in the DER-CAM model before the final report is issued. The project team has communicated the modeling issues to LBNL; as soon as LBNL provides the updated model, the project team will run DER-CAM again to re-produce the dispatch charts for the final report. However, with or without new runs, the project team does not expect any fundamental change to the current functional design of the Long Beach microgrid.



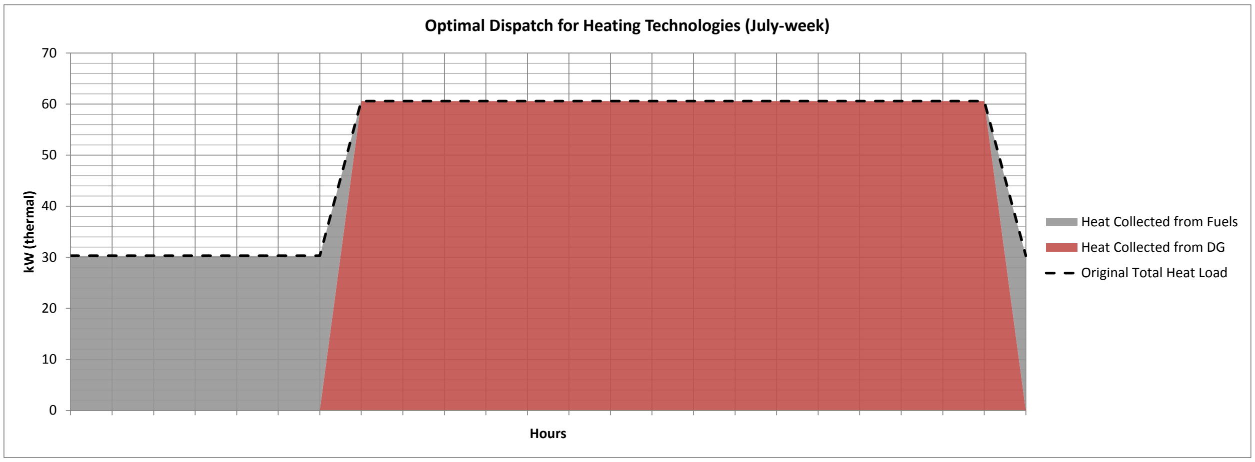
Microgrid Optimal Dispatch to Meet Electrical Load – July Normal Weekday
Figure 2-7

Figure 2-8 shows the microgrid operation during an emergency weekday in July. As can be observed, there is no utility purchase, and all microgrid load is met by on-site generation, including solar, battery, and also load curtailment.



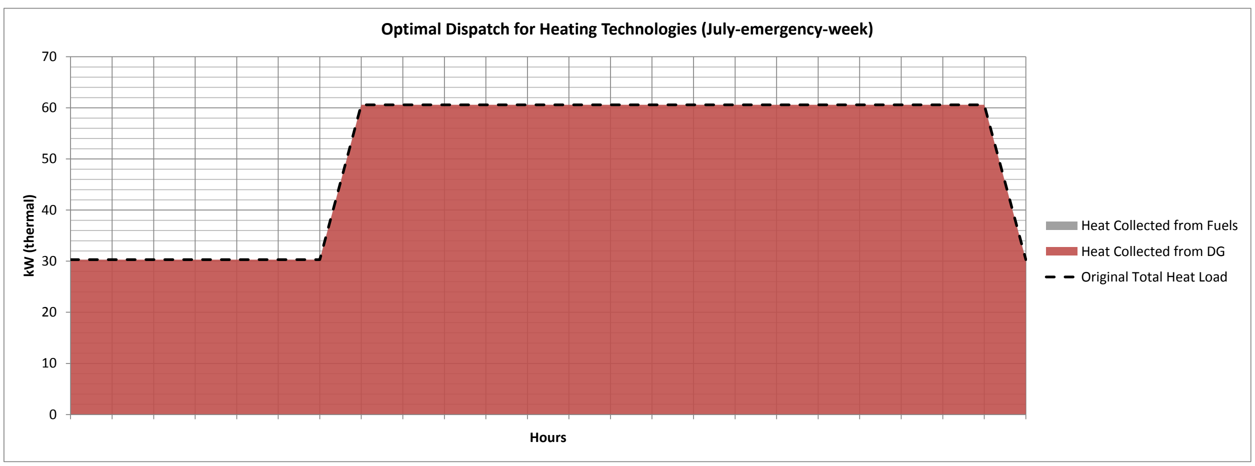
Microgrid Optimal Dispatch to Meet Electrical Load – July Emergency Weekday
Figure 2-8

A normal weekday thermal dispatch in July is shown in Figure 2-9. It appears that the CHP unit is only running during on-peak hours and hence, the thermal load is met by CHP only during the on-peak hours. The additional thermal load during off-peak hours is met by thermal energy from the conventional boilers.



Microgrid Optimal Dispatch to Meet Thermal Load – July Normal Weekday
Figure 2-9

However, during an emergency weekday, as shown in Figure 2-10, the entire thermal load is met by the CHP unit, since CHP and other generation resources are in operation all day in the absence of power availability from the larger grid.



Microgrid Optimal Dispatch to Meet Thermal Load – July Emergency Weekday
Figure 2-10

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.)?

During Superstorm Sandy, the existing backup generator at the Waste Water Treatment Plant was not flooded whereas the generator at the Water Purification Plant was flooded and rendered inoperable. The generator at the Water Purification Plant is being relocated to a higher elevation and the electrical distribution system relocated out of flood areas. These relocations should address the storm surge issues.

The new CHP unit will be installed above the flood plane at the Ice Arena and is therefore protected from most severe weather incidents, and flooding. Natural gas engines have an average availability of about 96% for units sized 100-800 kW[1], a forced outage rate of about 2%, and a scheduled outage rate of about 2.5%. The CHP unit, natural gas genset, Fuel Cell and battery storage, along with the backup generation at the three sites, results in a collective power system with very high reliability that is well-insulated from the forces of nature. The expected forced-outage rate of the entire power plant will be analyzed in Stage 2.

Superstorm Sandy damaged the Transco interstate gas pipeline, which required repairs that took several weeks. The local gas distribution system in Long Beach would be the source of gas supply for the Long Beach microgrid; this system is owned, operated, and maintained by National Grid. With the post-Sandy reinforcements, potential damages due to future storms may be limited, but there is always a remote chance that supply to the CHP, natural gas gensets, and Fuel Cell units could be interrupted in the most severe emergencies. Additional evaluation of required reinforcements to the natural gas infrastructure would be undertaken in future stages of this project, if it is selected.

The rooftop solar PV panels are at some risk of being partially or completely covered with snow cover during parts 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 microgrid controller should be able to recognize when solar PV panels are under-producing relative to normal expected operation, and can generate an inspection/maintenance signal. The battery storage systems at the Channel Park Homes and Ice Arena can be scheduled to be charged early during off-peak hours to carry enough storage to compensate for the loss of solar PV production due to inclement weather and snow cover.

[1] "Distributed Generation Operational Reliability and Availability Database," Energy and Environmental Analysis, Inc., submitted to Oak Ridge National Laboratory, Energy Solutions Center, and New York State Energy Research & Development Authority, January 2004.
<http://energy.gov/sites/prod/files/2013/11/f4/dg_operational_exec_summary_report.pdf>.

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 irradiance are the energy/fuel resources used for base load generation in this project. Table 2-6 above shows the average annual production for microgrid generation resources under normal circumstances. The table also shows the fuel consumption for each MWh produced. For the 100 kW of CHP generation, approximately 30.84 MMBtu of natural gas would be needed per day *during emergency conditions*.

The backup diesel generator at the Waste Water Treatment Plant, Water Purification Plant, and Municipal Building have a combined 6,900 gallons of fuel storage, enough to last about 3-4 weeks of continuous operation at full load.

Based on day-to-day analysis of weather patterns, the solar PV on the Channel Park Homes and Ice Arena are expected to produce energy for approximately 3,668 hours per year, or about 42% of the year.

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.

The project includes 100 kW of batteries and a 660 kW dual fuel generator, which are excellent for black start and load-following applications. Backup generators at the Waste Water Treatment Plant and Municipal Building can also be used for black start. 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 CHP unit (see Section 2.1.2). Once the CHP unit is back online, the backup generators may go offline, unless they are needed for frequency regulation.

If the diesel backup generation is not online, the CHP gas engines generally require only batteries or compressed air to black start. Reciprocating engines have high part-load efficiency, which ensures economical operation in load following applications.

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.

Some types of generators are more capable of providing frequency control than others. Fuel Cell and CHP units tend to be better suited to baseload operation than frequency control. For the Long Beach microgrid, the 500 kW of fuel cells at the Waste Water Treatment Plant and the 100 KW CHP unit at the Ice Arena will provide baseload power. A portion of the 660 KW capacity at the Water Purification Plant can also provide baseload power. Fast frequency regulation will come from the aggregate 100 kW batteries at the Ice Arena and Channel Park Homes, as well as the 660 kW dual fuel generator at the Water Purification Plant and possibly the new 250 kW natural gas engine at the Water Purification Plant. To augment this frequency regulation, load may also be controlled. The microgrid controller will be integrated with building management systems (BEMS) and control systems at the facilities to enable fast load shedding. Additionally, it may be necessary for solar production to be curtailed under some circumstances. This will also be managed by the controller. The specific demands for power matching/frequency regulation will be determined through study in Stage 2.

Unlike power matching/frequency regulation where some generators are better suited to respond quickly to changes in real power, most generators are capable providing VARs and reacting quickly to changes in voltage. Traditionally, a few types of generator controls are available: voltage control, VAR control and power factor control. For the Long Beach microgrid, some combination of these modes will be employed depending on the asset type. For example, the CHP unit will likely be in voltage control mode to provide fast voltage regulation/reactive power balance and to support voltage during a fault to allow the protection system to operate correctly. The PV and battery inverters may be in power factor control to smooth voltage variations due to intermittent power output. As with the power balance/frequency control, the specific roles of the different generation assets will be determined through study in Stage 2, and the microgrid controller will manage these assets in response to changing conditions.

NY State and PSEG-LI 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 point of interconnection ("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 Figure 2-2. The Long Beach microgrid uses combination of existing overhead and underground lines, new overhead lines, and a number of new and existing switchgear (with upgrades) and generation resources. Refer to Figure 2-1 for a geographic layout showing the location of the microgrid facilities, sections of existing feeders and routes. The electrical connection diagram is shown in Figure 2-2. The new overhead line will connect the Municipal Building to section of 2M-7N2 feeder in North Drive near the Waste Water Treatment Plant. The lines are expected to be routed along railway track behind the Channel Park Homes on to the parking lot and then to the Municipal Building. The actual route will be determined during Stage 2 of the project.

The only thermal load included in the microgrid network belongs to the Ice Arena and the Recreation Center. The CHP unit to be installed at that location will provide a substantial part of the thermal energy needed at that location. There are no additional thermal networks in the system since the CHP is meant to supply thermal energy only at the Ice Arena and the Recreation Center.

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 a combination of overhead and underground distribution lines. The largest risks to the electrical infrastructure are: 1) a widespread transmission outage, such as the 2003 Northeast blackout, 2) failure of the Long Beach 2M substation, such as during a catastrophic weather event or transformer failure, 3) storm surge and flooding leading to shut down. However, PSEG-LI has stated that the most significant impact to their system was flooding during recent events. The overhead lines were mostly unaffected, but some substations and underground connections were compromised. Due to the lack of vegetation (trees), the overhead system near the coastline is actually more resilient than the underground system.

The microgrid electrical infrastructure has both existing underground and overhead components. The existing underground lines, equipment and connections will be hardened and upgraded to meet submersible standards. Existing overhead lines will also be hardened via use of stronger poles and hardware where appropriate, and selective use of spacer cable. PSEG-LI is currently undertaking widespread activities to harden infrastructure in the area post-Superstorm Sandy. Any efforts on behalf of the microgrid will be coordinated with PSEG-LI. New construction for the microgrid will be overhead and storm-hardened.

During a widespread emergency (such as a blackout or substation transformer failure), the microgrid infrastructure would likely not be significantly affected and would be able to form an island. As noted earlier, Superstorm Sandy damaged the Transco interstate gas pipeline in Long Beach. Potential damage to gas infrastructure during future storms is still a possibility; however, post-Sandy repairs would have provided additional reinforcements. The backup diesel generation at the Waste Water Treatment Plant, Water Purification Plant, and Municipal Building have enough storage for 3-4 weeks of continuous operation at full load and can be re-supplied as needed. The major risk to the microgrid infrastructure is a very low-likelihood seismic event or tornado that might damage sections of existing distribution system that microgrid intends to utilize.

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 points of interconnection with the existing feeders, particularly 2M-7N2 which acts, in part, as a backbone of the microgrid. Because the facilities are spread around geographically as well as on four different feeders, the microgrid will pick up several non-critical customers in islanded mode. Since the microgrid uses some sections of existing lines, four new isolation switches and at least two transfer switches have to be installed and several others upgraded for interconnection between feeders. Please refer to Figure 2-1 and Figure 2-2 for the location of new and existing switches that need upgrades.

Because the microgrid sources are a mix of rotating machines and inverter-based generation, the protection schemes are very complex, and traditional protection schemes based on high fault currents will likely not be applicable when in islanded mode. The coordination of the protection schemes between grid-connected and islanded mode may 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)

  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 databases 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.

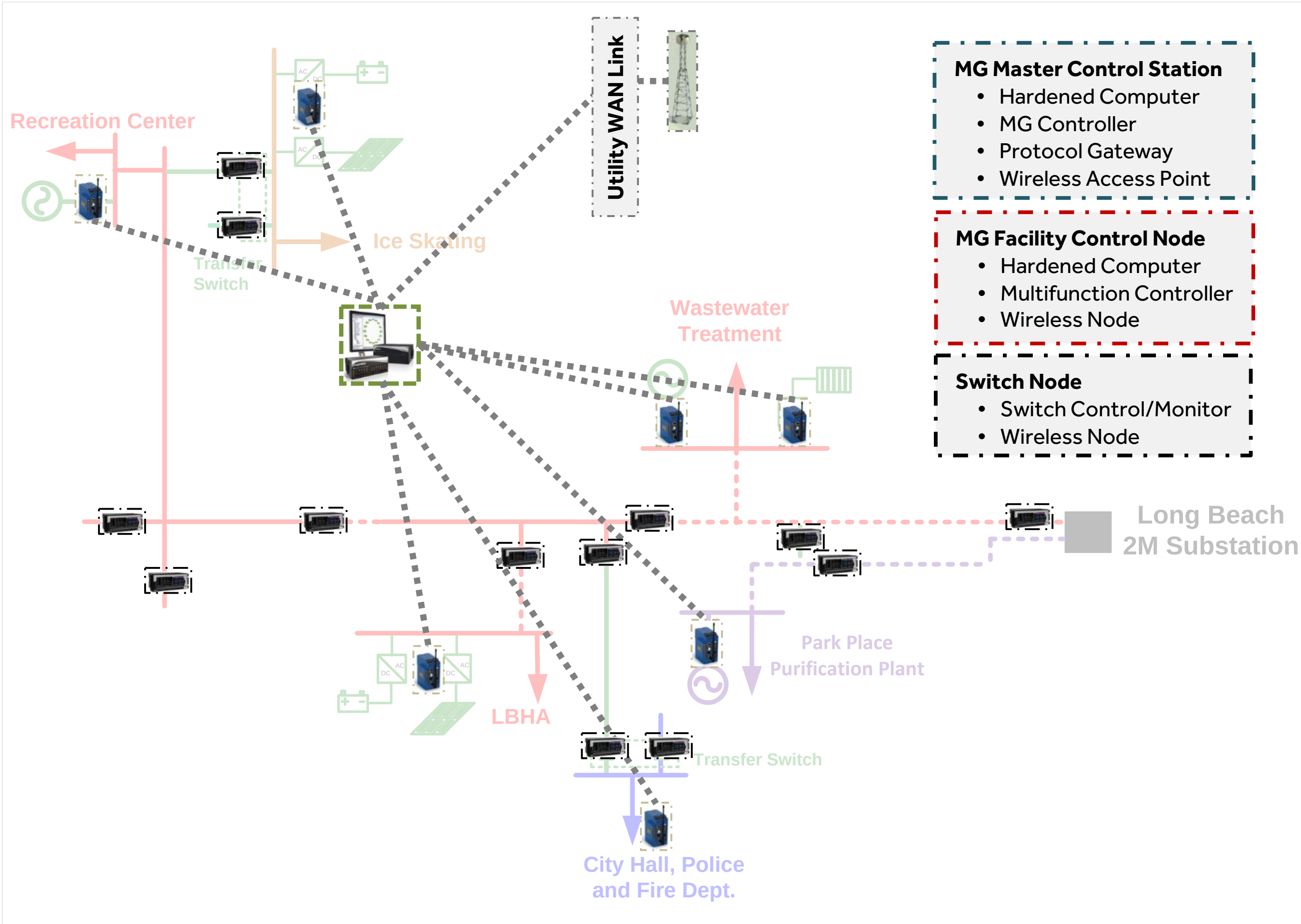
- Microgrid Facility Control Node (1 per facility)

  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 2-11 below shows control devices for the proposed Long Beach microgrid as an overlay on the electrical one-line diagram.



Long Beach Microgrid Electrical One-Line Diagram with Control and Communications Overlay
Figure 2-11

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 CHP and dual fuel units, the backup generators, as well as invertor-based generators (PV, Battery, and Fuel Cell). The start/stop commands as well as optimal set-points for real power, and sometimes even for reactive power, are sent to each generation unit. In addition to regulating the generation units, a primary task for the Microgrid Master Control Station is to coordinate the switching devices at the boundary of the microgrid. To simplify Figure 2-11, these communication links are not shown.

Both existing and new generation units are expected to be equipped with microprocessor-based controllers that can regulate either the natural gas engines or the inverter-based power conditioning systems. During a typical operation, while a unit is in standby or parallel modes, the controller issues power set-points, while continuously adjusting the engine speed to optimize efficiency.

The 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 set-point 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 (BEMS) to determine and set load set points. The diagram in Figure 2-11 assumes that the existing 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, HVAC systems, 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. This was described earlier in Section 2.1.2. 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.

The formation of a microgrid generally proceeds as follows:

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

Note: some steps may be performed in parallel.

The steps listed above are a combination of pre-determined operating procedures and automated control actions. For example, during the planning stages, the load and generation that make up the core or uninterruptable microgrid will be determined, and the sectionalizing scheme that isolates the core microgrid will be established. When an abnormal condition is detected (or an isolation signal is given), relay operations will then automatically perform the topology reconfiguration. At the same time, generation controls must be sufficiently flexible to survive a disturbance associated with an abnormal grid condition that requires the microgrid to go into islanded mode. Actions, such as the addition of loads and generation to the core microgrid, may be manual.

Automatic disconnection: The Long Beach microgrid is interconnected to the surrounding distribution system at seven locations (see Figure 2-2). 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 form in the manner described above.

Automatic connection: The Long Beach 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 (generally 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.

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 Long Beach microgrid, the standby generators, the dual fuel generator, or battery storage may be used to black start. Once the generators are up, the CHP, Fuel Cell, and the other invertor-based generators (as needed) may be added to the grid. Additionally, battery storage can be added to black start without the standby generators.

Generators designed for standby operation, such as those at the Long Beach 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 black start scheme.

Once the standby generation is energized, load and CHP and Fuel Cell generation will be added to the system in an incremental process. Standby generators will likely be used to follow load while the microgrid is being formed.

Performing Economic Dispatch and Load Following

The Long Beach microgrid will provide load following during emergency periods utilizing its currently existing backup generation at the Waste Water Treatment Plant (450 kW), Municipal Building (100 kW), and Water Purification Plant (660 kW).

The economic dispatch of the microgrid generation units during emergency periods will be performed by the microgrid controller and energy management system, based on the amount of generation needed to balance the time varying net load (i.e., load minus solar generation), and the microgrid generation unit efficiencies and constraints, fuel prices, and variable operations and maintenance (VOM) costs.

During normal/blue sky days, the microgrid economic dispatch will be based on the relative economic costs of on-site generation versus purchase from the utility or even sales to the larger grid or NYISO wholesale market, subject to applicable future REV framework. The on-site generation versus utility purchase is demonstrated in the DER-CAM modeling. Although simplified compared to actual operations, the DER-CAM model illustrates the amount of utility purchases that vary with time and are highly dependent not only on the relative energy costs of on-site generation versus utility purchases, but also on the applicable utility monthly and daily on-peak demand charges.

Demand Response

Load resources available for load shedding are also available for demand response. The initial plan is to have at least 5% (or perhaps 10% of the 3 largest facilities) of the microgrid peak load to be curtailable during long-term emergency when the microgrid goes into islanded mode. However, the end use control elements will be available to use these same load resources as demand response resources during normal/blue sky days. The 5% of peak load of the top 6 facilities is about 80 kW and can also be available as demand response during normal/blue sky days. The 10% of peak load the 3 largest facilities is about 105 kW. These demand response resources can be utilized in various utility price-based or event-based demand response programs in the future, such as critical peak pricing (CPP) or critical peak rebates (CPR) or even as part of aggregated demand response resources under management by third-party demand response providers, such as NRG Curtailment Solutions, who enroll customers in the NYISO demand response and load management programs.

Storage Optimization

As currently designed, the Long Beach microgrid incorporates two 50 kW battery energy storage systems as supplemental elements to proposed solar PV resources, one at the LBHA's Channel Park Homes site and one at the Long Beach Ice Arena site. In addition to smoothing the available power from solar generation, energy storage operation can be optimized to add value by shifting the energy availability from low to high price hours, or from low to high load periods. If seamless transition from grid-connected mode is a critical requirement, then storage is a good option.

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 Long Beach microgrid, a large portion of the generation will be from the dual fuel, CHP, and Fuel Cell units. The CHP and Fuel Cell generation will act as base-load generation and reserve margin. The faster acting dual fuel generator and other standby units in the microgrid will be used to manage fluctuations in load as well as variation in power output caused by solar PV. If additional control is needed, curtailable load may be used to help maintain the microgrid frequency, and solar 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, the CHP unit and standby 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.

Solar PV Observability and Controllability; Forecasting

Solar 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 2-11. The total nameplate capacity of solar PV installations is 300 kW, less than 15% of peak microgrid non-coincident load. The supplementary battery storage systems (100 kW in aggregate) at the two solar PV sites would provide partial generation and load flexibility to mitigate solar 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 project team may consider another layer of protection that is predicated on transfer trip signals from the controller.

Selling Energy and Ancillary Services

Subject to the evolving NY REV framework, and also NYISO market rules and proposed rule changes applicable to microgrids and distributed generation, it is expected that the distributed generation within the Long Beach microgrid will be able to sell energy into the larger grid though the Distribution System Platform (DSP) as being developed within REV, and also participate in the NYISO energy, capacity, and/or ancillary services markets.

The details of eligibility for selling energy to the utility and requirements for NYISO participation are to be determined within the REV process and NYISO market design development. From a theoretical perspective, the on-site generation would sell energy at times when applicable Locational Marginal Price + Distribution Component (LMP + D) are higher than the marginal cost of on-site generation.

Ancillary services, including regulation up and down and spinning and non-spinning reserves, can also be provided by the on-site generation subject to current and/or future market rules.

Finally, subject to eligibility and a must-offer requirement in the Day-Ahead Market, on-site generation may be able to participate in NYISO capacity auctions and be paid the applicable NYISO capacity prices.

Data Logging Features

According to the control architecture presented above, data logging is both local (at Microgrid Facility Control Nodes) and global (at the 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 Microgrid 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 -40º C to +70º 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 storm surge and 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, the project team is proposing a wireless field network as shown in Figure 2-11 for the microgrid communications backbone. 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 900 Mhz communication links.

In addition, each microgrid facility is equipped with a Microgrid Facility Control Node, a hardened computer hosting local control applications. At least the control node at the Municipal Building will integrate with the existing building management systems. Communication with the Microgrid Master Control Station is achieved through 900 Mhz or WiMax field network. The wireless communication links to the switchgear devices are not shown in the figure.

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 a 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 resources and load devices are under the control of the microgrid controller.

If the utility communications network is considered external to the microgrid communications network, an interposing server will be utilized to provide for controlled information flow. Firewalls will be utilized between the microgrid network and the interposing server and between the external link and interposing server to provide enhanced cyber security for this link.

The proposed communication infrastructure design assumes industrial-grade, long range, point-to-multipoint wireless communication with MIMO (Multiple-In, Multiple-Out) antennas that provide robust communications.

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)?

The City of Long Beach's population swells from approximately 34,000 permanent residents to a population of more than 55,000 in the summer.[2] The Municipal Building (City Hall and Police and Fire Headquarters), Waste Water Treatment Plant, and Water Purification Plant provide critical services to the City's entire community, including year-round residents and the summer population. LBHA's Channel Park Homes (500 Centre St.), with approximately 500 residents, is a complex of U.S. HUD-subsidized affordable housing apartment buildings for low-income families. LBHA's Michael Valente Apartments (415 National Blvd.), with approximately 100 residents, is a high-rise residence for low-income seniors and the disabled. The Municipal Building (1 West Chester St.) and Michael Valente Apartments are considered FEMA Critical Facilities, providing vital health and social services to the Long Beach community and affordable housing services to senior/disabled citizens, respectively.

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 project team believes there is potential to leverage planned DER for demand response participation in NYISO's voluntary response (EDRP) or mandatory response (ICAP-SCR) program. The Long Beach microgrid includes approximately 1.5 MW of capacity that would be available. NYISO's SCR Program involves a 100 kW minimum reduction in aggregate, mandatory response during reliability events for a minimum of four hours, and payments for capacity (monthly based on sales made through ICAP auctions or bilateral contracts) and energy (based on performance in capability tests & reliability events).

Current rules for NYISO demand response limit the capacity value of resources to the demand located at the same retail electric meter where the generation is connected. The aggregation and combined treatment of microgrid DER and loads will require a change in NYISO rules. NRG

[2] "Long Beach City Guide," Long Beach Chamber of Commerce. 3 March 2016. <http://www.thelongbeachchamber.com/long-beach-city-guide>.

believes such a rule change is warranted and achievable, to support the implementation of microgrids and other DER, consistent with NY State policies, and to support the use of the full capability of these resources in NYISO planning and operations.

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

The facility owners (the City of Long Beach, the Long Beach Housing Authority, and the MTA Long Island Rail Road) will be the expected purchasers of power, hot water, and other energy-related services from the Long Beach microgrid under Energy Services Agreement ("ESA") and/or Power Purchase Agreement ("PPA") contracts with a third-party microgrid services provider subject to future procurement solicitations by the City of Long Beach as may be required by law.

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

Local businesses and the population of ~34,000 year-round residents and the additional 20,000+ people visiting Long Beach during the summer will continue to receive critical police, fire, and emergency services during major outages. In addition, the ~500 residents of the Channel Park Homes and ~100 residents of the Michael Valente Senior Apartments will benefit from increased power reliability and resilience in the event of a protracted grid failure.

3.1.5 – Describe the relationship between the microgrid owner and the purchasers of the power?

Financing of the microgrid assets can generally be accomplished by either purchase of the assets by the facility owners or third-party ownership of the assets. It is preferred by the City of Long Beach for a third party to design, build, own, operate, and maintain the microgrid. NRG is one such party that can successfully fulfill this role on a "turn-key" basis, if selected to do so under a future competitive solicitation. The public entities noted above will be the expected off-takers of the power and microgrid services. Upon establishing the technical and economic feasibility of the Long Beach microgrid, the parties expect to commence discussion of commercial terms for further phases of work on the project. Unless otherwise exempted, the solicitation of future services provided for the City of Long Beach will be subject to procurement or other applicable requirements under general municipal law in NY State.

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 customer participants in the Long Beach microgrid will be expected to 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 PPA and/or ESA contracts will be entered into between microgrid customer participants and a third-party microgrid services provider. 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

A third-party project sponsor and operator, such as NRG, would be expected to assume responsibility for project guarantees or plant operational guarantees. This competitive services provider, subject to future solicitation and award under the City's contract procurement process, would also obtain appropriate capital project guarantees from equipment suppliers and contractors. This firm could also provide any operational availability, output, and/or heat rate guarantees to microgrid customer participants as negotiated and required under the PPA and/or ESA contracts.

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

Specific terms, conditions, roles, and responsibilities will be negotiated by the engaged parties as the project progresses through the detailed design and structuring phases. Procurement of services by the City of Long Beach will be subject to all applicable requirements under general municipal or other law. Although a third party, such as NRG, can serve as both the owner and operator, another option could be ownership by the customer participants (most likely the City of Long Beach) with a long-term contract with a third-party firm for dispatch/operational control of the DER assets and on-going O&M services.

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 third party firm, such as NRG, would be responsible for soliciting and registering the microgrid participants/customers in the proposed commercial structure, subject to future solicitation and selection by the City of Long Beach.

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

The proposed microgrid will provide hot water to the Long Beach Recreation Center's campus, including the indoor swimming pool, fitness center, and other facilities, although this facility is not considered a priority after an extreme weather event.

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?

The community, to include residents, businesses, and fire/police services, public works, and other city personnel, will benefit from the enhanced resilience and ensured operational continuity of critical water and wastewater infrastructure, as well as government, police and fire protection services. Under the proposed commercial structure, the upfront project costs will be absorbed by a third party firm, subject to the City of Long Beach's contract procurement process, and incorporated into the cost of power and thermal energy delivered by the microgrid. The CHP and solar PV systems are expected to create savings that will help offset the costs of other DER. Though thermal demand in summer is low, the CHP unit at the Ice Arena and Recreation Center may still operate to shave peaks and participate in NYISO markets on an opportunistic basis, subject to eligibility under current and/or future market design rules. As discussed in 3.2.8 and elsewhere in the study, all of the proposed DER may be capable of delivering tangible benefits through energy cost management and arbitrage, participation in demand response programs, and sales of energy, capacity, and/or ancillary services at the NYISO and/or distribution system level, to the extent market opportunities are available and resources are eligible under current and/or future rules.

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?

Utility costs depend on what role the utility is playing. If the utility is building the new lines and installing or upgrading switches in the field, then one model is that costs will be financed and recovered the traditional utility way, except that the base of customers *might* be restricted to direct and indirect beneficiaries of the microgrid. This is admittedly more a benefit than a cost since any investment will be recovered with a return. For the Long Beach Microgrid, there is a new line, several new switches, and upgrades to automated switches.

PSEG-LI stands to benefit from reduced stress and losses on the LIPA distribution system due to the local DER present in the Long Beach microgrid. In the case of emergencies or an overloaded grid, capacity from the microgrid's generation assets, as well as demand-side curtailment, can offset peak load and improve the stability of the macrogrid through participation in demand response.

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 Long Beach 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 stable, low-risk partners to private entities developing microgrids. The City of Long Beach is an investment-grade counterparty with an improved credit outlook; Moody's Investors Service upgraded the City's bond rating to Baa1 from Baa2 in February 2016.[3]

The microgrid participants have expressed interest in a public-private partnership (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. The customer participants recognize that the project would likely 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, own, and maintain the microgrid.

The City of Long Beach would be expected to conduct a Request for Proposals process in the future for service providers as required by general municipal law in NY State. One such company that can perform on a "turn-key" basis is NRG, which is a recognized and respected competitive energy solutions provider that designs, finances, builds, owns, operates, and maintains DER and microgrids.

An added benefit of the P3-DBOOM approach is that it allows the private entities to monetize tax benefits associated with the deployment of certain distributed generation technologies, including solar PV, fuel cells, and cogeneration. This ability to take advantage of benefits not otherwise available to tax-exempt entities would be expected to translate into a lower cost of power and energy services for microgrid customer participants, all else equal.

[3] "Long Beach officials pleased with city's improved finances." Newsday. 2 February 2016. <http://www.newsday.com/long-island/long-beach-officials-pleased-with-city-s-improved-finances-1.11415956>.

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

Internal

Strengths

- No upfront capital required from microgrid customer participants. Also, the local utility will not need to incur additional cost as a result of the proposed microgrid project
- Public entities in Long Beach with long-term financial stability, high energy loads, and critical operating requirements that are attractive microgrid hosts/off-takers
- Immediate energy cost savings can accrue to hosts/off-takers
- Procurement can be expedited because no funds need to be budgeted and dispersed by public entities (City of Long Beach, LBHA, or MTA LIRR)
- Scalable for host if it has other sites
- Leverage underutilized resources/assets (roofs, land)
- Financial and technical risk is mitigated

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
- Limited list of interested/capable P3 partners in the multi-customer, public purpose microgrid space
- 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
- Help to explore the market opportunity and create a flexible, scalable, and replicable platform for community microgrids in NY State

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?

Located on a barrier island off Long Island's South Shore in Nassau County, the City of Long Beach was devastated by Superstorm Sandy. The site includes critical water and wastewater treatment facilities, as well as essential government, police and fire protection command centers. The Ice Arena and Recreation Center are included in the microgrid and together serve as points of distribution and a base for first responders and rescue teams. Technology and DER include zero and low emissions generation such as solar PV, fuel cells, and cogeneration, all of which will contribute to a more reliable and resilient energy supply system in the event of a prolonged power grid interruption.

3.2.5 – What makes this project replicable? Scalable?

The proposed project will explore the market for enhanced reliability/resiliency services and a technical, regulatory, and contractual framework for the development of community microgrids. The proposed P3-DBOOM business model will likely expedite and simplify the commercial procurement process, and a number of service providers, such as NRG, have replicated this third-party ownership and operations business model with customers. The primary generation is supplied by a combination of cogeneration, fuel cells, solar PV, and battery storage, which are all technologies that are scalable and applicable to a variety of setting and facility types.

Furthermore, the project team will use its best efforts to build a flexible and scalable platform that can support future expansion and development in the project area, which may include additional DER and/or a phased build-out. For example, the owner of two private commercial facilities (8,000 sq. ft. co-working space and payment processing company's leased headquarters) on the eastern side of Long Beach Blvd. has expressed interest in the microgrid project. Other facilities and their DER may be considered for potential inclusion in future phases, as well as the results of longer-term plans for waterfront economic development (see Section 3.6.3).

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.

Superstorm Sandy caused estimated damages of $200 million to city facilities and infrastructure and total damages to all of Long Beach likely exceeding $1 billion. Vital services (including utilities, water, and sewage systems) were left without power for an extended period. The community and city's infrastructure remain vulnerable to future storms, as almost the entire city is within a FEMA Special Flood Hazard Area.

The proposed microgrid is designed to promote clean/efficient localized electrical generation, enable the city to sustain vital functions and emergency responder services in the event of power disruptions, and reliably serve critical facilities in Long Beach. The purpose of this project is to ensure that these critical facilities remain operational during an extreme and highly protracted power grid failure. Tens of thousands of residents depend on these facilities daily to provide safe drinking water, treat wastewater, and facilitate commuter rail services. Also, critical police and fire service as well as facilities that serve as points of distribution and a base for first responders and rescue teams are supported by the microgrid.

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 CHP and fuel cells, solar PV plus battery storage, and a dual fuel emergency backup generator, 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 on the ability to provide operational continuity during an extreme and highly protracted power grid failure. Energy savings and long-term supplies of power at fully or partially fixed costs through PPA and/or ESA contracts can provide a hedge against electricity cost increases without an upfront investment by the City or other customer participants.

A microgrid with behind-the-meter distributed generation has the direct benefit of reducing 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 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%.

Potential revenue from future power market participation represents, at a fundamental level, the value of broader transmission and distribution system efficiency. In these ways, the Long Beach microgrid value proposition directly benefits the utility and advances the goals of REV, which calls for, among other things, the creative and targeted deployment of DER to improve the efficiency and resilience of the electric grid.

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

The cogeneration system will provide energy savings, as will the 300 kW of solar PV. The battery storage (total of 100 kW) could enable arbitrage and participate in demand response and frequency regulation markets. In general, with the potential enactment of new policies and market rule changes to allow "behind-the-meter net generation" or "BTM-NG" to participate in the NYISO wholesale markets by the end of 2016, it is hoped that the microgrid will sell power, capacity, and/or ancillary services to the grid and receive new on-going revenues as a result. NYISO's current proposal for BTM-NG would apply to a generator (or interconnected group of generators) that serves load behind the meter and has excess generation capability (at least 1 MW of energy to export) after serving its retail load. The intent is to allow for routine "exports" into the NYISO markets for over-sized BTM capacity, while smaller DER will be considered in the future, perhaps under a different set of rules. The magnitude of these potential revenues is difficult to predict at this stage given the emerging nature of these grid services and markets. Many of the market rules would have to be changed in order to fully support selling into *both* the DSP (or Distribution System Platform envisioned under REV) and the NYISO.

Allocation of added market-based revenues would be subject to the commercial structure, to be negotiated and agreed upon by the engaged parties in a future phase of the project. The ability of a third-party operator, such as NRG, to optimize the microgrid system from a value creation perspective (i.e. maximizing additional revenue generation opportunities, while still maintaining reliability or other objectives) would be expected to translate into a lower cost of power and energy services for microgrid customer participants, all else equal.

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 optimized generation and storage of power at a local level in a resilient, low carbon manner. The project team believes that the proposed microgrid will serve to advance innovative energy solutions, including market-based technologies, products, services, and business models, in NY State. The project will explore the market opportunity for the local utility, its customers, and competitive solutions providers to establish public-private partnerships for microgrids, provide enhanced reliability/resiliency services, and determine value steams and commercial structures that may be replicated and used to engage additional customers.

By working closely with the local electric utility and utilizing its distribution infrastructure, PSEG-LI stands to benefit from a "smart load center" that can respond to the needs of the macrogrid during times of congestion, instability, and/or high cost periods. In this manner, PSEG-LI can serve as a distribution system operator (DSO), enabling more penetration of DER, creating a marketplace for grid support services, and orchestrating the generation and distribution of power from a variety of local DER as "grid assets."

In addition, the proposed project aligns with resiliency recommendations presented in the Long Beach NY Rising Community Reconstruction Plan. Specifically, the project advances the plan's recommendation to investigate a "Microgrid for Select Community Assets," proposing to use localized power generation (natural gas and fuel cells) to maintain power to key community assets if the utility grid becomes de-energized in the next storm event.

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, battery storage, fuel cells, cogeneration, 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 reliability and resilience, and reduce carbon emissions.

Task 3.3 – Commercial Viability – Project Team

NY Prize Stage 1 Applicant and Project Design Firms: NRG is a Fortune 200 company, the largest competitive power producer in the U.S., and one of the nation's largest developers and owners of renewable generation. NRG is a competitive energy solutions provider with a proven track record of developing and implementing microgrids incorporating multiple generation and storage technologies under an integrated control and optimization platform at locations such as Princeton HealthCare System's University Medical Center of Princeton at Plainsboro. Burns Engineering and GE Energy Consulting have been engaged to provide technical design, engineering, and analysis services for the Stage 1 feasibility assessment.

Local Distribution Companies: PSEG-LI, a subsidiary of Public Service Enterprise Group, Inc. (NYSE: PEG), is the local electric distribution company managing the Long Island Power Authority ("LIPA") electric utility system and serving 1.1 million LIPA customers. National Grid is the local gas distribution company in Long Beach.

Local Government, Customer Participant, and DER Host Sites: The City of Long Beach is located on the Barrier Island on Long Island's South Shore in Nassau County and is a 50-minute train ride from New York City.

The City of Long Beach operates with a council-manager form of government. It is the responsibility of the City Manager, who is appointed by the five member City Council, to administer the daily operations of the City's government. On January 3, 2012, Jack Schnirman was sworn in as City Manager. Mr. Schnirman has led Long Beach through fiscal crisis and a major natural disaster in Hurricane Sandy. Mr. Schnirman is leading the City's recovery efforts with a focus on rebuilding stronger, smarter and safer. The City's Department of Public Works has the capability to hire professional firms and contractors to carry out public works projects in Long Beach in compliance with federal and state law. Jim LaCarrubba, the Commissioner of Public Works, specializes in building construction and maintenance, erosion control and beach replenishment, highway construction and maintenance, drainage design/installation and disaster preparedness and recovery. With an estimated $150 million in damages to the City from Sandy, he now oversees not only the day to day needs of the City but the recovery effort as well. As part of the recovery effort, Jim LaCarrubba led the reconstruction the City's iconic boardwalk (the main pedestrian and cycling thoroughfare in Long Beach) post-Superstorm Sandy, a $40 million dollar project that was on time and under budget and an additional $60 million in infrastructure and road rehabilitation projects.

Customer Participant and DER Host Sites: LBHA is a public housing authority that operates 375 Federal public housing units and administers 389 housing choice vouchers, under the U.S. Department of Housing and Urban Development ("HUD") Section 8 program. LBHA's affordable housing developments within the project footprint include the Channel Park Homes (108 rental units for families with ~500 residents) and Michael Valente Apartments (65 units for low-income seniors and the disabled with ~100 residents).

Customer Participant: The MTA LIRR is a key link in New York's transportation system and the busiest commuter railroad in North America, with the Long Beach Station located at Park Place and Park Avenue in the city center of Long Beach. Today, the Long Beach Branch has approximately 20,000 customer trips each weekday.

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

The City of Long Beach, the Long Beach Housing Authority (operates the Channel Park Homes and Michael Valente Senior Apartments), and the MTA LIRR are all active participants in the project and support the effort going forward. NRG and the City of Long Beach are parties to an agreement outlining the specified objectives of the microgrid and initial collaborative efforts to determine overall suitability, preliminary design and energy/infrastructure components, and proposed commercial structures. Depending on findings and recommendations of the feasibility study, project team members may enter into subsequent definitive agreements as necessary to proceed with future phases of work, including detailed design and structuring. Procurement of future services for the City of Long Beach will be subject to all applicable requirements under general municipal law in NY State.

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?

NRG, on behalf of the City of Long Beach, the Long Beach Housing Authority, and the MTA LIRR, is the NY Prize Stage 1 applicant. The City of Long Beach expects to solicit and engage a third party to oversee the further assessment and follow-on engineering and design of the microgrid as part of Stage 2. Burns Engineering and GE Energy Consulting are interested in continuing to provide technical engineering and analysis services. Looking forward to Stage 3, NRG is interested in offering a design-build-own-operate-maintain solution that includes project financing. If the project moves forward, the solicitation and award of future design, engineering, construction, or other services for the City of Long Beach and other customer participants will be subject to applicable contract procurement requirements.

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 project's commercial viability. This P3 approach will overcome two issues that would otherwise present major hurdles going forward: (1) project financing and (2) microgrid design, construction, operations, and maintenance. It is proposed that a third party would develop, finance, design, build, own, operate, and maintain. In turn, the City of Long Beach, the Long Beach Housing Authority, and/or the MTA LIRR would sign long-term power purchase or energy services agreements with a third-party provider, thus providing a means for a private capital provider to recover its upfront costs and earn a reasonable return on 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.

A third party is expected to be selected as the project lead and eventual owner, although the City of Long Beach could also elect to be the applicant in future stage and take an ownership interest in the microgrid project company . NRG is the NY Prize Stage 1 applicant and a third party that can potentially serve as the long-term owner and operator of the Long Beach microgrid. With $693 million of unrestricted cash and $2.1 billion in liquidity at the NRG Corporate level as of December 31, 2015, as well as $14.7 billion in annual operating revenues in 2015, NRG has sufficient liquidity to fund and deliver the proposed microgrid development and construction project on balance sheet. Sources of NRG equity would include its current cash balances as well as future cash flows generated by its existing operations.

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?

Future services for the City of Long Beach will be competitively solicited through a Request for Proposals process and subject to all applicable requirements under general municipal law. If the project moves forward, NRG would like to continue to work together with the project partners and serve as the lead developer and applicant in future phases of the project. Likewise, Burns Engineering and GE EC are interested in continuing to provide technical engineering and analysis services. The qualifications of NRG, Burns Engineering, and GE EC are described below.

NRG – NRG is the largest competitive power producer in the U.S. and owns and operates nearly 50,000 MW of net generation capacity nationwide, representing a diversified mix of fuel sources, generation technologies, output configurations, and geographical locations. NRG is also one of the nation's largest renewable generation owners and developers -- both at the utility and distribution scale -- with 3,000+ MW of wind generation assets and with 2,000+ MW of solar in operation, construction, and development.

NRG's ability to provide a turn-key, single point of responsibility for design, engineering, permitting, construction, financing, commissioning, and long-term operations and maintenance minimizes risk and effort for customers. A single master developer could best manage the economic risk that the assets will perform as expected and also contract with the various OEMs/sub-contractors. NRG has significant expertise in the structuring, negotiation, execution, and management of EPC arrangements for power generation projects. NRG's procurement and construction personnel are skilled at negotiating contracts with vendors and suppliers to maximize quality, limit cost, and ensure adherence to schedules.

For an efficient integrated microgrid, the coordination and optimization of DER enhances the functionality of the microgrid. The project team views it as a strength if a single, capable entity owns and operates the assets as a system to optimize performance and reduce risk and costs to microgrid customer participants.

Engineering and Construction: NRG's engineering and construction team has extensive experience across a wide array of conventional and renewable energy generation technologies, and a track record for on-time and on-budget performance. The typical project execution approach is for NRG to directly manage and oversee project engineering and on-site construction, as performed by NRG-qualified contractors and suppliers. To ensure cost-effective execution in-line with requirements, NRG typically selects contractors and suppliers via competitive solicitations from among a pool of pre-qualified and well-proven contractors. NRG engages the contractors via EPC contracts with built-in risk management techniques, including, for example, date certain fixed price contracts, with appropriate retainage, liquidated damages and warranties. During the execution phase, NRG in-house experts would manage construction, actively overseeing the contractors' activities to ensure on-time and on-budget delivery consistent with the project specifications. One such partner that NRG has engaged for technical design and engineering services in NY Prize Stage 1 is Burns Engineering.

Operations: Consistent with NRG's normal practice and if selected in the future as the project's O&M services provider, NRG would manage and operate the microgrid project utilizing a team of highly experienced internal experts, supplemented by qualified subcontractors where beneficial. NRG has a strong historical record for safety and high reliability. Depending on project and customer needs, NRG's operations and technical staff would develop and implement a strategy to deliver long-term reliable performance, utilizing tools such as 24x7 equipment monitoring, regular preventive maintenance, spare parts inventory and supply management, and performance reporting and assessment. In addition, NRG would maintain appropriate levels of insurance, and where available, obtain long-term warranties from original equipment manufacturers and construction contractors to ensure high levels of equipment performance.

NRG has significant experience in the design, engineering, and implementation of cost-effective, resilient, and efficient energy systems that include innovative solutions and clean energy to serve customer needs. NRG has operational microgrids incorporating multiple generation and storage technologies and modular, integrated control and optimization systems at locations such as Princeton HealthCare System's University Medical Center of Princeton at Plainsboro. Below are some examples of NRG's proven microgrid capabilities and successful project experience involving partnerships with host customers.

- NRG Energy Center Princeton – State-of-the-art and self-sufficient, with the lowest net energy consumption and highest reliability available for a healthcare facility, this CHP-based microgrid supplies the total energy needs of the University Medical Center of Princeton at Plainsboro – under a long-term full requirements contract to provide steam, chilled water, electricity from a gas turbine generator and solar, back-up generation, and thermal storage. NRG was selected to finance, design, build, own, operate, and maintain the sustainable energy system. The project commenced commercial operations in January 2012 ahead of schedule and on budget, and NRG's solution dramatically cuts energy bills and emissions while increasing reliability.
- Arizona State University – NRG entered into an agreement with ASU to design, construct, and operate the Sun Devil Energy Center, a CHP plant and emergency back-up assets connected to on-campus laboratories and research facilities that require reliable and resilient energy supplies on a 24/7 basis. In addition, NRG has provided significant solar generation for the ASU campus, with over 12 MW of solar currently installed. Applications include rooftop, elevated parking arrays, and single axis ground mount solar solutions.

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, cogeneration, and fuel cells. No decisions have been made to pre-select any technology, though the design team has identified best in class vendors and would only procure technology with a proven performance record. Similarly, no contractors have been determined. The project team will commence discussions with potential contractors as part of Stage 2. Procuring equipment and construction services will be done through a competitive process at the appropriate time. In addition, future procurements by the City of Long Beach would be conducted through a Request for Proposals process as required by general municipal law in NY State.

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?

The commercial structure may involve a third party, such as NRG, as the project financier and ultimate owner, subject to a competitive solicitation by the City of Long Beach. Another option is majority or minority ownership by the City of Long Beach and/or other customer participants with a long-term contract for dispatch/operation control of the DER assets and on-going O&M services with a third-party company. Details of the commercial arrangement between the microgrid owner(s) and/or operator and the microgrid customer participants (or power purchasers) will be confirmed in the future,

If selected in the future to serve as financier, NRG would strive to finance the energy system in the most optimal, cost-effective manner, which could involve a combination of NRG and third-party funds. NRG would also take steps to increase the attractiveness of the project to sources of potential financing, as well as other project participants, such as EPC contractors. This would include efforts to structure financeable, long-term power purchase or energy services agreements with customer participants. NRG has ample balance sheet liquidity, NRG Yield (NYSE: NYLD) as a potential financing vehicle and long-term owner upon commercial operation, deep relationships with third-party capital providers, including lenders, tax equity investors and institutional investors, and experience with government grants and incentive programs, including for innovative renewable energy projects.

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?

As an owner and operator of power generation assets and on-site energy systems nationwide, NRG is familiar with navigating the regulatory landscape, including working to identify and overcome regulatory barriers at the municipal, state, and federal levels. NRG has an experienced team in Market & Regulatory Affairs, as well as Government Affairs and Legal professionals dedicated to these issues. NRG actively comments on regulatory proceedings and has effectively helped to shape the legal and regulatory landscape within which third-party generators compete at the utility and distribution scale, both behind and in front of the meter. NRG is participating in NY State's REV proceeding, supporting the REV objectives of competitive markets, customer choice and participation, renewable deployment and integration, enhanced system efficiency, reliability, and resiliency. The NY Prize community microgrid projects will present new challenges for regulators as well as for the parties implementing the projects, and

NRG is well-positioned to work cooperatively and constructively with state regulators, utilities, customers, and other stakeholders to craft workable business models and market rules within which microgrids and DER can operate efficiently and profitably.

NRG has had a strong operating presence in New York State since 1999, with energy customers and generation assets across the state. NRG owns and operates more than 4,100 net MW of wholesale generation in New York State and has hundreds of additional MWs of demand response (through NRG Curtailment Solutions f/k/a Energy Curtailment Specialists) and retail load (through brands such as NRG Home, Green Mountain Energy, and Energy Plus), giving NRG extensive experience with the NYISO markets and the permitting, regulatory, and legal environment in the state.

Through its wholesale generation, demand response, and retail businesses in New York State, NRG is fully compliant and conversant with NYISO's interconnection requirements, including metering, ancillary service provisions, operating policies, criteria, rules, guidelines and tariffs, and employs Good Utility Practice in all markets in which it operates and conducts business.

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 DER technologies were chosen based on a number of factors. The project team's design engineers started with overall system optimization and initial asset selection, sizing, and configuration by using Lawrence Berkeley Lab's 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 DER in the microgrid.

This was then 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. Cogeneration was chosen and sited by the Recreation Center because it could provide base load electricity and heating for the pool. High electrical efficiency fuel cells with no heat recovery were sited adjacent to loads with limited or no heating requirements. Solar PV was selected and sized based on available roof areas. An existing backup diesel generator was selected to be retrofitted with dual-fuel capability to enhance reliability and reduce emissions.

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

The Long Beach microgrid participants have existing backup generation assets with a combined nameplate capacity of 1.21 MW, and a standard operating capacity of 1.16 MW. Included in the above is a 660 kW dual fuel backup generator at the Water Purification Plant that will be able to operate without concern for diesel fuel availability.

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

The specific demands for power matching/frequency regulation will be determined through study, and the microgrid controller will manage assets in real time, in response to changing conditions. The project includes 100 kW of batteries and a 660 kW dual fuel generator, which are both excellent for black start and load-following applications. In grid-connected mode (parallel to the grid), microgrid generation 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. However, in islanded mode, microgrid resources will need to provide power balance/frequency control and reactive power balance/voltage control.

For the Long Beach microgrid, the 500 kW of fuel cells at the Waste Water Treatment Plant and the 100 kW CHP unit at the Ice Arena and Recreation Center will provide baseload power totaling 600 kW. A portion of the 660 kW dual fuel and 250 kW natural gas capacity at the Water Purification Plant can also provide baseload power. Fast frequency regulation will come from the aggregate 100 kW batteries at the Ice Arena and Channel Park Homes, as well as the 660 kW dual fuel generator at the Water Purification Plant. To augment this fast frequency regulation, load may also be controlled. The microgrid controller will be integrated with BEMS and control systems at the facilities to enable fast load shedding. Additionally, it may be necessary for solar PV production to be curtailed under some circumstances. This will also be managed by the microgrid controller.

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. Alternatively, the City of Long Beach and/or other customer participants may elect to take an ownership interest in the microgrid project company and then solicit additional private investors and/or a third party to operate the system and provide on-going O&M services. The City of Long Beach is required to follow general municipal law when soliciting and contracting for future development, construction, and operations services.

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 flow to the community in a number of direct and indirect ways. By ensuring the long-term operational continuity of the City of Long Beach's critical government, police, fire, commuter rail, and water purification and sewage treatment related facilities in the face of a severe, protracted grid failure, the microgrid will provide significant benefits to the more than 34,000 people who rely on these facilities and services daily, and roughly double that population during the summer months. In addition to no upfront capital requirements expected from customer participants under the proposed commercial structure, potential revenues and savings from the microgrid operation will also provide budget relief for the City of Long Beach and help keep taxes from rising.

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?

The electrical interconnection of the facilities uses portions of two PSEG-LI feeders (2M-598 and 2M-7N2). During a large-scale grid outage, sections of the feeders will be disconnected from rest of LIPA's system by switches and used to form the microgrid, along with a dedicated new line running from City Hall north to connect into 2M-7N2. Selected switches on LIPA's system that define the boundaries of the microgrid will be automated to facilitate quick formation. This automation can only be accomplished in cooperation with PSEG-LI, as the operator of LIPA's system, and operation of the switches will be subject to hierarchical control from PSEG-LI's control center.

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 cells, cogeneration, solar PV, and battery storage 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 may incorporate GE's proven U90Plus Microgrid Cost Minimizer to dispatch the DER and the D400 RTU/Controller to implement various operational control strategies. GE is currently developing a DOE funded Enhanced Microgrid Control System ("eMCS") 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 in Potsdam, NY. The U90Plus algorithm is being incorporated into the D400 controller, and this solution will be deployed in mid-2016 in a microgrid at the University of Ontario Institute of Technology.

Another proven solution that could be utilized is GE's 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 successfully deployed and demonstrated at the Portsmouth Naval Shipyard under a U.S. Department of Defense 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.

The Long Beach microgrid will take advantage of the existing connection between the Municipal Building (City Hall and Police and Fire Department Headquarters), the Recreation Center and Ice Arena (and Senior Community Center), the Waste Water Treatment Plant, and the Long Beach Housing Authority's Channel Park Homes on PSEG-LI Feeders (2M-598 and 2M-7N2).

During blue sky days, solar panels distributed amongst the sites will store excess energy in their paired battery systems, while a 100 kW CHP unit located at the Recreation Center will provide baseload power to the microgrid. A 500 kW baseload fuel cell, which will be located at the Waste Water Treatment Plant, will offset power usage of the combined facilities, i.e. the Municipal Building (City Hall and Police/Fire HQ), LIRR Station, and WWTP.

During normal operations, the microgrid controller will dispatch units when economical and provide frequency and voltage regulation to PSEG-LI for the LIPA system. Additional generation, such as the 660 kW dual fuel generator at the Water Purification Plant, can be brought online to serve a role in demand response applications.

When utility grid power is not available, the system will utilize fast acting switches similar to a G&W Viper Switch to island within 5 cycles. Black start capabilities and system response will be provided by the 660 kW dual fuel unit and the 100 kW natural gas fired CHP unit. These systems, in tandem with the microgrid controller, will operate in droop control to provide fast voltage and frequency response. The microgrid controller will integrate as necessary into the building BEMS systems to ensure priority loads remained powered. Solar capacity may need to be curtailed in island mode to maintain proper voltage and frequency in the system. The fuel cell models specified on the project will involve the UPM model to ensure that the fuel cells are able to produce power during an outage.

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 purchase and/or energy services agreements with the various customer participants wherein the price per kWh, price for thermal energy, and other pricing components would be established and agreed upon by all parties. The microgrid owner would provide electrical and thermal energy, as well as reliability/resiliency services, to customer participants via a pricing structure that may include a combination of fixed and variable pricing components as well as a resiliency and/or subscription fee. Costs would be charged to the customer associated with the meter where the DER asset is tied, and 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 model and commercialization plans are appropriate for this project. Long-term power purchase and/or energy service 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 for 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, such as NRG, 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?

The microgrid design team has a comprehensive understanding of P3 structures and working experience with third-party ownership/operations structures for energy projects. NRG has successfully completed several operational microgrid projects for host customers as described in Section 3.3.5, and Burns has participated in several P3 projects 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 construction and facilitate ownership and operation of distributed generation resources central to the microgrid.

3.4.14 – Has the market been identified and characterized?

The market of private energy companies capable of providing a P3 – DBOOM solution has been identified and is well understood by the Long Beach microgrid's development and design team.

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 600 kW of base-load electric sales (CHP, fuel cells), with a relatively smaller amount of renewable electricity sales from the solar PV systems (300 kW in aggregate). Sales of baseload and solar electricity could earn gross annual revenues of approximately $571,000 based on preliminary modeling (i.e. DER-CAM simulations of output for each resource type multiplied by electric rate). This amount does not include any savings that would accrue to the off-taker participants, but it is expected that a negotiated discount to current/projected business-as-usual energy costs will be necessary to incentivize the participants. Additional revenues are foreseen from participation in NYISO demand response and energy and ancillary services markets, subject to current/future market design rules.

The specific contractual arrangements between a third-party services provider and customer participants will be further discussed and negotiated in the detailed design and structuring phases; revenues would accrue to the microgrid owner via a pricing mechanism detailed in power purchase and/or energy services agreements that may include a combination of fixed and variable pricing components as well as a reliability/resiliency and/or subscription fee for premium energy services.

A sample pricing structure could be comprised of the following components: (i) electricity, (ii) hot water, (iii) emergency power, (iv) fixed O&M, (v) variable O&M, (vi) fuel energy, (vii) purchased power from the grid, and (viii) resiliency or subscription fees. The first three pricing components, along with the resiliency or subscription fees, would cover debt service and fees (if applicable), upfront and on-going capital recovery, and a reasonable return on equity. Fixed O&M would cover the cost of property taxes, insurance, billing & administration, etc., while variable O&M would cover maintenance, repairs, water, sales & use tax (if applicable), etc. Fuel energy will represent recovery of costs for commodity, transportation, and emissions. This fuel energy charge would typically be based on billing heat rate guarantees for CHP, fuel cells, and emergency power and the cost of delivered fuel. The expected solar PV pricing under an ESA/PPA would be in $/kWh on the generation with a reasonable annual inflation adjustment factor.

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 future 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. The proposed 150 kW solar PV systems at the Ice Arena and Channel Park Homes will take advantage of net metering.

In addition, PSEG-LI recommended incentives to install CHP for systems of 1.3 MW or below in the Utility 2.0 Long Range Plan Update Document dated October 6, 2014. Systems of this size on Long Island are currently excluded from the CHP program (PON 2568) offered by NYSERDA. Although the actual incentive structure would be determined through further information gathering and analysis, PSEG-LI proposed a combination of capacity incentive (paid upon achieving certain milestones) and production incentive (during the first 18 months of operation) to support projects. PSEG-LI also indicated that it would consider the critical nature of the facility in selecting projects for incentive funds.

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 fully installed capital cost of the proposed microgrid is estimated to be approximately $8 million before rebates and incentives, plus a $2 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

$1,017,500, with most of the costs related to variable O&M. Fixed O&M costs are currently estimated at $40,000 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
100kW CHP Unit	$0.4	25	For Ice Arena/Recreation Center
250kW NG Generator	$0.6	25	For Additional Feeder Load
500kW Fuel Cell	$3.5	20	To be located at the WWTP
200kW Solar/Storage	$0.5	20	For Channel Park Homes
200kW Solar/Storage	$0.5	20	For Ice Arena
Transformers	$0.6	30	Distribution Transformers
LV Paralleling Equipment	$1.0	30	Equipment to connect fuel cells to bus
Cabling	$0.6	30	Connecting locations, including directional boring
Communication Backbone	$0.5	30	Microgrid Controllers
Subtotal - Capital Costs	$8.2		
Initial Planning & Design	$2.0		Project Design, Permitting, Financing
Total	$10.2		

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

The P3-DBOOM 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 third-party owner and capital provider is reasonably assured of a return of and on investment, assuming fulfillment of the party's obligations under the contract. For electric commodity, the agreement will allow the third-party owner to increase electric rates if the utility rates or on-going costs (including fuel) increase, while still delivering a level of energy cost savings, in addition to the benefits of increased reliability/resiliency and lower emissions, for the microgrid off-takers compared to default utility tariff rates. This additional revenue will help protect the third-party owner against unforeseen circumstances and costs.

The P3-DBOOM business model also lowers the total amount of capital that has to be recovered and thus the pricing to end-users because the private entity is able to monetize tax credits and utilize 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 power generation projects wherein a construction loan and/or equity is used to fund construction costs that are then recovered along with a reasonable return on investment under the long-term energy off-take and services agreements. NRG is one such company that has sufficient liquidity on balance sheet to fund and deliver the proposed microgrid development and construction project, assuming it meets corporate investment criteria and receives required approvals for the allocation of funds.

NRG has successfully raised financing for construction projects in the last several years that range in size from large and small utility scale to distributed and residential scale. NRG has financed 3,700+ net MW of development projects on a non-recourse basis, resulting in over $7 billion of project debt financing at competitive terms. NRG has experience structuring and closing various types of financial arrangements that optimize the economic viability of projects with unique or complex features.

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 proposed project ownership structure is based on 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 partner, such as a specialty equipment vendor, the lead technical services/engineering firm, or the host customer. For the Long Beach microgrid, the primary owner is expected to be a third party firm, which would be selected through the City of Long Beach's contract procurement process. For the Fuel Cell unit, a key vendor partner might be Bloom Energy or FuelCell Energy.

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?

The primary owner of the Long Beach microgrid is expected to be a third party, such as NRG, subject to procurement policy requirements of the customer participants and future competitive solicitations for services as may be required under law. NRG is capable of and interested in serving in such a role for the Long Beach microgrid customer participants. If selected in the future as the project owner, NRG would establish a single purpose, project-specific limited liability company that would hold and own project contracts, assets, and property, including the long-term agreements referenced in Section 3.1.7. This special purpose entity would most likely be a wholly-owned project subsidiary of NRG, or it could be majority-owned by NRG with minority equity ownership encouraged from microgrid customer participants or other strategic partners. Alternatively, the City of Long Beach and/or other customer participants may elect to take a sole or majority ownership interest in the microgrid project company and then solicit additional investors as needed as well as a third party to operate the system and provide on-going O&M services.

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 Long Beach microgrid will utilize existing land and roof space to accommodate the DER equipment. The participant off-takers - the City of Long Beach, Long Beach Housing Authority, and MTA LIRR - all own their properties, which serve as the sites for the proposed microgrid DER. The owner of the microgrid is expected to be a third party, which would undertake to secure use of the available space through site access and control agreements with the owners, or potentially the City of Long Beach and/or other customer participants. Upon establishing the technical and commercial feasibility, the parties expect to commence discussion of commercial terms for further phases of work on the project, including a conversation on the potential for future site control through lease, purchase and/or option agreements.

The 2016 Local Waterfront Revitalization Program (LWRP) and Comprehensive Plan (CP) update process is underway with the Long Beach community and its officials.[4] City officials have proposed longer-term re-development concepts for the Central Business District and Bayfront areas that the microgrid project team members will further discuss with key stakeholders as the LWRP & CP process unfolds. The City confirmed that the future footprint of the Waste Water Treatment Plant, if operations are consolidated at the Bay Park Sewer Treatment Plant and the Long Beach facility becomes a pumping station, can incorporate the proposed 500 kW fuel cell. Overall, the proposed microgrid project aligns closely with the City's vision statement from its NY Rising Community Reconstruction Plan to "develop a vibrant, resilient, sustainable and green community" and also the "Creating Resilience" theme of the current planning initiative.

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, such as solar PV generation, from the private party to the public hosts or off-takers are commonplace 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.

[4] Long Beach Listens, Comprehensive Plan/LWRP. <http://www.longbeachlistens.com/comprehensive-plan-and-lwrp2.html>.

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?

The development and implementation of "first-of-a-kind" community-based microgrids that are both reliable and economic will involve complexity and challenges. For example, state legislatures and public utility commissions may need to act to resolve legal issues related to local distribution utility exclusive franchise rights and whether microgrids serving multiple, unaffiliated end users fall under public utility regulations. If a new line is built without PSEG-LI's involvement, the microgrid would need regulatory approval to cross public rights of way. The following issues may arise due to a utility's involvement in microgrid projects: 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 DER (LMP+D).

NRG, Burn Engineering, and GE EC are well-positioned to work cooperatively and constructively with state regulators, utilities, communities, customers, and other stakeholders to lead and support the project team through the NY Prize Competition process (if selected in the future under the City of Long Beach's contract procurement process), craft workable business models and structures within which DER and microgrids can operate, and increase the likelihood of successful development and implementation of a Long Beach microgrid project, thus advancing the objectives of NY Prize and NY State's REV policy initiative.

In addition, the expected use of capital from a third party, such as NRG, and/or customer participants will prove out the commercial viability of the project and minimize the risk of cost assignment to LIPA's rate base customers. However, where non-participating customers will benefit from community facilities, emergency services, and/or essential retail or commercial services served by a public purpose microgrid, it may be appropriate to socialize a portion of the project's costs through LIPA's rates or other form of cost recovery under REV, as determined by the New York Public Service Commission ("PSC").

Given the complexities involved in the design, engineering, development, and implementation of reliable and economical microgrid systems, communities and other customer participants are encouraged to partner with energy service companies, such as NRG and its project design partners, which have a proven track record and the necessary financial, technical, and regulatory expertise. As a competitive energy services provider and third-party owner/operator of DER, NRG is leading the transition to a clean renewables-driven, increasingly distributed, and grid-resilient future.

Section 4 – Microgrid Benefit-Cost Analysis

Task 4.0 – Benefit-Cost Analysis Summary Report

PROJECT OVERVIEW

As part of NYSERDA's NY Prize Community Grid Competition, the City of Long Beach and its partners have proposed development of a microgrid that would serve a number of facilities within the city, including:

- City of Long Beach City Hall, Police and Fire Headquarters;
- City of Long Beach Water Pollution Control Plant;
- City of Long Beach Park Place Water Purification Plant;
- Long Beach Housing Authority's Channel Park Homes (~500 residents in subsidized family housing units) and Michael Valente Apartments (~100 residents in rental units for low-income senior and the disabled);
- City of Long Beach Ice Arena and Recreation Center;
- MTA Long Island Rail Road (LIRR) Long Beach Station; and
- Additional feeder load (approximately 150 residences and 20 small commercial entities), including the Magnolia Senior Community Center and Park Avenue Extended Care Facility.

The microgrid would incorporate five new distributed energy resources (DER): a 100 kW combined heat and power (CHP) natural gas generator; a 500 kW natural gas-powered fuel cell; two solar photovoltaic (PV) plus battery storage installations (400 kW in aggregated); and one 250 kW natural gas-powered generator. The microgrid would also incorporate an existing 660 kW generator converted to operate as a dual fuel unit. Combined, these DER have a capacity of approximately 1.9 MW.

To assist with completion of the project's NY Prize Stage 1 feasibility study, Industrial Economics, Incorporated (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 (BCA) 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 societal costs and benefits of developing community 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.[5] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the present value of the project's costs and

[5] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO_2 emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO_2, NO_x, and PM2.5, 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.]

benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[6]

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

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.9 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.9 DAYS/YEAR
Net Benefits - Present Value	-$8,460,000	$675,000
Benefit-Cost Ratio	0.5	1.0
Internal Rate of Return	N/A	7.7%

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)

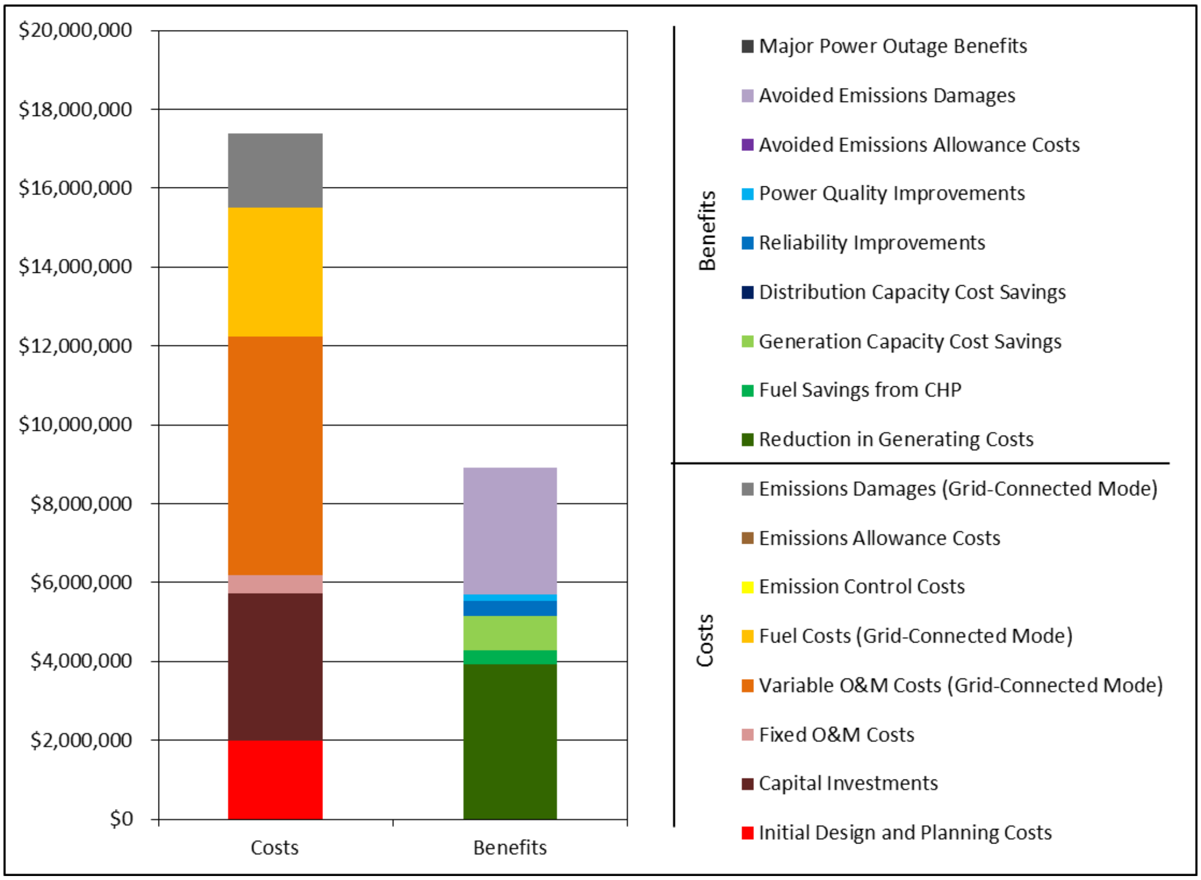


Table 2 – Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$2,000,000	$176,000
Capital Investments	$3,730,000	$286,000
Fixed O&M	$453,000	$40,000
Variable O&M (Grid-Connected Mode)	$6,050,000	$534,000
Fuel (Grid-Connected Mode)	$3,280,000	$290,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,860,000	$122,000
Total Costs	**$17,400,000**	
Benefits		
Reduction in Generating Costs	$3,930,000	$347,000
Fuel Savings from CHP	$359,000	$31,700
Generation Capacity Cost Savings	$859,000	$75,800
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$392,000	$34,600
Power Quality Improvements	$154,000	$13,600
Avoided Emissions Allowance Costs	$1,970	$174
Avoided Emissions Damages	$3,230,000	$211,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$8,930,000**	
Net Benefits	**-$8,460,000**	
Benefit/Cost Ratio	**0.5**	
Internal Rate of Return	**N/A**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the proposed microgrid. The project team estimates initial design and planning costs to be $2.0 million. The present value of the project's capital costs is estimated to be $3.7 million, including costs associated with the installation of the CHP unit, transformers, fuel cell paralleling equipment, cabling, communication backbone, and 250 kW natural gas generator. The project team also estimates $40,000 a year in fixed O&M costs associated with software, licensing, and miscellaneous expenses. The present value of these fixed O&M costs is $453,000 over 20 years.

Variable Costs

The project team assumed power purchase agreement (PPA) structures for both the 500 kW fuel cell and the two solar plus storage installations, which would be owned and operated by a third party. To facilitate analysis, the delivered prices of the PPA structures are specified as variable costs rather than capital costs.[7] In addition to these costs, the project team reported O&M costs for the CHP unit and the 250 kW natural gas generator. In total, these costs have a present value of approximately $6.1 million. The model also estimates the cost of fuel. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's State Energy Plan (SEP), adjusted to reflect recent market prices.[8] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $3.3 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the DER that serve the microgrid, 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. The majority of these damages are attributable to emissions of CO2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $1.9 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. For the City of Long Beach microgrid project, a major source of cost savings would be a reduction in demand for electricity from bulk energy suppliers, with a resulting reduction in generating costs. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $3.9 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based.

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[7] The value of the PPAs likely reflects the third party's financing costs and return on investment. If this is the case, the PPAs will overstate the true social cost of the fuel cell and solar plus storage installations.

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

The CHP system at the Ice Arena would also provide savings on heating costs due to a reduction in fuel consumption; the present value of these savings is approximately $360,000. These changes would curtail emissions of CO2, SO2, NOx, and particulate matter from the Ice Arena's heating system and from bulk energy suppliers, yielding emissions allowance cost savings with a present value of approximately $2,000 and avoided emissions damages with a present value of approximately $3.2 million.[9]

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.[10] The project team estimates the project's impact on demand for generating capacity to be approximately 1.0 MW per year. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $860,000 over a 20-year operating period. The project team does not anticipate any impact on distribution capacity requirements.

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

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $35,000 per year, with a present value of approximately $390,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption

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

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

Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[11]

- System Average Interruption Frequency Index (SAIFI) – 0.72 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 81.6 minutes.[12]

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.[13] 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 estimate of the number of power quality events that development of the microgrid would avoid each year. In the case of the City of Long Beach microgrid project, the project team has indicated that approximately five power quality events would be avoided each year. The team notes that the Long Beach Ice Arena and the residential units at Channel Park Homes would experience these improvements in power quality. Given this assumption, the model estimates the present value of this benefit to be approximately $154,000 over a 20-year operating period.

[11] www.icecalculator.com.

[12] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values, excluding major storm events, for PSEG Long Island.

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

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.5; i.e., the estimate of project benefits is approximately 50 percent of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[14,15]

As noted above, the City of Long Beach microgrid project would serve both residential and commercial customers, in addition to several critical police, fire, wastewater, and water facilities. The project's consultants indicate that at present, the City Hall, Wastewater Treatment Plant, and Water Purification Plant facilities are the only facilities with diesel backup power. The backup generator at City Hall, which houses the community's Police and Fire Department Headquarters, has sufficient capacity to support only 30 percent of normal levels of service; operation of this generator costs approximately $210 per day.[16] In contrast, backup generation at the Wastewater Treatment Plant and Water Purification Plant has sufficient capacity to support ordinary levels of service; backup generation for each of these facilities costs approximately $1,800 and $1,200 per day, respectively. The remaining facilities – the Channel Park Homes development, the Long Beach Ice Arena and Recreation Center, the MTA LIRR Long Beach Station, and the additional residential and commercial components of the feeder load – could maintain service through the

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

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

[16] The project team notes that costs for the operation of existing backup generation would be minimal. Since the project team's estimates did not include fuel costs, IEc sums the costs provided by the project team with a separate calculation of fuel costs, based on the fuel consumption specifications provided by the project team.

use of portable generators; the costs associated with doing so are listed in Table 3. In the absence of backup power – i.e., if backup generation failed and no replacements were available – all facilities with the exception of the Channel Park Homes development, the MTA LIRR Long Beach Station, and the residential component of the feeder load would experience a 100 percent loss in service (see Table 3).

Table 3 – Backup Power Costs and Level of Service, Scenario 2

FACILITY NAME	ON-GOING COST OF MAINTAINING SERVICE WITH PORTABLE GENERATOR ($/DAY)	PERCENT LOSS IN SERVICE WHEN BACKUP GENERATION IS NOT AVAILABLE
City Hall, Police and Fire Headquarters[17]	NA	100%
Water Pollution Control Plant[18]	NA	100%
Park Place Water Purification Plant[19]	NA	100%
Channel Park Homes	$4,750	50%
Long Beach Ice Arena and Recreation Center	$2,000	100%
MTA LIRR Long Beach Station	$750	75%
Additional Feeder Load-Residential Component	$1,000	50%
Additional Feeder Load-Commercial Component[20]	NA	100%

The information provided above serves as a baseline for evaluating the benefits of developing a microgrid. Specifically, the assessment of Scenario 2 makes the following assumptions to characterize the impacts of a major power outage in the absence of a microgrid:

- The City Hall, Wastewater Treatment Plant, and Water Purification Plant facilities would rely on their existing backup generators. City Hall would be able to maintain operations at 30 percent of normal levels, while the Wastewater Treatment Plant and Water Purification

[17] This facility is already equipped with a backup generator. As the baseline for this analysis, IEc assumes that if the existing backup generator fails (15 percent failure rate), the facility would experience a total loss of service.
[18] This facility is already equipped with a backup generator. As the baseline for this analysis, IEc assumes that if the existing backup generator fails (15 percent failure rate), the facility would experience a total loss of service.
[19] This facility is already equipped with a backup generator. As the baseline for this analysis, IEc assumes that if the existing backup generator fails (15 percent failure rate), the facility would experience a total loss of service.
[20] As indicated by the site's project team, both the residential and commercial components of the feeder load could be maintained with portable generation. The site team estimates that the total cost of this generation for both residential and commercial entities would be $1,000/day. To avoid double counting this cost, the analysis assigns the $1,000/day value to the residential component of the feeder load.

Plant would each maintain full capabilities while their backup generators operate. If the backup generators fail, all three of these facilities would experience a total loss of service.

- The Channel Park Homes development, the Ice Arena and Recreation Center, the MTA LIRR Long Beach Station, and the commercial and residential components of the feeder load would rent portable generators, maintaining full capabilities while these generators operate. Table 3 shows the assumed loss in service for each facility should these generators fail.

- In all cases, the supply of fuel necessary to operate backup generators would be maintained indefinitely.

- At each facility, there is a 15 percent chance that the backup generator would fail.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities of interest. The analysis employs the approach described below to estimate these costs.

- The impact of a loss in the city's water and wastewater treatment services, police services, fire services, and emergency medical services is estimated using standard FEMA methodologies.

- For residential facilities, the analysis assumes that the residents being served would be left without power; the impact is valued as a social welfare loss using standard FEMA methods.

- For the assisted living component of the Channel Park Homes, IEc calculates the daily value of service by multiplying the estimated annual cost of assisted living in the Long Island area ($67,500 per resident) by the 500 residents served by the facility.[21] IEc then converts this annual value to a daily value of approximately $93,000.

- For the MTA LIRR Long Beach Station and the Ice Arena and Recreation Center, the cost of an interruption in electrical service is estimated using the U.S. Department of Energy's ICE Calculator.[22] The daily costs for these facilities are approximately $58,000 and $107,000, respectively.

- For the commercial component of the feeder load, IEc also estimates the cost of an interruption in electrical service using the ICE calculator.[23] Since data are not available regarding the percentage of these entities involved in the construction or manufacturing

21 https://www.genworth.com/corporate/about-genworth/industry-expertise/cost-of-care.html.

22 http://icecalculator.com/.

23 In developing this estimate, IEc assumes that commercial and industrial customers account for approximately 69.2 percent of the total load, as specified by the project team.

industries, IEc uses the default values for New York State provided in the ICE calculator interface. IEc also assumes that none of these commercial entities have existing backup power, as specified by the site contact. With these assumptions, the estimated cost of an outage for the commercial component of the feeder load is approximately $148,000 per day.

Summary

Figure 2 and Table 4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.9 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2 – Present Value Results, Scenario 2 (Major Power Outages Averaging 0.9 Days/Year; 7 Percent Discount Rate)

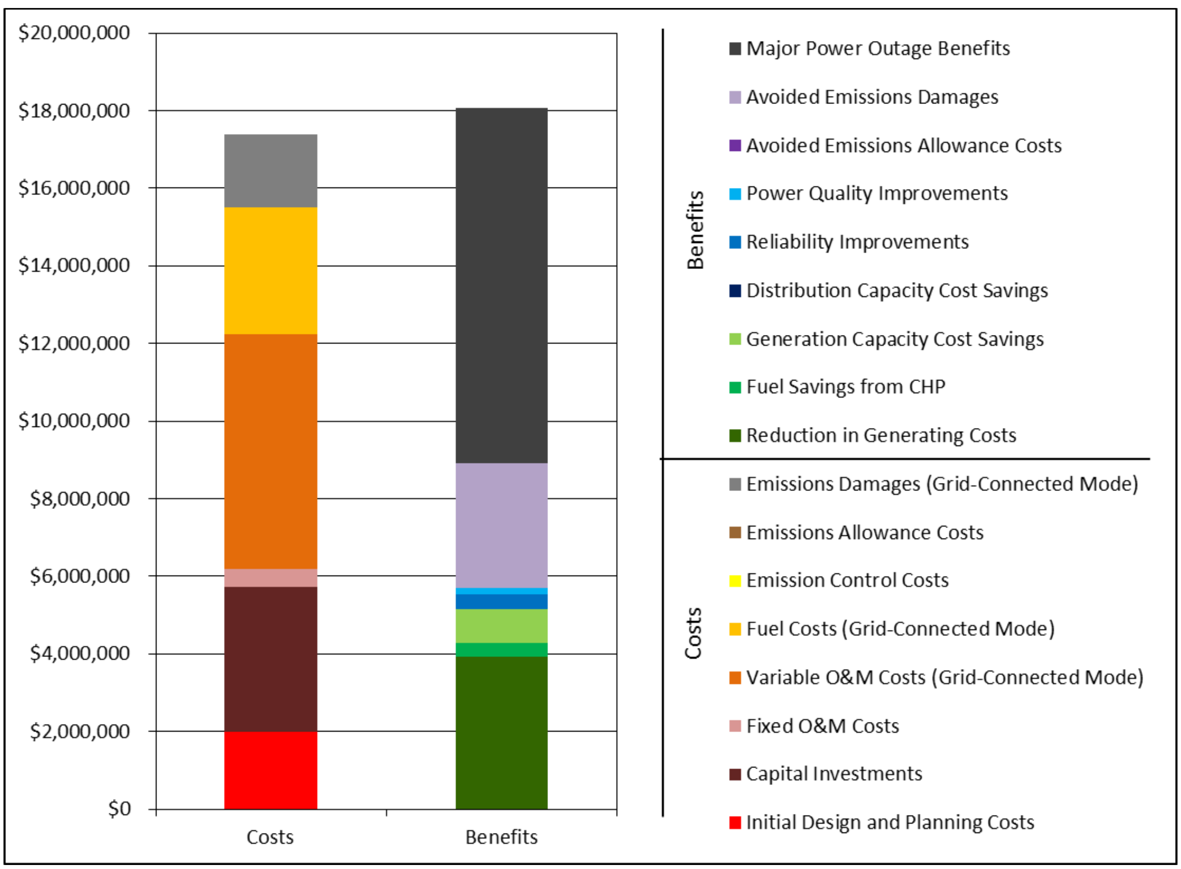

Table 4 – Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.9 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$2,000,000	$176,000
Capital Investments	$3,730,000	$286,000
Fixed O&M	$453,000	$40,000
Variable O&M (Grid-Connected Mode)	$6,050,000	$534,000
Fuel (Grid-Connected Mode)	$3,280,000	$290,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,860,000	$122,000
Total Costs	**$17,400,000**	
Benefits		
Reduction in Generating Costs	$3,930,000	$347,000
Fuel Savings from CHP	$359,000	$31,700
Generation Capacity Cost Savings	$859,000	$75,800
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$391,000	$34,500
Power Quality Improvements	$154,000	$13,600
Avoided Emissions Allowance Costs	$1,970	$174
Avoided Emissions Damages	$3,230,000	$211,000
Major Power Outage Benefits	$9,130,000	$806,000
Total Benefits	**$18,100,000**	
Net Benefits	**$675,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.7%**	

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 (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
City Hall, Police and Fire Dept. Headquarters	Large Commercial/Industrial (>50 annual MWh)	Office Building	All other industries	993.185	.32573	100%	24
Water Pollution Control Plant	Large Commercial/Industrial (>50 annual MWh)	Wastewater Treatment Plant	All other industries	987.720	.18386	100%	24
Park Place Water Purification Plant	Large Commercial/Industrial (>50 annual MWh)	Water Treatment Plant	All other industries	1,463.7	.25887	100%	24
Channel Park Homes (LBHA)	Residential	Public Housing / Apartments	Residential	1,206.481	.2175	100%	24
Long Beach Ice Arena and Recreation Center	Large Commercial/Industrial (>50 annual MWh)	Indoor Ice Rink and Recreation Center	All other industries	1,360.357	.40239	100%	24
Long Island Railroad (LIRR)	Large Commercial/Industrial (>50 annual MWh)	Train Station	All other industries	332.76	.066	100%	24
Additional Feeder Load	Mix of Commercial and Residential	Multiple Customers	All other industries	1,322.824	.284	100%	24

Task 4.2 – Characterization of Proposed Distributed Energy Resources

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
Combined Heat & Power (CHP) NG Generator	Long Beach Ice Arena and Recreation Center	Natural Gas	.100	768.252	2.4	12.85	MMBtu/MWh
500 kW Fuel Cell	Sited at WWTP to supply City Hall, Police/Fire Dept. Headquarters, LIRR Station, and WWTP	Natural Gas	.500	3,157.98	12	7.26	MMBtu/MWh
250 kW NG Genset	Park Place Water Purification Plant (for Additional Feeder Load)	Natural Gas	.250	788.4	6	12.18	MMBtu/MWh
660 Dual Fuel Genset	Park Place Water Purification Plant	Diesel/Natural Gas	.660	1,130.04	15.84	8.15	MMBtu/MWh
Solar PV	Channel Park Homes (LBHA)	Solar	.150	550.128	1.5072	0	N/A
Battery	Channel Park Homes (LBHA)	Solar	.050	23.3	0.06384	0	N/A
Solar PV	Ice Arena	Solar	.150	550.128	1.5072	0	N/A
Battery	Ice Arena	Solar	.050	23.3	0.06384	0	N/A

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?
Combined Heat & Power (CHP) NG Generator	Long Beach Ice Arena and Recreation Center	.100	☐ Yes
500 kW Fuel Cell	City Hall, Police and Fire Dept. Headquarters, LIRR Station, and Water Pollution Control Plant	.500	☐ Yes
250 kW NG Genset	Park Place Water Purification Plant (for Additional Feeder Load)	.250	☐ Yes
660 kW Dual Fuel Genset	Park Place Water Purification Plant	.660	☒ Yes
Solar PV/Storage	Channel Park Homes (LBHA)	.080	☐ Yes
Solar PV/Storage	Ice Arena	.080	☐ Yes

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently
City Hall, Police and Fire Dept. Headquarters, LIRR Station, and Water Pollution Control Plant	.500	0
Park Place Water Purification Plant	.660	.660
Channel Park Homes (LBHA)	.080	0
Long Beach Ice Arena and Recreation Center	.180	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, PSEG-LI'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.

A CHP unit is planned for the Ice Arena and Recreation Center. Energy savings relative to current heating systems are projected to be approximately 4,633 MMBtu per year.

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 only the natural gas generators, rather than all DER in the microgrid.

Emissions Type	Emissions per MWh	Unit
CO_2	.5488	Metric tons/MWh
SO_2	0	N/A
NO_x	.0215	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 $8 million before rebates and incentives, plus a $2 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 $1,017,500, with most of the costs related to variable O&M. Fixed O&M costs are currently estimated at $40,000 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
100kW CHP Unit	$0.4	25	For Ice Arena/Recreation Center
250kW NG Generator	$0.6	25	For Additional Feeder Load
500kW Fuel Cell	$3.5	20	To be located at the WWTP
200kW Solar/Storage	$0.5	20	For Channel Park Homes
200kW Solar/Storage	$0.5	20	For Ice Arena
Transformers	$0.6	30	Distribution Transformers
LV Paralleling Equipment	$1.0	30	Equipment to connect fuel cells to bus
Cabling	$0.6	30	Connecting locations, including directional boring
Communication Backbone	$0.5	30	Microgrid Controllers
Subtotal - Capital Costs	**$8.2**		
Initial Planning & Design	$2.0		Project Design, Permitting, Financing
Total	**$10.2**		

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
100kW CHP Unit	Ice Arena/Rec Center	Indefinitely	1,116	scfh
500kW Fuel Cell	City Hall/Police & Fire HQ	Indefinitely	3,560	scfh
660kW Dual Fuel Generator (NG Usage)	Water Purification Plant	14	1,241,025.7	Cubic feet
250kW NG Genset	Water Purification Plant (for Additional Feeder Load)	Indefinitely	2,983	scfh
660kW Dual Fuel Generator (Diesel Usage)	Water Purification Plant	14	4,173.12	Gallons
150kWh Solar/Storage	Channel Park Homes	Storage	0	N/A
150kWh Solar/Storage	Ice Arena/Rec Center	Storage	0	N/A

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		
City Hall, Police/Fire Dept. HQ	Diesel	0.100	50	1.2	15	MMBtu per day	1	30
Wastewater Treatment Plant	Diesel	0.450	100	10.8	94	MMBtu per day	1	30
Water Purification Plant	Diesel	0.660	100	15.84	146	MMBtu per day	1	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?
City Hall, Police/Fire Dept. HQ	Ongoing Measures	OEM Measures	50,000	$/month	In event of natural disaster
Wastewater Treatment Plant	Ongoing Measures	OEM Measures	52,950	$/month	In event of natural disaster
Water Purification Plant	Ongoing Measures	OEM Measures	40,630	$/month	In event of natural disaster

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?
City Hall, Police/Fire Dept. HQ	One-Time Measures	Hooking up portable generator	1,500	$	Year Round
City Hall, Police/Fire Dept. HQ	Ongoing Measures	Daily cost of portable generator	2,000	$/day	Year Round
City Hall, Police/Fire Dept. HQ	Ongoing Measures	OEM Measures	50,000	$/month	In event of natural disaster
Wastewater Treatment Plant	One-Time Measures	Hooking up portable generator	1,000	$	Year Round
Wastewater Treatment Plant	Ongoing Measures	Daily cost of portable generator	1,000	$/day	Year Round
Wastewater Treatment Plant	Ongoing Measures	OEM Measures	52,950	$/month	In event of natural disaster
Water Purification Plant	One-Time Measures	Hooking up portable generator	1,000	$	Year Round
Water Purification Plant	Ongoing Measures	Daily cost of portable generator	1,000	$/day	Year Round
Water Purification Plant	Ongoing Measures	OEM Measures	40,630	$/month	In event of natural disaster
Long Beach Station (MTA LIRR)	One-Time Measures	Hooking up portable generator	500	$	Year Round
Long Beach Station (MTA LIRR)	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round
Rec Center/Ice Arena	One-Time Measures	Hooking up portable generator	1,500	$	Year Round
Rec Center/Ice Arena	Ongoing Measures	Daily cost of portable generator	2,000	$/day	Year Round
Channel Park Homes	One-Time Measures	Lost Rent Payments	160,000	$/month	During extended loss of electric utility service

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Channel Park Homes – 1 Azalea Court	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 1 Azalea Court	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 3 Azalea Court	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 3 Azalea Court	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 1 Community Drive	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 1 Community Drive	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 6 Birch Court	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 6 Birch Court	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 7 Birch Court	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 7 Birch Court	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 9 Oak Court	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 9 Oak Court	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 10 Sycamore Court Bldg 11	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 10 Sycamore Court Bldg 11	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 10 Sycamore Court Bldg 10	One-Time Measures	Hooking up portable generator	350	$	Year Round
Channel Park Homes – 10 Sycamore Court Bldg 10	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
Channel Park Homes – 5 Dogwood Court	One-Time Measures	Hooking up portable generator	500	$	Year Round
Channel Park Homes – 5 Dogwood Court	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round

Task 4.6 – Services Supported by the Microgrid

The total population served by Police/Fire Departments in Long Beach is approximately 34,000 permanent residents (population swells to ~55,000 during the summer months) in a Metropolitan Statistical Area. The nearest alternative fire station and EMS provider are 2 miles away. For police, fire, and emergency medical services during a power outage, the average response time would not be expected to decline if backup generators are functioning but would decline by ~75% when backup generation is not available. The Waste Water Treatment and Water Purification Plants serve the entire population of Long Beach, both businesses and residential customers.

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.
City Hall, Police/Fire Dept. HQ	70%
Wastewater Treatment Plant	0%
Water Purification Plant	0%
Rec Center/Ice Arena	N/A
Channel Park Homes	N/A
LIRR Station	N/A

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
City Hall, Police/Fire HQ	100%
Wastewater Treatment Plant	100%
Water Purification Plant	100%
Rec Center/Ice Arena	100%
Channel Park Homes	50%
LIRR Station	75%

Section 5 – Feasibility Study Results

Superstorm Sandy had a devastating impact on the City of Long Beach. It destroyed or badly damaged critical infrastructure, crippled the City's ability to provide essential basic services, including water purification, and left tens of thousands of people without power, including vulnerable populations such as the elderly and low-income. In total, more than $200 million of damage was inflicted on city facilities and infrastructure, and total estimated damages to all of Long Beach likely exceeded $1 billion.

The proposed microgrid would enable many of the critical services impacted during and after Superstorm Sandy to remain intact and operational in the event of a protracted power failure. The microgrid is designed to provide significantly enhanced power reliability and resilience based on the use of proven technologies such as fuel cells, combined heat and power, solar PV, and battery storage.

In total, the proposed microgrid comprises 33 acres, and the close proximity of so many critical facilities and services limits the need to rely on PSEG-LI infrastructure or undertake an extensive and costly build-out of new distribution lines to support the proposed microgrid. Available land, open rooftops, and very favorable constructability make it possible to cost-effectively deploy a diverse array of zero/low carbon distributed energy resources. These factors together with a clear, concentrated need for enhanced resilience help to make the proposed City of Long Beach microgrid a compelling "public purpose" microgrid that will yield day-to-day economic and environmental benefits when the sun is shining, and enable critical, life-protecting benefits and services when the grid is down.

The Long Beach microgrid will provide power for a number of critical and community support facilities primarily using existing utility infrastructure. The Long Beach microgrid will connect the Municipal Building (houses City Hall, Police and Fire Department Headquarters), the Waste Water Treatment Plant, the Water Purification Plant, the Channel Park Homes and Michael Valente Senior Apartments (Long Beach Housing Authority), and the Ice Arena and Recreation Center.

In order to leverage the existing electric distribution system, the project team decided to expand the scope of the Long Beach microgrid to include additional commercial and residential establishments located on the same feeders as the critical loads. Since these loads are clustered in the same feeders as the designated critical facilities, it was determined that it would be relatively straightforward to connect these customers to the microgrid circuit and supply them with power in the event of an outage to the main grid. Incorporating these loads not only provides additional resilience benefits, it also obviates the need to isolate these facilities from the main grid and other local critical loads in the event of an outage.

The proposed Long Beach microgrid features a diverse array of distributed energy resources, including an existing 660 kW diesel unit converted to operate as a dual fuel unit, a new 100 kW CHP unit, a new 500 kW fuel cell, and a new 250 kW natural gas engine. Renewable resources include 150 kW of solar PV at the Channel Park Homes and 150 kW of solar PV at the Ice Arena. Both of these solar PV systems would be new, and each will be supplemented with 50 kW battery energy storage systems. Total nameplate capacity of the microgrid is 2,540 kW. The selection, sizing, configuration, and optimization of DER assets was completed using Lawrence Berkeley Lab's DER-CAM tool supplemented by other tools and best engineering practices. Site surveys and "constructability" assessments provided further guidance.

During normal operations, the additional generation installed for the microgrid will continue to operate, reducing the peak demand and energy cost of the facilities. During emergency conditions, once the DER restart and stabilize, the microgrid will be able to meet both base and peak loads.

The proposed DBOOM business model 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 and/or energy services agreements with qualified off-takers. This enhances the project's overall appeal and financial feasibility to the City of Long Beach and other microgrid participants.

The project design team offers the following conclusions and recommendations for proceeding with the Long Beach project and promoting other microgrid projects:

Conclusions

1. *A Long Beach microgrid would provide significant economic, environmental, and societal benefits.* These benefits would accrue to the people and City of Long Beach, first responders and emergency personnel, the LIRR and its commuters, vacationers and seasonal residents, and Long Island in general. In particular, the vulnerable population of residents at the Channel Park Homes, Michael Valente Apartments, and Park Avenue Extended Care Facility stand to benefit in the event of power outage.
2. *The Long Beach community microgrid is technically feasible, but will require government subsidies and/or other incentives to attract private funding for build-out in its proposed form.* Incentives could include NYSERDA grants, favorable gas tariffs, and/or credits for DER generation or capacity. Some level of incentives is generally needed for community microgrids on Long Island, since the zonal prices for energy and capacity alone are not sufficient to justify investment in DER.

3. *Microgrid project design and development is complex and costly.* The costs to obtain, compile, and analyze data from multiple facilities, design the DER and controls, and develop a project, are 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, such as the water and wastewater treatment facilities, during blue sky days.
5. *Public-private partnerships are a viable and important business model for community microgrids*. Specifically, P3 structures that shift financial and operational risk away from government and local entities that lack the capital as well as technical and operational expertise to design, build, own, operate, and maintain microgrids can accelerate the deployment of microgrids.
6. *Microgrids will benefit utility partners.* Microgrids will benefit electric utilities by reducing the need for peak power facilities and/or new transmission and distribution infrastructure, providing more reliable and resilient power for utility customers. Gas-fired DER provide additional demand for gas distribution and supply companies; also, new gas supply infrastructure needed to serve DER can stimulate new demand from other customers.
7. *The Long Beach microgrid will benefit PSEG-LI.* PSEG-LI operates a 4160V underground and above ground distribution network. This network, due to its lower than normal voltages and higher current, introduces significant impedances losses into the electric power system. Reducing the load on the feeder network will serve PSEG-LI by lessening the current on the cables, decreasing the subsequent heat losses, and increasing the overall efficiency of the system. Load reduction will directly lead to an increase in the projected cable lifespan, and help alleviate congestion issues on the 4160V network should Long Beach have an increase in electrical demand.
8. *The Long Beach microgrid will advance the objectives of the REV policy initiative.* The proposed microgrid in Long Beach will incorporate renewable energy, energy storage, and an advanced control system, provide improved efficiency and enhanced resiliency, offer significant choice and control to customer participants, and prove out an innovative business model, all of which is exactly in line with the REV objectives.

9. *The Long Beach microgrid could also be a candidate under the NYISO Pilot Framework.*[24] NYISO will be exploring the use of Pilot Programs to test new energy technologies in support of REV demonstration projects. Challenges associated with microgrid wholesale market participation could be identified through this project, and needed market design changes may be identified. While there are no direct revenues from participation in the NYISO program, the technical support and engagement of NYISO may help identify and secure additional market revenue streams.

Recommendations

1. *The Long Beach microgrid project should proceed with design, development, and financing, with continued 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, negotiating Microgrid Energy Service Agreements (MESAs) with customers, arranging fuel supply contracts, obtaining construction bids and selecting an EPC contractor, refining the financial modeling and projections, identifying a project investor and/or lender, and completing project documentation and due diligence.
2. *NYSERDA should continue to promote microgrids.* NYSERDA should continue to provide financial and technical assistance for the development of community microgrids.
3. *NYSERDA should consider microgrid energy or capacity credits*. NYSERDA should consider providing microgrid energy credits and/or capacity payments ("MECs" or "MCAPs"), similar to RECs for renewable energy sources, to provide financial incentives for DER 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 community microgrids.
4. *Utilities should do more to help facilitate development of community microgrids*. Electric and gas utilities should evaluate new incentives for microgrids to reflect their financial and operational benefits. Electric utilities should also expedite measures to harden local distribution infrastructure to support microgrid projects, and facilitate interconnection policies to streamline deployment of DER. Gas utilities should offer favorable microgrid gas supply tariffs, and prioritize infrastructure improvements needed to serve microgrids.

[24] NYISO 2017 Project Candidates - "NYISO Pilot Framework" (Page 12 of 30). 30 June 2016. <http://www.nyiso.com/public/webdocs/markets_operations/committees/mc_bpwg/meeting_materials/2016-06-24/2017 Project Candidate Descriptions 2016_06_30_clean.pdf>.

5. *Continue the development of analytical tools for multi-resource, multi-customer projects*. Government entities should continue development of analytical tools, such as DER-CAM, for analyzing microgrids.
6. *Continue to pursue and implement legal, market, and/or regulatory changes that support the widespread consumer-driven deployment of microgrids in NY State.* The project team believes robust deployment of microgrids can be best accomplished through competitive development driven by customer engagement and value, and that microgrids can and should be financed by customers or by third parties. Based on "NRG's Response to Notice Soliciting Comments on Microgrids" (filed with the PSC on May 1, 2015), NRG offers the following three recommendations to help enable microgrid development:
    1) Just as the PSC has directed that utility ownership of DER should be very limited, the PSC should restrict utilities (and DSPs) in their ownership of microgrids in order to ensure that market-based solutions drive microgrid adoption. Keeping the burgeoning microgrid industry competitive will enable the robust deployment of microgrids and create a business environment in which competitive providers of microgrids can bring their innovation and private capital to bear on meeting customer and community objectives. Regulated utility ownership and control of microgrids would delay and constrain deployment, add to utility costs, and thus expose ratepayers and utility investors to excessive risk.
    2) Properly valuing and accounting for the multiple benefits a microgrid offers – to its individual customers, the community, the wholesale market, as well as to the distribution system – is a crucial element in ensuring their widespread adoption. Microgrids become more cost-effective if they are operated more frequently than just as a back-up solution, but this requires the development of markets and revenue generation opportunities that appropriately compensate microgrids for the services they provide. As envisioned under REV, an important role of the DSP will be to pay DER for the "value they provide to the grid… in fair and open markets." The DSP will serve as a means of providing a price signal for enhanced resiliency, delayed distribution upgrades, and other values that currently are not expressly valued in our energy infrastructure. Likewise, NYISO rules must enable participation by microgrids in the wholesale markets.
    3) PSC precedent allowing microgrid developers to connect adjoining or related facilities is well-established, but it would be helpful for developers if the PSC clarifies that related facilities are those that may cross a right of way as of right, without seeking an additional PSC ruling and running afoul of utility franchise laws. The ability to connect two or more related sites is extremely important in reducing customer costs, because spreading the fixed costs of a microgrid development across a wider array of customers and/or facilities can allow additional economies of scale and reduce costs for each participating customer.