19 - Brownsville Van Dyke Community (Brooklyn)

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Notice

Project: NY Prize Brownsville - Van Dyke Community-Owned Microgrid Feasibility Assessment

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0.0: Brownsville Microgrid Introduction

New York State continues to lead the nation in implementing innovative and sustainable energy policy, and the recent NYSERDA initiatives on the development of community grids is another exciting example of NY State's commitment to environmentally-responsible energy infrastructure development. BlocPower is honored to be selected to participate in the NY Prize competition for microgrid development technical assistance and is pleased to submit the following Final Written Report for the Brownsville Community-Owned Microgrid. BlocPower and our engineering partner, TRC Solutions, look forward to the benefits the microgrid will deliver to the underserved community of Brownsville, and we hope our innovative approach to engineering and financing, combined with our intent to leverage NY State Public Service Commission initiatives like "**Reforming the Energy Vision**", the **Brooklyn-Queens Demand Management Program**, and the **Community Distributed Generation Order** will deliver tangible and lasting economic, environmental, and social benefits to one of New York's poorest communities.

The microgrid design we are proposing for feasibility assessment funding would:

(1) Allow the local community to own a portion of the microgrid in combination with third party financiers
(2) Lower electricity costs for low-to-moderate income residential customers
(3) Provide cash flow to the New York City Housing Authority ("NYCHA") for internal building repairs
(4) Protect vulnerable seniors and children from the impact of climate-change-induced and grid-constraint-induced blackouts
(5) Create significant demand reduction for the local utility, Con Edison.

This microgrid will leverage a combination of distributed generation, energy storage, and microgrid control technology to dramatically improve energy resiliency for a core microgrid inside 6 blocks, and create options for an extended microgrid over a broader 20 block area of public multifamily housing (Brownsville NYCHA, Van Dyke NYCHA, Tilden NYCHA), private single family housing (Nehemiah Program), and several blocks of commercial buildings including a healthcare facility (Brownsville Multi-Service) in the heart of the Brooklyn-Queens Demand Management zone. By providing 8.7 MW of local distributed generation, the microgrid will provide power for the community within these 6 core blocks, and support full electrical loads at critical facilities (three NYC Office of Emergency Management "cooling centers", a public library, and a health care facility). The microgrid will also provide increased resiliency for the nearly 10,000 tenants in NYCHA housing and lower energy bills for the owners and residents of 4,500 single family affordable homes developed by the East Brooklyn Congregations and financed by NYC Department of Housing Preservation and Development.

Section 1 will provide a description of microgrid capabilities as designed by TRC. Microgrid capabilities were developed by the engineering team at TRC Solutions to reflect the core microgrid and support full load and islanding capabilities within the 6 blocks tagged as item 23 in Figure 1 below. Section 2 provides a direct response to each NY Prize capability. Section 3 outlines the commercial and financial feasibility of the core microgrid as described in Sections 1 and 2. Section 3 also outlines the potential for expanding the core microgrid, leveraging NY Public Service Commission "REV" (Reforming the Energy Vision) principles and the NY Public Service Commission's order establishing Community Distributed Generation within the Brownsville Microgrid by selling power to commercial and residential customers tagged in item 24 and 25 in Figure 1.

Figure 1: Brownsville Microgrid

#	Entity	Location	Notes
1	Brownsville 14	268 Osborn St	Central Boiler Plant for Brownsville Houses
2	Brownsville 22	528 Mother Gaston Blvd	Brownsville Senior Center & OEM Cooling Center
3	Van Dyke 12	393 Dumont Ave	Central Boiler Plant for Van Dyke I Houses
4	Van Dyke 23	430 Dumont Ave	Van Dyke Senior Center & OEM Cooling Center
5	Tilden 5	265 Livonia Ave	Central Boiler Plant for Tilden Houses
6	Tilden 8	630 Mother Gaston Blvd	Tilden Senior Center & OEM Cooling Center
7	PS 284	213 Osborn St	Lew Wallace School
8	PS 150	364 Sackman St	Christopher School
9	PS 298	85 Watkins St	Dr Betty Shabazz School
10	PS 327	111 Bristol St	Dr Rose B English
11	PS 401	51 Christopher street	Christopher Ave Community School
12	FDNY Ladder 210	107 Watkins St	FDNY Battalion 44 / Engine 231 / Ladder 120
13	NYPD 73rd Precinct	1470 East New York Ave	NYPD 73rd Precinct
14	BMS Family Health	592 Rockaway Ave	Brownsville Multi-Service Family Health Center
15	BMS Health Center	408 Rockaway Ave	Brownsville Multi-Service Health Center
16	Van Dyke Community Center	392 Blake Ave	Van Dyke Community Center
17	Brooklyn Public Library	581 Mother Gaston Blvd	Stone Ave Branch
18	Brooklyn Public Library	61 Glenmore Avenue	Brownsville Branch
19	Crossroads Juvenile Center	17 Bristol St	Crossroads Juvenile Center
20	400 Rockaway	400 Rockaway Ave	Assemblymember's Office
21	Greg Jackson Center	519 Rockaway Ave	Greg Jackson Center for Brownsville
22	Fiesta Adult Daycare	50 Belmont Ave	Fiesta Adult Daycare
23	Brownsville Core Microgrid		To island, peripheral bldgs require inclusion
24	Nehemiah Homes		Single family LMI housing
25	Pitkin Ave BID		Pitkin Business Improvement District

Table 1: Brownsville Microgrid Critical and Community Facilities

1.0: Description of Microgrid Capabilities

This section provides a summary of the technical description of the Brownsville Microgrid.

1.0.1: Goals

There are a number of stakeholders with a range of goals which this project is aiming to integrate and meet to develop an inclusive and beneficial project. Below are the identified project goals associated with key stakeholders:

Goal	Primary Stakeholder	Project Impact
Powering community safe havens during emergency	Residents	Key facilities able to provide energy services during an emergency and operate in island mode
Brooklyn/Queens Demand Management (BQDM) load reduction	Con Edison	Reduce peak load demand through generation, storage, and load management and have demand response capabilities
Operating cost reduction and revenue generation	NYCHA	Energy generation/storage is cost competitive
Community participation	Residents	Community ownership of DG assets for benefit of the community
Sustainability/GHG emissions/ Community air quality	Residents, NYC	Energy generation with low emissions to support site air quality and NYC GHG reduction goals `

Table 2: Stakeholder Goals

1.0.2: Capabilities

The feasibility of the Brownsville – Van Dyke Community-Owned Microgrid project will be assessed to provide all minimum and desired capabilities.

1.0.3: Site Inclusion

An approximately twenty block area was considered for inclusion in the microgrid as shown in Figure 1. After meeting with Con Edison it was determined that the microgrid to be assessed for feasibility under NY Prize will be comprised of the six adjacent blocks (highlighted in yellow on Fig. 1) that includes three NYCHA housing developments: Brownsville, Van Dyke, and Tilden. The following priority loads are included in the six block area (figures represent the site locations identified in Fig. 1):

- (1) NYCHA Brownsville Building 14 (boiler plant location)
- (2) NYCHA Brownsville Building 22 (NYC Office of Emergency Management cooling center location)
- (3) NYCHA Van Dyke I Building 12 (boiler plant location)
- (4) NYCHA Van Dyke II Building 23 (senior citizen housing)
- (5) NYCHA Tilden Building 5 (boiler plant location)
- (6) NYCHA Tilden 8 (NYC Office of Emergency Management cooling center location)
- (7) PS 284 Lew Wallace School
- (16) NYCHA Van Dyke I Building 24 (community center & NYC Office of Emergency Management cooling center)
- (17) NYC Public Library: Mother Gaston Branch Library (aka Stone Ave Branch)

The microgrid will include power distribution systems along the perimeter of the 6 block area. The perimeter segments feed both sides of the street. For this reason portions of the street across from the 6 block area will be included depending on their point of connection to the grid (as represented in the yellow dashed line on Fig. 1). The following sites are on the perimeter and could be included but their point of access to the grid may need to be changed:

- (14) Brownsville Multi-Service Family Health Center
- (8) PS 150 Christopher School
- (21) Greg Jackson Center for Brownsville

For the purpose of the NY Prize feasibility study, the Brownsville Multi-Service Family Health Center is included. Additional facilities could represent a second stage or an expansion of the project.

Figure 2: Microgrid Map of sites considered for inclusion with proposed primary residential facilities (blue), additional residential facilities (yellow outline), critical facilities (red), and community benefit facilities (green).

1.0.4: Efficiency

NYCHA facilities have existing plans to achieve energy efficiency upgrades in 2016-2017. The specific upgrades are not currently known. NYCHA and the City of New York are in the process of issuing a separate set of Requests for Proposal (RFPs) to achieve energy efficiency targets and the Project Team will have an opportunity to weigh in on specific energy efficiency upgrades to maximize the mutual impact of the microgrid and energy efficiency RFPs.

1.0.5: Load Reduction

The NYCHA facilities account for the majority of the load in the microgrid. Demand response controlled window AC units are proposed for load reduction.

1.0.6: Generation/Storage

The microgrid includes the following distributed energy resources:

- Rooftop Solar Photovoltaic (PV)
- Battery/Inverter, and
- Natural Gas Reciprocating Engines.

Combined heat and power (CHP) was not considered during the feasibility study due to constraints at microgrid participant locations, including on-going and pending heat-related energy efficiency retrofits. The maximum technically viable solar PV was selected and may be a part of a community solar effort. A community solar program would involve leasing excess rooftop space from NYCHA to install solar PV, and signing up subscribers from surrounding single family private sector residential buildings, multi-family private sector residential buildings, direct-metered NYCHA buildings, and commercial buildings in the surrounding community. These buildings currently pay more per kWh for electricity than NYCHA given they are served by Con Edison and do not have access to cheaper NYPA rates. The approach to energy storage is a single storage system that will tie into the Con Edison primary (27 kV) distribution system, along with on-site generation sufficient to handle the islanding requirements and provide additional demand reduction in grid paralleled mode when needed. Natural gas based reciprocating engine generation was selected and sized to provide additional demand reduction when needed to support the utility and to provide peaking power to fully support the critical facilities when islanded.

1.0.7: Distribution

The microgrid will provide power to low income NYCHA apartment buildings, New York City critical community facilities, and Brownsville community benefit facilities. The existing Con Edison secondary distribution system will be sectionalized to permit isolation of the microgrid from the remainder of the utility network in the event of a loss of the utility source. This will enable the microgrid to remain energized in an emergency. Additional sectionalizing will be installed on the 27 kV primary circuits serving the microgrid to permit the generation and energy storage resources to maintain power to the microgrid when islanded. In grid paralleled mode, the distributed generation and energy storage systems will be operated to maximize economic benefit, and reduce peak demand. In island mode, the generation to load ratio relationship will be controlled by the microgrid controller using a high speed load shedding scheme with dynamic, preplanned multi-tiered load preservation strategies. The system will be designed to seamlessly disconnect and reconnect to the grid for island mode, with little to no impact to the critical loads.

1.1: Minimum Required Capabilities

The capabilities described in this section were designated as minimum required capabilities by NYSERDA NY Prize. The approach being assessed will include all minimum required capabilities as described below.

1.1.1: Critical Facilities

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

Project Approach: The feasibility assessment has considered the inclusion of the below listed critical facilities in Table 3. This included twelve critical facilities. In addition, 5 other residential and community facilities were identified that are within a 3 block radius of the tier 1 critical facilities.

Facilities Considered for Inclusion		
Priority Level for Microgrid Inclusion	**Facility**	**Critical Level**
Primary Microgrid Facilities	PS 284 Lew Wallace School	Tier 1 - Critical
	PS 150 Christopher School	Tier 1 - Critical
	PS 298 Dr. Betty Shabazz School	Tier 1 - Critical
	PS 327 Rose B. English School	Tier 1 - Critical
	PS 401 Christopher Ave Community School	Tier 1 - Critical
	Fire Department of New York Engine 231/Ladder 120	Tier 1 - Critical
	New York Police Department Precinct 73	Tier 1 - Critical
	Brownsville Multi-Service Family Health Center	Tier 1 - Critical
	Brownsville Multi-Service Health and Wellness Center	Tier 1 - Critical
	NYCHA Van Dyke I Building 24 (NYC OEM cooling center)	Tier 1 - Critical
	NYCHA Brownsville Building 14 (boiler plant location)	Tier 2 - Residential
	NYCHA Brownsville Building 22 (NYC OEM cooling center)	Tier 1 - Critical
	NYCHA Van Dyke I Building 12 (boiler plant location)	Tier 2 - Residential
	NYCHA Van Dyke II Building 23 (senior citizen housing)	Tier 2 - Residential
	NYCHA Tilden Building 5 (boiler plant location)	Tier 2 - Residential
	NYCHA Tilden 8 (NYC OEM cooling center)	Tier 1 - Critical
	400 Rockaway Ave	Tier 2 - Community
Secondary Microgrid Facilities	NYCHA Brownsville Buildings 1-13, 15-21, 23-27	Tier 2/3 - Residential
	NYCHA Van Dyke I Buildings 1-11, 13-22	Tier 2/3 - Residential
	NYCHA Tilden Buildings 1-4, 6, 7, 9	Tier 2/3 - Residential
	NYC Public Library: Mother Gaston Branch Library	Tier 2 - Critical
	NYC Public Library: Brownsville Branch Library	Tier 2 - Critical
	Crossroads Juvenile Detention Center	Tier 2 - Critical
	Greg Jackson Center for Brownsville	Tier 3 - Community
	Fiesta Adult Day Care	Tier 3 - Community

Table 3: Facilities Considered for Inclusion

Based on discussions with Brooklyn Engineering Team at Con Edison it was assessed that the facilities within the core six blocks [identified in yellow on Figure 1] were the most feasible for inclusion for the scope of the NY Prize assessment. The six block include 3544, 3561, 3760, 3576, 3777, and 3794. It was determined that distribution systems along the perimeter of the area would be included in order to include all buildings within the area and to support street lighting. Because of this many buildings across the street from the area will be included. Table 4 identifies buildings to be included in the microgrid.

Microgrid Facility Inclusion				
Status	**Facility**	**Building Type**	**Community Benefit**	**Critical Level**
Included	PS 284 Lew Wallace School	School	Potential Safe Haven	Tier 1 - Critical
	NYCHA Van Dyke I Building 24	NYCHA Residential	NYC OEM Cooling Center	Tier 1 - Critical
	NYCHA Brownsville Building 22	NYCHA Residential	NYC OEM Cooling Center	Tier 1 - Critical
	NYCHA Tilden 8	NYCHA Residential	NYC OEM Cooling Center	Tier 1 - Critical
	Mother Gaston Branch Library	NYC Public Library	Potential Safe Haven	Tier 2 - Critical
	NYCHA Van Dyke II Building 23	NYCHA Residential	Senior Citizen Housing	Tier 2 - Residential
	NYCHA Van Dyke I Building 12	NYCHA Residential	Central Heating Plant	Tier 2 - Residential
	NYCHA Tilden Building 5	NYCHA Residential	Central Heating Plant	Tier 2 - Residential
	NYCHA Brownsville Building 14	NYCHA Residential	Central Heating Plant	Tier 2 - Residential
	NYCHA Brownsville Buildings 1-13, 15-21, 23-27	NYCHA Residential	Low Income Housing	Tier 3 - Residential
	NYCHA Van Dyke I Buildings 1-11, 13-22	NYCHA Residential	Low Income Housing	Tier 3 - Residential
	NYCHA Tilden Buildings 1-4, 6, 7, 9	NYCHA Residential	Low Income Housing	Tier 3 - Residential
	Brownsville Baptist Church	NYCHA Residential	Low Income Housing	Tier 3 - Community
	Brownsville Multi-Service Health and Wellness Center	Healthcare facility	Emergency Services	Tier 1 - Critical
	PS 150 Christopher School	School	Potential Safe Haven	Tier 1 - Critical
	Greg Jackson Center for Brownsville	Community Center	Potential Safe Haven	Tier 3 - Community

Table 4: Microgrid Facility Inclusion

1.1.2: Primary Generation Not Diesel Generators

Requirement: The primary generation source capacity cannot be totally diesel fueled generators.

Project Approach: No new diesel generators will be utilized as part of the generation mix. The primary non-utility generation source will be a mixture solar PV and low emissions natural gas fueled generation.

1.1.3: Combination of Generation

Requirement: A combination of generation resources must provide on-site power in both grid-connected and islanded mode.

Project Approach:
The primary non-utility generation source will be a mixture solar PV and natural gas. Solar PV will provide approximately 7% of the energy needed by the microgrid in grid paralleled operation. Power to recharge the energy storage batteries will be sourced from NYPA during off peak hours, and supplemented as needed by peaking generation in the form of reciprocating generators. The peaking generators and energy storage system will be used to support the power needed by the microgrid during island mode, the peaking generators will also be brought on-line for further BQDM demand reduction.

The energy storage system will manage the power from these sources to maximize demand reduction, and reduce Brooklyn-Queens Demand Management (BQDM) Program area's peak demand.
The remainder of the electricity will come from Con Edison and NYPA as it currently does.

At a minimum, power will be provided to maintain safe occupancy of these buildings and will maintain heating systems, elevators, public area lighting, and ventilation. Power to individual apartments will be curtailed on a rolling basis when necessary during maximum demand periods, to assure all critical facilities such as the K284 Lew Wallace School are fully supplied 24/7 for the duration of any island operation.

1.1.4: Intentional Island

Requirement: Must be able to form an intentional island.

Project Approach: Upon a request from Con Edison, the microgrid controller will bring all distributed generation on line, at the same time, pre-planned load shedding of non-critical loads will occur. The distributed generation will then assume 100% of the microgrid load. A command will then be issued to open sectionalizing switches that are installed in Con Edison's secondary network service to separate the microgrid from the utility grid. Simultaneously, all generator voltage regulators will switch from power factor to voltage control mode. Microgrid system frequency will be maintained by the peaking generators operating in isochronous mode, and by energy storage system inverters which will provide both frequency regulation and VAR support.

1.1.5: Automatic Disconnect and Restoration

Requirement: Must be able to automatically separate from grid on loss of utility source and restore to grid after normal power is restored.

Project Approach: In the event of a loss of utility power, the microgrid will automatically separate from the grid. Upon sensing a loss of the utility source, the sectionalizing switches will isolate the microgrid from Con Edison's secondary network. A preprogrammed high speed load shedding operation will be initiated by the microgrid controller to direct power only to the most critical facilities and loads. These loads will be maintained by the energy storage system in conjunction with any other generation that was on line at the time of the utility outage. Peaking generation will be brought on-line, and the microgrid controller will then sequentially restore all loads up to the maximum capacity of the generation. While islanded, all generator voltage regulators will operate in voltage control mode.
Once the normal utility voltage and frequency is restored, the system will wait for five minutes, then it will initiate automatic re-synchronization with the utility grid. The microgrid frequency and voltage will be automatically adjusted to match the utility, and a close command will be issued to the sectionalizing

switches in Con Edison's primary and secondary network distribution system. At that point, generator voltage control will switch to power factor mode, and all governor controls will be set to droop. Generator dispatch will revert to the economic dispatch control system.

1.1.6: 24-7 Uptime

Requirement: The system 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 hours per day and 7 days per week utilization of the power produced by these resources.

Project Approach: The system will be capable of continuous, dispatchable energy generation 24 hours per day, 7 days per week. Energy from the PV system will be stored and managed by the energy storage battery/inverter system and dispatched to meet the needs of the microgrid. The types of DG resources to be utilized for this project are designed for continuous duty and have long run times between maintenance intervals. Any down time for maintenance will be scheduled so as to not impact the capacity of the microgrid. The use of multiple DG resources provides near N+1 reliability.

1.1.7: Grid Tied Operation

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

Project Approach: When in Grid Paralleled operation, the microgrid voltage and frequency are controlled by the utility grid. Microgrid generation will provide kW and kVARS to the system based on the generator load set points determined by Economic Dispatch. During grid paralleled mode, generators will be operated as a constant power factor intended to present a load power factor to the utility grid between 0.80 and 0.95. When operating in Island Mode, generator voltage regulators will maintain the system voltage, with the VAR contribution of each generator proportional to the generator load. The energy storage inverters will also provide VAR support to maintain voltage. System frequency will be maintained by isochronous operation of the peaking generators.

1.1.8: Microgrid Control

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

Project Approach: The entire microgrid communications and control system will be NERC CIP compliant using a dedicated and redundant fiber optic communications network, with password authentication. A secure communications gateway with firewall will be constructed to allow Con Edison to monitor operation of the microgrid and allow them to have operational control of sectionalizing and other functions.

1.1.9: Customers

Requirement: 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.

Project Approach: The microgrid will support a NYCHA housing development area which includes three primary housing developments: Brownsville, Van Dyke, and Tilden. Included in this 6 block area are critical facilities including, a New York City Public School, 3 NYCHA community centers and Office of Emergency Management (OEM) cooling centers, a public library and a church. A range of commercial and residential buildings are on the perimeter, across the street from the area and will be included. These include grocery and convenience stores, ATM's, restaurants, drug stores and a community health care clinic. Future expansion of the microgrid could include a health center, another school, and another community center. See Figure 1 and Table 2 for more information regarding facility inclusion.

Figure 1 shows the microgrid impact map including the proposed primary NYCHA residential facilities hosting NYC Office of Emergency Services cooling centers and central heating plants for NYCHA in blue, additional NYCHA residential facilities outlined in yellow, critical facilities serving as potential safe havens or providing emergency services in red, and community benefit facilities in green.

One key consideration for NYCHA inclusion in the project will be the ability to generate direct revenue for NYCHA through solar rooftop leases from NYCHA buildings (shown in white in Figure 1). Solar power produced by the NYCHA solar array will be sold to single family residential customers (shown in purple in Figure 1), commercial customers, and will offset purchased utility power to recharge the energy storage batteries to direct-metered NYCHA residents.

This project will support critical facilities and safe haven(s) which will support the residents of the three housing developments; this will impact a population of up to 10,092 occupants, 1,247 of whom are elderly.

Direct Population Impact		
Development	**Total Population**	**Total Elderly Population**
Brownsville	3,306	399
Tilden	2,628	312
Van Dyke I	4,028	411
Van Dyke II	130	125

Table 5: Direct Population Impact

The total monthly demand for the microgrid ranged from 3.7 MW in winter to 9.2 MW in summer.

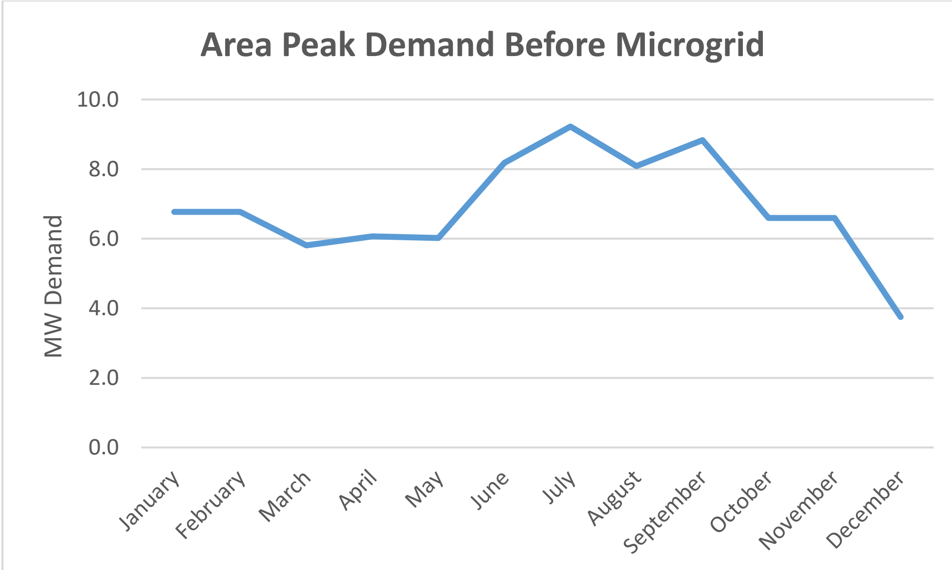

Figure 3: Area Peak Demand before Microgrid Development

The NYCHA building types are highly homogenous. For instance there are two building types represented at Brownsville, these building types range from 6-7 floors, and have an average of 50 +/- 5 units. Van Dyke has two distinct types one with 3 floors and 18 units and one with 14 floors and 110 +/- 2 units. Tilden has one distinct type with 16 floors and 125 +/- 1 units.

1.1.10: Uninterruptible fuel

Required: Must include an uninterruptible fuel supply or minimum of one week of fuel supply on-site.

Project Approach: Natural gas will be the primary uninterruptible fuel source for gas-fired generators.

1.1.11: Resilience to Natural Disaster

Requirement: 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.

Project Approach:
The NYC area has recently been deeply impacted by volatile weather due to climate change like hurricanes and superstorms. Hurricane Sandy had a significant impact on the NYC area: close to 2 million people were without power, 6,500 patients were evacuated from hospitals and nursing homes, and 1.1 million children were unable to attend school for a week. During Sandy more than 400 NYCHA buildings and approximately 35,000 housing units lost power, heat, or hot water putting tenant safety and quality of life at risk.

While the Brownsville area was affected by Hurricane Sandy, the effects were comparatively less than other NYC areas. The primary sites directly damaged by Sandy tended to be coastline and waterfront infrastructure, 1-story light-frame buildings, and below ground infrastructure/transportation. In contrast, the Brownsville-Van Dyke site consists of substantial buildings located inland from the coastline. However, being part of the BQDM area, Brownsville could lose its power from the grid during a regional emergency. The microgrid approach developed for this project focuses on providing infrastructure that can operate independent of the grid so that the residents' basic needs are met. Because of the site location, the microgrid systems are not anticipated to be at particular risk for damage and direct impact during an emergency. The emphasis of providing power to the school, NYCHA community centers, NYCHA housing, and a medical facility is in line with mitigating the types of impact that occurred after Hurricane Sandy.

In addition to Hurricanes, heat waves can have a devastating impact on populations, particularly elderly. In 2014, NYCHA facilities housed three separate cooling centers designated by the NYC Office of Emergency Management as cooling centers, "a facility, such as a senior center or community center, where people may go to enjoy air-conditioned comfort during a heat emergency." Since the heat wave in July and August of 2006 which claimed 46 lives and disrupted power throughout the city, cooling centers have played a major role in the lives of seniors and other citizens prone to heat-related illness. Within these 6 blocks of NYCHA housing, there are approximately 1,000 senior citizen residents. Brownsville Senior Center, Van Dyke Community Center, and Tilden Community Center were all OEM designated cooling facilities in 2014.

The Microgrid Center includes the microgrid central control location and DER resources. One of the primary considerations for the location of the Microgrid Center is resilience to flooding and high winds. The first choice option for the Microgrid Center is at the building on the south-east corner of Rockaway Ave and Black Ave. This location is naturally slightly elevated but offers ground space for a raised and protected platform.

1.1.12: Black-Start

Requirement: Provide black-start capability.

Project Approach: The energy storage system will provide power to start the system in case of a complete outage. Also, the natural gas based peaking generation will have its own stored energy systems for rapid starting without the need for external power.

1.2: Preferable Microgrid Capabilities

The capabilities described in this section were designated as preferred microgrid capabilities by NYSERDA NY Prize. The approach being assessed will include both of the two primary preferred capabilities as described below.

1.2.1: Advanced, Innovative Technologies

Preferred Requirement: 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, and Energy Storage.

Project Approach: The microgrid load management system incorporates real time metering and preplanned prioritizing of loads to permit the system to react to contingencies during islanded operation while maintaining system voltage and frequency and spinning reserve. Energy storage is utilized for efficient dispatch of solar PV, load reduction, and black start capabilities. An economic dispatch system provides lowest cost power from solar PV, utility and natural gas energy sources based on continually shifting market prices and load reduction requirements. The capabilities of the distributed generation resources allow the project to participate in ancillary market opportunities. The microgrid controller will smoothly integrate efficient generation dispatch and economics while maintaining reliable power under both grid paralleled and islanded operation.

1.2.1.1: Optimized Control

Preferred Requirement: Include an active network control system that optimizes demand, supply and other network operation functions within the microgrid.

Project Approach: A fully integrated control system will be incorporated into a high speed, cyber secure communications system to monitor and control all aspects of microgrid operation, power generation and load management.

1.2.1.2: Demand Management

Preferred Requirement: Include energy efficiency and other demand response options to minimize new microgrid generation requirements.

Project Approach: NYCHA has an existing commitment to energy efficiency and will issue an Energy Performance Contract (EPC) for energy efficiency in its Brownsville, Van Dyke, and Tilden buildings. The project will assume that these reductions will result in a reduction of 10% energy consumption and 5% demand reduction. NYCHA has a new construction building in process which is currently enrolled in the NYSERDA Multifamily Performance Program. Additional, energy efficiency opportunities will be considered for the school and other non-NYCHA critical facilities that are included in the microgrid.

The battery storage and natural gas based generation will be used to reduce demand in response to Con Edison's signal and optimal economic dispatch.

1.2.1.3: Interconnection Considerations

Preferred Requirement: 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).

Project Approach: The interconnection of the energy storage and peaking generation resources will be to Con Edison's primary distribution system which can absorb and distribute the estimated 8 MW of power delivered for Demand Reduction during grid paralleled operation. The existing Con Edison secondary network system, which is already a highly reliable underground distribution network, will be utilized as the distribution system to end users of the microgrid system. This will be accomplished by the installation of remotely monitored and operated sectionalizing switches that will allow separation of the microgrid distribution from the remainder of the network in the event of an outage.

Communications will be over a secure dedicated and fault tolerant fiber optic network, independent of the internet and of common carrier telecom facilities.

1.2.1.4: REV

Preferred Requirement: Coordinate with the Reforming the Energy Vision (REV) work to provide a platform for the delivery of innovative services to the end use customers

Project Approach: Early in the development of the community ownership concept for this project, the Project Team engaged Con Edison's Utility of the Future Group and its Distributed Generation Group to evaluate the feasibility of creating a REV demonstration project. Based on the REV principle of utility ownership of distributed generation assets in low income communities as an owner of last resort, the Project Team explored a cooperative ownership structure where community members would own a 51% majority of microgrid assets alongside a 49% minority ownership by Con Edison. Equity capital would be provided by the utility with debt capital coming from third party investors. Community relationship assets would be utilized to change community members' energy consumption habits, lowering consumption while maintaining an Energy Services Agreement based on historical consumption.

Project partners originally include Con Edison, the Brooklyn Alliance for Sustainable Energy, the New York City Environmental Justice Alliance, NYCHA, New York Power Authority, NYC Mayor's Office, BlocPower, and TRC Energy Services.

After engaging with all Project Partners, the 51-49 cooperative ownership structure for community members and Con Edison was replaced with a new cooperative ownership structure that took advantage of the Public Service Commission's Order Establishing Community Distributed Generation (CDG). By offering solar PV through CDG to local community members, the Project Partners were able to reduce legal, regulatory, and reporting requirements that might have hindered the success of the cooperative ownership structure under the original plan. Direct community ownership of equity shares in the microgrid could prove problematic for several reasons, including: (1) voting rights, (2) administration, (3) the separation of asset ownership and operational control of assets, (4) contract structuring and rights enforcement, and (5) individual tax implications.

Based on recent developments with Project Partners, including NYCHA, NYPA, and NYC Mayor's Office, the Brownsville-Van Dyke microgrid will demonstrate three distinct REV principles:

(1) Innovative new business models that allow the utility to act as a Distributed System Platform Provider,
(2) A Community Solar Program for low income residential and commercial utility customers, and
(3) Load reduction in congested utility infrastructure (Brooklyn-Queens Demand Management).

The Public Service Commission's Order Establishing a Community Distributed Generation Program and Making Other Findings dated July 17, 2015 outlines a Community DG framework, coordination with REV, and Low Income Customer Policies. The PSC also established a Low Income Customer Collaborative "to accomplish removal of obstacles to low income participation in Community DG" and to "consider devising demonstration projects directed toward encouraging broad low-income customer participation in Community DG"[1]. As the project sponsor for a Community DG project, the Brownsville Microgrid Special Purpose Entity (SPE) will become a DER provider according to REV principles

The Brownsville Microgrid's battery installation will enable NYCHA's participation in Con Edison's Demand Response efforts and Brooklyn-Queens Demand Management Program load reduction efforts, both of which are outlined in Con Edison's response to the PSC's Order Establishing Brooklyn/Queens Demand Management Program dated December 12, 2014.

1.2.1.5: Multi-Perspective Cost-Benefit

Preferred Requirement: Take account of a comprehensive cost/benefit analysis that includes, but is not limited to, the community, utility and developer's perspective.

Project Approach: At a minimum, the requirements of task 3 and task 4 of the statement of work will be met. In addition the following analysis is anticipated:

Community – Create economic incentives for community members to engage in conservation. The community members would have partial ownership of microgrid system in the form of conservation related engagement and corresponding payments.

Utility – Develop system that creates value to Con Edison by addressing the BQDM capacity reduction requirement. Intend for Con Edison to have partial ownership of the microgrid system.

Investor – Distributed generation assets will be selected and sized to maximize investor appeal.

1.2.1.6: Capital Investment

Preferred Requirement: 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.

Project Approach: Ownership and cost recovery mechanisms will be explored as part of the task 3 commercial feasibility assessment. Private sector capital providers continue to express interest in the project. Most recently, updates on project development have included Goldman Sachs, Deutsche Bank, and Generate Capital.

1.2.1.7: Clean Power Supply

Preferred Requirement: 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.

Project Approach: Solar PV will be assessed with the goal to optimize the amount of carbon-free energy generation and achieve highest possible penetration and adoption. Solar PV will provide 7% of the energy required for the building – it could be roughly approximated that for buildings with solar PV 7% of residents would be covered by carbon-free energy generation. The project will assess the extent of

[1] State of New York Public Service Commission; CASE 15-E-0082 - Proceeding on Motion of the Commission as to the Policies, Requirements and Conditions for Implementing a Community Net Metering Program; Order Establishing a Community Distributed Generation Program and Making Other Findings, page 31

the population that will be covered at this level which will depend on the number and type of buildings that have solar PV planned.

The use of large scale energy storage for demand reduction avoids the need for operation of larger peaking power generation and its ability to be recharged off peak via clean hydro power sourced from NYPA is a further environmental benefit.

1.2.1.8: Community Benefit

Preferred Requirement: 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.)

Project Approach: The microgrid includes 59 residential NYCHA buildings, 6 critical facilities, community benefit facilities, and will impact over 10,092 occupants, 1,247 of which are seniors. Table 3 provides a list of facilities included, their building type, and anticipated community benefit. The residents will benefit from the project in terms of availability of safe havens during an emergency and from a NYCHA Tenant Repair Fund. NYCHA tenants have experienced a significant number of brownouts and blackouts due to constrained in-building electrical infrastructure and grid-level constraints, and the Tenant Repair Fund will help address those in-building constraints.

The ability of the microgrid to support surrounding local business functions along with street lighting, traffic lights and other functions is critical to the safety and comfort of the community during an emergency, and allows residents to shelter in place for extended periods if needed.

1.2.2: Grid and Customer

Preferred Requirement: 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.

Project Approach: Residents will have the opportunity to participate in a demand response (DR) window-unit AC control program. The reduction of electrical use by residents during an emergency will be to their benefit by reducing or eliminating curtailments during island mode operation. If they participate in the program their load will not be curtailed. Essential and life-safety services such as hallway lighting and elevators will not be curtailed.

2.0: Preliminary Technical Design Costs and Configuration

2.1: Proposed Microgrid Infrastructure and Operations

This section provides a high level/simplified infrastructure overview and then a narrative of how the system will operate in normal and emergency modes.

2.1.1: Infrastructure Overview

The microgrid will incorporate portions of Con Edison's existing underground 27 kV Primary distribution system and portions of the existing Low Voltage Secondary (208/120V) system.

New switching equipment and protective relays will be installed to monitor and control the separation of this microgrid system from the remainder of Con Edison's system when necessary due to planned or unplanned outages of the utility infrastructure.

The Distributed Energy Resources (DER) which will support the microgrid consist of a 4 MW/ 32 MWh battery and inverter type energy storage system, two 3.0 MW natural gas fueled reciprocating generators, and total of 2.0 MW of solar photovoltaic (PV) generation.

All of the DER with the exception of the PV will interconnect with Con Edison's 27 kV primary distributions via two new 27 kV feeders to run underground on Rockaway Ave. The power from the energy storage systems and the generators will be paralleled at 13.8 kV, then stepped up to 27 kV via two 10 MVA transformers New switching equipment will allow power to be fed from the DER to any or all of the 8 existing primary feeders.

The energy storage and natural gas generators will be arranged so that one-half of their capacity is fed to each of the two microgrid feeders. A Tie Breaker is provided that will allow the entire DER to be connected to a single feeder in an emergency or to accommodate maintenance.

The PV consists of rooftop installations on multiple buildings and will interconnect with the microgrid via the existing underground secondary distribution system. The amount of power produced by the PV in total does not exceed the customer demand on the secondary network, therefore it does not appear at this time that any modifications to the network protector operation on the network transformers will be required.

There is no thermal component to the DER specified for the microgrid. DER value is in demand reduction and to a lesser extent in its ability to operate in island mode in the event of a major electrical outage.

The Microgrid Center includes the microgrid central control location, reciprocating engines, battery/inverter, step-up transformers. The first choice option for the Microgrid Center is at the building on the south-east corner of Rockaway Ave and Black Ave.

Figure 4: Brownsville – Van Dyke Community Microgrid area (inside yellow dashed area) with key critical microgrid loads (red star), solar PV locations (yellow suns), and the Microgrid Center (red dot) identified.

Microgrid Equipment Survey

Type	Equipment Name	Rating	Status	Location
Distribution Infrastructure	Con Edison 8 Primary Distribution Feeders	Private Data	Existing	Location distributed
	Con Edison Low Voltage Secondary Feeders	Private Data	Existing	Location distributed
	24 switches and secondary isolation switching		New	Location distributed
	Two Primary Feeders	27 kV	New	Run underground on Rockaway Ave
	Two Step-Up Transformers	10 MVA	New	SE corner of Rockaway Ave & Blake Ave
Generation & Storage	NYCHA Rooftop Solar PV	2.4 MW		Distributed on Brownsville, Van Dyke, Tilden NYCHA buildings, located between Sutter Ave and Livonia Ave, and between Rockaway Ave and Powell St, Brooklyn, NY 11212
	NYC – Library Solar PV	0.05 MW		Brooklyn Public Library, Mother Gaston Branch Library (aka Stone Ave Branch), 581 Mother Gaston Blvd, Brooklyn, NY 11212
	NYC – School Solar PV	0.18 MW		PS 284 Lew Wallace School, 215 Osborn St. Brooklyn, NY 11212
	Natural gas reciprocating engine #1	3 MW		SE corner of Rockaway Ave & Blake Ave
	Natural gas reciprocating engine #2	3 MW		SE corner of Rockaway Ave & Blake Ave
	Battery and inverter	4 MW/ 29 MWh	New	SE corner of Rockaway Ave & Blake Ave
Demand Management	Window AC Control	1 MW	New	Distributed on Brownsville, Van Dyke, Tilden NYCHA buildings, located between Sutter Ave and Livonia Ave, and between Rockaway Ave and Powell St, Brooklyn, NY 11212
Controls	Microgrid Central Control	N/A	New	SE corner of Rockaway Ave & Blake Ave
Key Critical Facilities	PS 284 Lew Wallace School	N/A	Existing	215 Osborn St. Brooklyn, NY 11212
	NYCHA Van Dyke I Building 24	N/A	Existing	392 Blake Ave, Brooklyn, NY 11212
	NYCHA Brownsville Building 22	N/A	Existing	320 Blake Ave, Brooklyn, NY 11212
	NYCHA Tilden 8	N/A	Existing	630 Mother Gaston Blvd, Brooklyn, NY 11212
	Mother Gaston Branch Library	N/A	Existing	581 Mother Gaston Blvd, Brooklyn, NY 11212
	Brownsville Multi-Service Family Health Center	N/A	Existing	592 Rockaway Ave, Brooklyn, NY 11212

2.1.2: Operation Narrative

2.1.2.1: Normal Operation Mode

Grid Paralleled Operation

During normal operation, all of the isolation switches on both the primary and secondary distribution systems will remain closed. The distribution will operate within the Con-Edison system as it presently does.

The two new microgrid feeders will each be connected to one of the primary feeders to establish the connection with the DER. The choice of which feeder is connected to the DER is optional and may be changed at any time via remotely controlled switching.

This switching may be entirely controlled by Con Edison dispatch to permit normal system maintenance operations.

DER utilization

During periods of low demand, the two generators will remain off-line. The energy storage batteries will be brought up to full charge at a rate that will allow them to be fully charged at the beginning of the next anticipated demand period. The economic dispatch function of the microgrid controller will utilize historical demand profiles as well as current demand and weather data to anticipate the need for demand reduction to maintain pre-determined daily and monthly demand limits.

Where necessary to charge the batteries at a high rate to meet the next demand reduction cycle, one or more of the natural gas generators will be brought on line to limit the overall microgrid demand seen by Con Edison.

During On-Peak hours and periods of high demand, the operation of the energy storage system and the generators will be dispatched to maximize the economic benefit of the demand reduction by varying the output of the energy storage system and by use of the natural gas fueled generators where needed to limit the overall system demand to pre-determined targets.

The microgrid is a summer peaking load, therefore during the peak demand periods of the summer, the natural gas generators will be dispatched to maximize demand reduction during on-peak hours and may be also utilized within the limits of their capacity, to provide further demand reduction service to Con Edison during periods of high demand on the utility system.

During normal operation, the Energy Storage system may also provide ancillary services to the grid by Frequency regulation and or volt/VAR support.

2.1.2.2: Emergency Operation Mode

Emergency Operation- Partial loss of utility source

In the event of an unplanned loss of power to one or more of Con Edison’s feeders that supply the microgrid, the feeder can be isolated at both east and west ends and can be supplied with power via a connection to the new microgrid feeders. Power can then be supplied to the affected area via the remaining unaffected Con Edison feeders; by the microgrid DER or a combination of both.

Under this scenario, there would be no change in the switching configuration of the secondary system which would remain networked as presently operated. The existing network protectors on the secondary transformers would prevent reverse power flow into the inoperative feeder(s) when de-energized.

Complete loss of utility source

If an unplanned loss of all utility power occurs due to transmission failure or other major event, all of the primary and secondary isolations will immediately open to electrically isolate the microgrid from the remainder of the Con Edison system. Simultaneously all switches connecting the microgrid feeders to the Con Edison primary system will close.

DER operation

The microgrid load management system will shed a predetermined quantity of load at the building level to limit the demand to a maximum of 4 MW from the energy storage system. The energy storage system will maintain the voltage and frequency of the microgrid as additional generation is brought on-line. With a fully charged battery, the energy storage system can provide its full rated 4 MW output for 7 hours before the battery will be depleted.

On a loss of the utility, both 3 MW natural gas fueled generators will immediately be commanded to start and synchronize with the bus. Once on-line, these two generators will assume the microgrid base load, and the energy storage system will provide peaking capacity.

The energy storage battery will be maintained at 70-80% capacity while operating in island mode to allow sufficient margin for absorbing excess power, reducing the ramping requirements on the two generators in the event of sudden load rejection.

The generator capacity will be adjusted during island operation to leave sufficient headroom for peaking generation via the energy storage inverters.

The combined capacity of all DER can meet 100% the demands of the microgrid in an island mode under all conditions. In the event of a failure of one or more of the DER assets, the microgrid can continue to operate at reduced maximum capacity. Under many conditions of operation this would not require load shedding.

2.2: Load Characterization

2.2.1: Load Summary

The microgrid load is comprised of facilities owned by NYCHA, NYC, and other customers as shown in the Microgrid Load Summary table below. The NYCHA load is 29,879 MWh/year and peak demand is 7.02 MW. The NYC load is 860 MWh/year and peak demand is 0.24 MW. Other customers include the Brownsville Multifamily Health Center, Brownsville Baptist Church, and aggregate small commercial and residential that are on the microgrid perimeter which are owned by a range of owners including NYCHA. The other customers load is estimated at 17,407 MWh/year and peak demand is estimated at 3.00 MW.

The majority of the other customer load is associated with residential loads located along the microgrid perimeter.

Microgrid Load Summary			
Customer	**Facility Name**	**MWh/yr**	**Peak MW**
NYCHA/NYC	**NYCHA & NYC Subtotal**	**30,739**	**7.26**
Other	Brownsville Community Centers	1,221	0.22
	Aggregate Small Commercial on Perimeter	3,523	0.62
	Aggregate Residential on Perimeter	12,663	2.16
	Other Subtotal	**17,407**	**3.00**
Total		**48,146**	**10.27**

Table 6: Microgrid Load Summary

Load data was provided for most NYCHA and NYC loads included in the microgrid. Exceptions were: NYCHA Van Dyke I Building 24 – NYC OEM Cooling Center and NYCHA Van Dyke II Building 23 – Senior Citizen Housing which were estimated to be similar to NYCHA Tilden 8 – NYC OEM Cooling Center, and Street Lighting which was estimated. The other customer loads were estimated based on estimated building type and size. NYC load data was provided based on monthly billing data and NYCHA load data was provided based on both monthly billing data and 15 minute interval data.

2.2.2: Load Profile

From a load size perspective, NYCHA is the primary microgrid load accounting for 62% of the annual energy consumed and 68% of the power demand. The 15 minute interval data that was provided for NYCHA is graphed below, note that there was not a direct correlation between the monthly billing data that was provided and therefore does not exactly match the NYCHA load summary data. 15 minute interval data was provided for 2015 and was provided up to Sept. 2015. Demand data is based on the 15 minute average demand.

The load duration profile is provided to summarize the frequency that the NYCHA load is at different levels. Peak represents the maximum value, near peak represents 97.5 percentile, near base represents 2.5 percentile, and base represents the minimum value. Two graphs are provided the first which shows the load of each 15 minute interval data point to show the overall load frequency and the second which shows the daily peak load to show the frequency that a day reaches a given load. The load peaks above 6 MW and baseload is above 2MW.

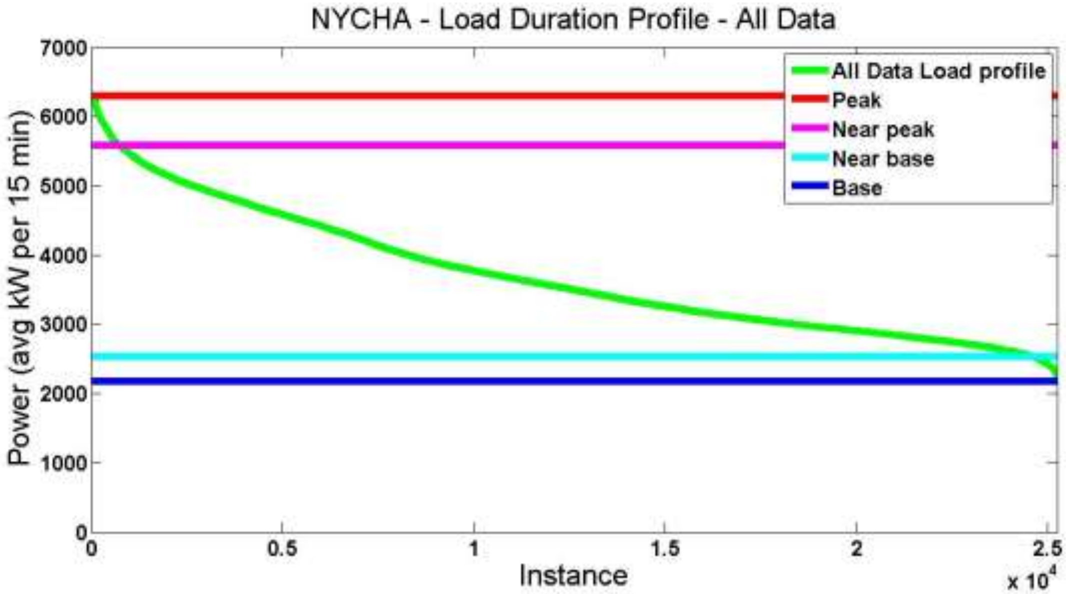

Figure 5: NYCHA Load Duration Profile - All Data

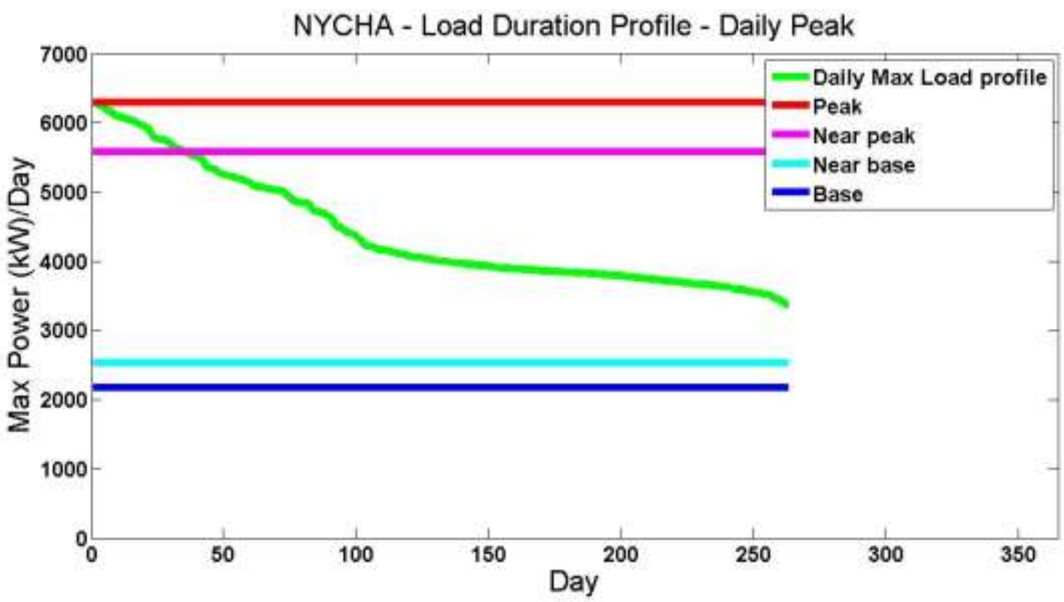

Figure 6: NYCHA Load Duration Profile - Daily Peak

Graphs below show the NYCHA load over the course of the day of the year and hour of the day graphed in both 3D and 2D. The time of day based variations in load is on the order of 2 MW. Peak demand of both the overall NYCHA load and within individual buildings typically occurs between 10-11 pm.

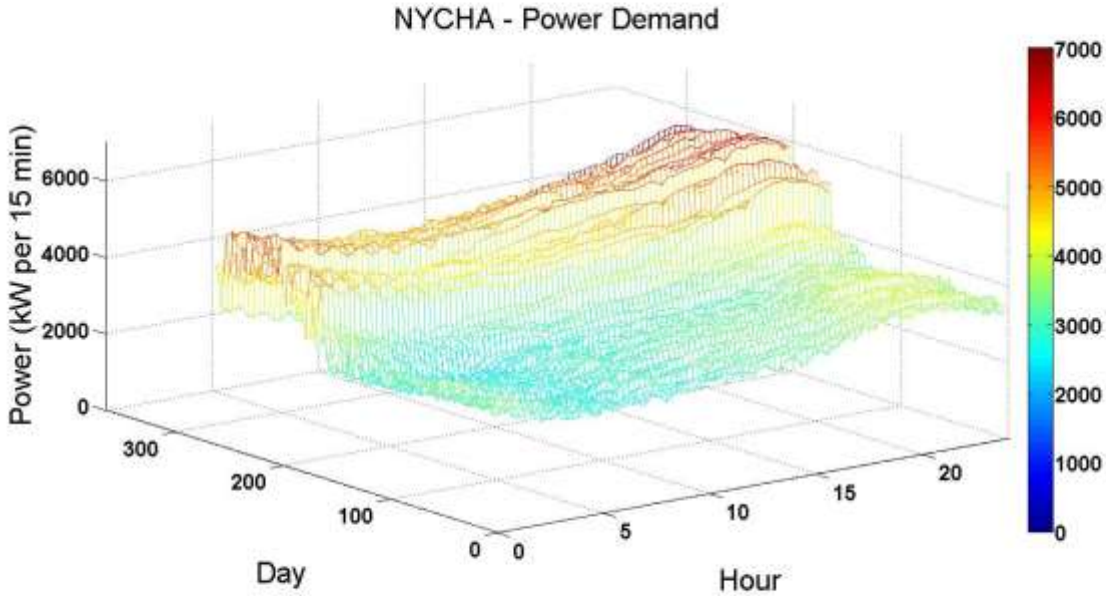

Figure 7: NYCHA Power Demand Daily & Hourly (3D)

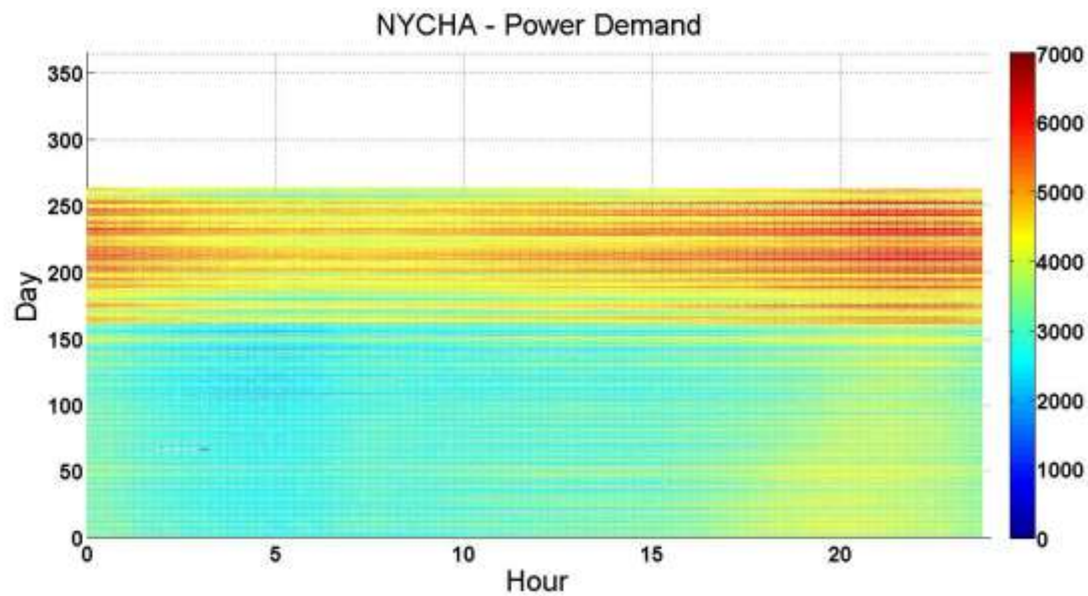

Figure 8: NYCHA Power Demand Daily & Hourly (2D)

The July and January months represent high and low energy consumption months respectively and are graphed over the day of the month and hour of the day. The difference between the two months is on the order of 2 MW during the same time of day.

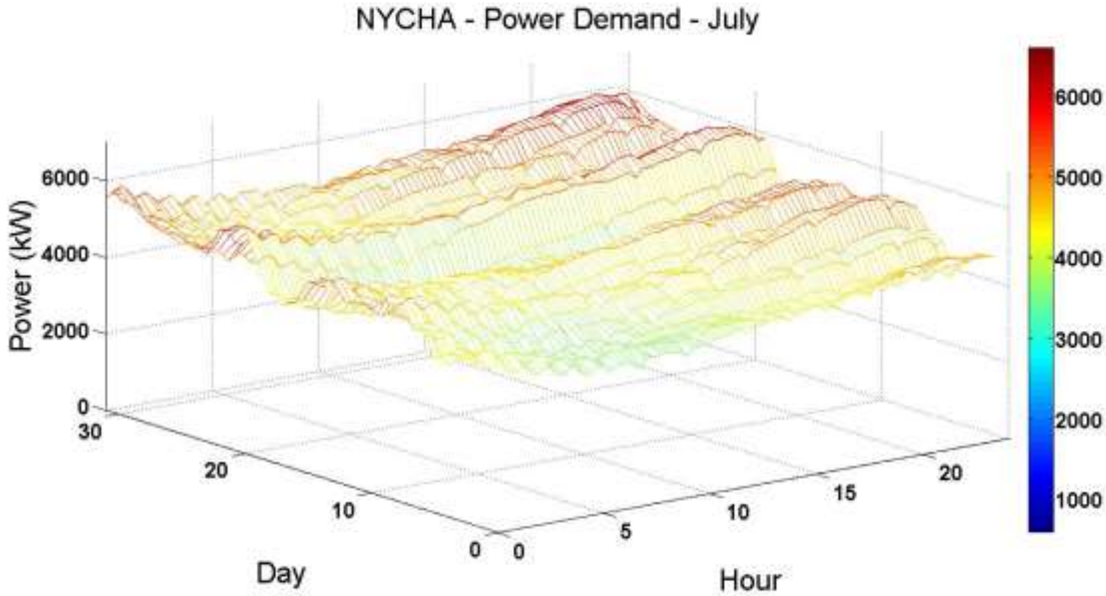

Figure 9: NYCHA Power Demand Daily & Hourly (July)

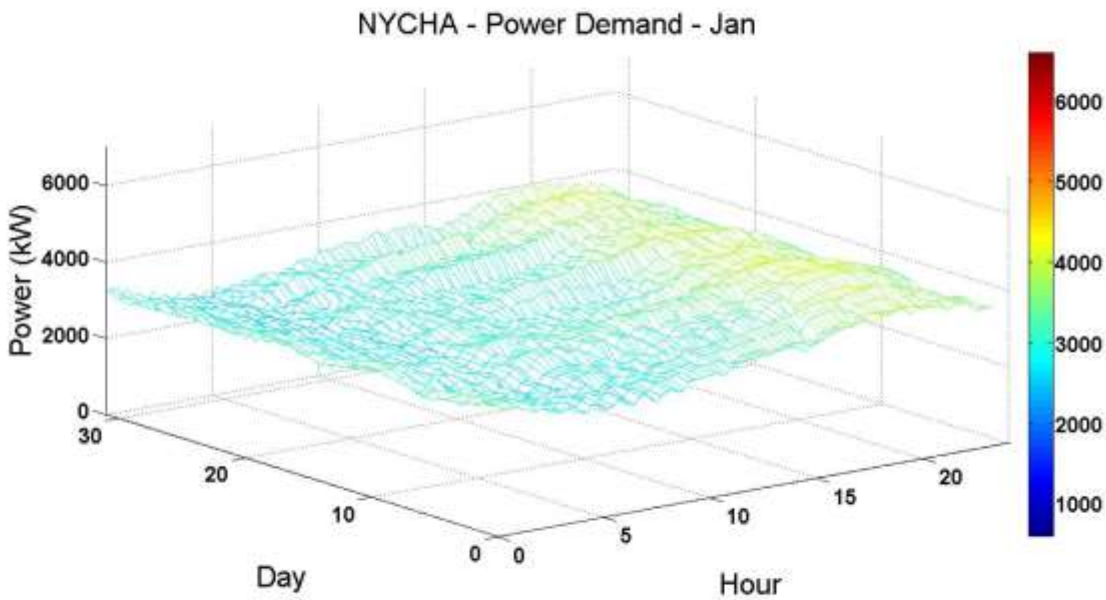

Figure 10: NYCHA Power Demand Daily & Hourly (January)

It is estimated that time of day (primarily behavior based) trends account for around 2 MW of load variance and time of year (primarily heating/cooling based) trends account for around 2 MW of load variance totaling to around 4 MW of total variance in load over the year.

2.2.3: Load Sizing Reduction

The primary mechanism for load reduction will be deployment of the microgrid battery. The Project Team has specified a 4 MW / 32 MWh zinc hybrid battery that will draw NYPA-supplied grid power from existing NYCHA interconnections to the grid and from the two 3 MW gas reciprocating engines. By charging the battery from the grid during off-peak hours and discharging the battery during peak hours, we will be able to reduce peak load according to the table below.

Month	Prior Peak	New Peak	Peak kW Reduction
January	6,768.3	4,000.0	2,768.3
February	6,768.3	4,125.0	2,643.3
March	5,809.5	4,031.0	1,778.5
April	6,063.9	3,889.9	2,174.0
May	6,019.9	3,016.3	3,003.6
June	8,177.8	4,000.0	4,177.8
July	9,222.3	4,025.5	5,196.8
August	8,088.6	4,000.0	4,088.6
September	8,831.0	5,000.0	3,831.0
October	6,593.8	3,000.0	3,593.8
November	6,593.8	3,221.8	3,372.1
December	3,748.9	1,500.0	2,248.9

Table 7: kW Reductions from Microgrid Operations

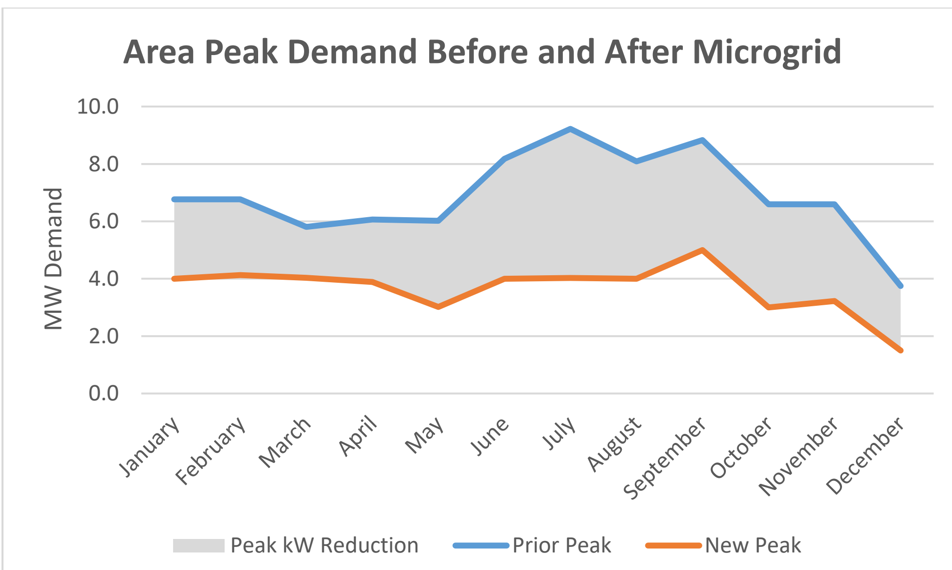

Figure 11: Peak Reduction

At present, the economic imperative for operating the battery requires charge and discharge to be set around the on-peak window for NYPA service, which begins at 8:00 AM and concludes at 6:00 PM, Monday through Friday. In order to generate the requisite revenue to support the installation of the microgrid assets, the generators and the battery work in concert to maximize load reduction by discharging the battery at a constant rate through the daily on-peak window and recharging the battery once the on-peak window ends in order to be fully charged by 8 AM the following morning. The generators act as a supplement to grid energy to charge the battery, required in grid parallel mode only in the months of May through November, where overall microgrid demand is high and grid power cannot be used to recharge the battery completely between daily on-peak periods.

This operational design maximizes the bill savings for the microgrid by focusing discharge on the period during which the host would incur demand charges. However, charge and discharge schedules are set by configurable/reconfigurable software, and there is substantial idle available capacity in the generators year round, so this design could be easily changed for alternative operational and/or economic optimization should price signals change in the marketplace. For instance, should greater monetization for the battery be available through Con Ed's planned Brooklyn Queens Demand Management Reverse Capacity Auction, the battery charge/discharge schedule could be adjusted to match the needs of that program, and the generators could be used to supplement grid power for charging, supplement battery discharge in load relief events, or both.

Additional measures that may impact peak load reduction include targeting the summer load associated with cooling. The Project Team deduced that much of Brownsville site's peak energy consumption is attributed to individual window Air Conditioner units. With the exceptions of PS 284, the public library and a number of designated community centers with larger, centralized AC systems, all NYCHA buildings solely rely on window AC systems to provide cooling. This means that tenants cool their own units by installing and operating window AC units as desired.

Recognizing window ACs to be the largest loads in residential homes, Con Edison has an on-going Residential Smart Appliance Program, CoolNYC, which targets residential customers with window ACs by making them "smart" and DR ready. The program provides residents with ThinkEco's "self-installable plug-load management solution" Modlets, devices that go between the window AC plug and the electric outlet. During DR events, Con Edison sent a signal via broadband or cellular gateways to curtail window AC usage with temperature offset. Participating customers then receive a rebate for successful participation in DR events called by Con Edison during the cooling season[2].

The TRC team proposes a similar scheme with NYCHA residents within the microgrid territory. The Microgrid may distribute similar devices to residents to enable window AC management. When operating conditions calls for major demand reduction, the microgrid controller will send appropriate curtailment signals to implement window AC temperature offset and reap the demand reduction benefits. With conservative assumptions, the team estimates a maximum demand reduction potential from window ACs to be 2,460 kW. Accounting for participation rate of 43% (based on CoolNYC program experience), a realistic demand reduction potential is just over 1,060 kW.

Window AC Penetration Assumptions, by number of bedrooms in units and 80% overall saturation.

Number of Bedrooms/ Unit	0	1	2	3	4	5	Total
Window AC penetration/ Unit	1	2	2	2	3	3	--
Apartment Unit Counts	165	809	2,165	1,302	169	21	4,631

Table 8: Window AC Assumptions

With 80% overall saturation, the total window AC population within the NYCHA buildings are 7,430, with an average number of AC per unit to be 1.6 (compared to 2.3 amongst ConEd's CoolNYC participants).

[2] *Consolidated Edison Company of New York, Inc. Report on Program Performance and Cost Effectiveness of Demand Response Programs*, to State of New York DPS. December 2, 2013. P. 45 on CoolNYC Program Operations.

With an average kW reduction per window AC of 0.331 kW, the maximum and realistic potential from NYCHA window AC population become 2,460 and 1,060 kW respectively. The realistic potential accounts for a 43% participation rate; the participation rate takes into account the portion of participants who install, operate and participate successfully (without opting out), therefore the target load reduction via AC control is around 1 MW.

2.3: Distributed Energy Resource Characterization

The Distributed Energy Resources (DER) which will support the microgrid consist of a 4 MW/ 29 MWH battery and inverter type energy storage system, two 3.0 MW natural gas fueled reciprocating generators, and total of 2.7 MW solar photovoltaic (PV) generation.

All of the DER with the exception of the PV systems, will be located on a property that currently includes an empty and deteriorating building, located on the corner of Blake Avenue and Rockaway Avenue. The present plan would be to acquire that land, remove the deteriorated structure and construct a new building that would house the two 3.0 MW generators, electrical switchgear, engine starting compressors compressed air storage tanks, station service battery, and microgrid control systems.

The energy storage batteries and inverters will be located behind this new building on a concrete slab at ground level, allowing for easy replacement of batteries when needed. The second option for the location of this equipment is next to Tilden Building 1, 300 Dumont Ave.

The PV systems will be located at roof level on buildings including NYCHA Brownsville, Van Dyke, and Tilden housing and community centers and NYC Brooklyn Public Library, Mother Gaston Branch Library (aka Stone Ave Branch) and PS 284 Lew Wallace School. The NYCHA nominal aggregated capacity is 2.48 MW with a modeled energy generation of 3,434 MWh/year, which accounts for 11% of the current NYCHA load (MWh) included in the microgrid. The NYC nominal aggregated capacity is 0.220 MW with a modeled energy generation of 262 MWh/year, which accounts for 30% of the NYC load (MWh) included in the microgrid. The total microgrid nominal capacity is 2.7 MW with a modeled energy generation of 3,697 MWh/year, which accounts for 7% of the total estimated microgrid load (MWh).

All of the DER equipment will be contained within structures that are designed to be weather tight and resistant to rain, snow wind, ice etc. The area is not within a FEMA designated Flood zone.

The energy storage system and natural gas fueled generators are capable of operation 24/7 when needed and are unaffected by weather conditions. The PV systems are by nature affected by overcast conditions which will reduce the output and by snow cover which can reduce or curtail the output. However the capacity of the microgrid to operate in island mode is not affected by reduced output of the PV. The only result would be increased fuel consumption by the two generators for the duration of the reduced PV output.

The two natural gas fueled generators are started by stored compressed air. Sufficient air will be stored to allow a minimum of 3 normal starting cycles by both generators before recharging of compressed air supply is necessary. Two air compressors will be installed providing redundancy for the starting air supply. These provisions will allow both generators to be started in a “black start” event.

Power for operation of the electrical switchgear and for operation of the control system will be provided by a 125 volt DC station service battery system, so all controls and switching functions will be operable in the event of a total electrical outage.

During normal utility operation, the system voltage and frequency are set by the interconnection with the utility. In the event a loss of voltage or an underfrequency condition is detected on any of the Con Edison primary feeders that comprise the microgrid distribution, isolation switches will open and those feeders will be connected to the DER.

The DER in normal grid paralleled operation will synchronize and follow the system frequency and voltage set by the grid. Each generator will operate in a fixed power factor mode as long as the utility grid is connected.

In a completely isolated island condition, the two natural gas generators will operate as base load generation in droop mode. The energy storage inverters will provide peaking power and will operate in isochronous mode. System voltage will be set by all generators providing VARS proportional to their power output, while minimizing circulating currents between generators. Control of voltage regulators in island mode will be by the microgrid controller.

The generator protection relays and 27 kV feeder breaker relays will have separate settings for island vs. grid paralleled operation to allow for low voltage low frequency ride through when islanded.

Grid paralleled interconnection will meet IEEE-1547 requirements as well as NPCC-A03 low frequency ride through standards. Unintentional islanding will be detected by the 81R function on the primary isolation switches, which will detect a high rate of frequency change and cause the isolation switch to open.

2.4: Electrical and Thermal Infrastructure Characterization

This microgrid project does not have a thermal component. The primary operating objectives are to provide demand reduction during grid paralleled operation and provide additional reliability of electric power delivery during partial or complete grid outages

2.4.1: Electrical infrastructure

Portions of Con Edison's existing 27 kV primary distribution system and portions of the existing low voltage (208/120V) secondary network system will be incorporated into the microgrid.

There will be a total of 8 points of interconnection with Con Edison's 27 kV primary system.

Remotely operable isolation switches equipped with protective relays that sense voltage, frequency synchronization and power flow will monitor and control the isolation switches to isolate the sections of the primary feeders that have failed or lost power feed from the utility system.

A series of isolation switches will be installed on secondary network to allow its separation from the remaining network in the event of a widespread power outage when the microgrid would be operating in island mode, without any utility source.

The Con Edison primary feeders within the microgrid run under each of the four parallel east-west streets: Sutton Ave., Blake Ave., Dumont Ave., and Livonia Ave. There are two feeders per street, a total of 8 feeders in total.

Two new feeders to connect the microgrid DER to the primary feeders will run north-south on Rockaway Ave.

Isolation switches at the east and west ends of each feeder allow the section containing the microgrid to be separated from the microgrid in the event of an outage.

Additional remote switches will allow the two new microgrid feeders on Rockaway Ave. to connect to each of the 8 east-west feeders. This will allow feeding power from other Con Edison feeders to the affected area in a partial outage and or power from the DER can be directed to this area.

In the event of an unplanned loss of power to one or more of Con Edison's feeders that supply the microgrid, the feeder can be isolated at both east and west ends and can be supplied with power via a connection to the new microgrid feeders. Power can then be supplied to the affected area via the remaining unaffected Con Edison feeders; by the microgrid DER or a combination of both.

Under this scenario, there would be no change in the switching configuration of the secondary system which would remain networked as presently operated. The existing network protectors on the secondary transformers would prevent reverse power flow into the inoperative feeder(s) when de-energized.

If an unplanned loss of all utility power occurs due to transmission failure or other major event, all of the primary and secondary isolations will immediately open to electrically isolate the microgrid from the remainder of the Con Edison system. Simultaneously all switches connecting the microgrid feeders to the Con Edison primary system will close.

Regardless of grid paralleled or island operation, power will be delivered to all buildings within the microgrid area via the existing secondary distribution system which will remain unchanged from its present networked configuration, with the exception of the isolation switches which will be activated only during a islanding event. Service connections to individual buildings and customers are unaffected by the microgrid.

2.4.2: Weather Resiliency

Both the primary and secondary distributions are completely underground and will be unaffected by weather. The new isolation switches and related equipment will be installed in underground vaults and will be designed to be protected from damage due to accidental submersion.

2.4.3: Black Start

The microgrid is capable of initiating operation from a completely "black" condition (total lack of power on the microgrid). A 125 volt DC battery and DC power distribution system will provide power to operate all microgrid protection and controls, communication and load management control systems, computer servers and remote terminal units. The stored energy in the battery/inverter system will maintain power to the most critical facilities throughout a major loss of power.

Each of the two 3 MW natural gas fueled generators is started by a stored energy system consisting of compressed air stored at 500 PSIG. Two independent compressed air systems will be provided each with sufficient compressed air storage to allow 3 start cycles without the need for recharging. Two AC power driven air compressors will be installed to recharge the starting air tanks once the generators are running.

2.4.4: Load following operation – Grid paralleled

During grid paralleled operation the reciprocating engines and battery are operated to provide demand reduction for optimal financial benefit to the system owners. The current grid-parallel model assumes that the primary goal is utility demand charge reduction based on the current demand charge structure as seen in appendix D: Grid Parallel Model Results. The engines and battery are dispatchable assets and their load reduction strategy can be modified based on system ownership and financial incentive structure.

2.5: Microgrid and Building Controls Characterization

See Appendix C, Control Architecture Diagrams CA-1 and CA-2 for a graphical representation of the control architecture. All microgrid controls will communicate over a dual redundant fiber optic network using SONET fiber communications protocols. The fiber network will be looped, and can operate with the complete loss of either loop and will automatically redirect network traffic in the event one or more cable sections are damaged.

SONET protocol allows both TDM and Ethernet communications over dedicated ePipes that establish low latency high speed communications for time critical operations and conventional packet switched Ethernet for non-time critical operations.

Protective relays and RTU's will communicate using NERC-IP compliant IEEE-61850 messaging allowing GOOSE and other message formats in a secure environment.

All devices on the control network will have redundant power supplies, at least one of which is DC supplied from the dedicated station service batteries. AC control power via the AC station service system will be used for control power as a redundant source and to power instruments that to not have DC power capability.

2.5.1: Servers

Dual Industrial hardened servers will be installed for each major function. Dual servers will be used for the Microgrid Controller, Data Historian, Event Recorder and HMI servers.

The Data Historian servers will run industry standard PI software for archiving and data retrieval.

The HMI servers will provide operational data to 2 operator workstations, each capable of performing all control and monitoring functions. The HMI software will be industry standard Wonderware.

All devices will receive an IRIG-B time synchronization signal from a GPS clock, distributed over the fiber network and corrected for latency at the multiplexers.

2.5.2: Microgrid Controller

The Microgrid Controller will monitor and control all interconnection switching devices as well as all distributed energy resources.

During grid paralleled operation, it will provide commands to the energy storage system for charging and discharging as well as kW charging and discharging level and power factor commands. It will also start, stop and monitor the operation of the two 3.0 MW generators, and issue kW setpoint voltage regulator mode and power factor commands. The microgrid controller will monitor the energy storage battery capacity and determine the optimum recharge time and rate.

During Island mode, the microgrid controller will monitor the voltage and frequency of the microgrid and issue voltage commands to the generator voltage regulator as well as to the energy storage inverters to maintain bus voltage. It will also monitor bus frequency and power demand and issue kW commands to the two generators to control the base load power production while maintaining desired headroom for peaking operation by the energy storage system.

2.5.3: Load management

The Microgrid controller will also provide the function of load management. All microgrid loads will be categorized into three levels: Level 1 are most critical, must run loads that are not shed for any reason.

Level 2 are less critical loads that may be shed temporarily to balance the generation/load ratio of the microgrid while operating in island mode. This could be the result of a sudden unanticipated increase in power demand, or the loss of one or more DER assets.

Level 3 loads are shed only in a major system emergency and only when necessary to maintain power to the Level 1 loads and prevent complete loss of power to the microgrid.

Under normal grid paralleled operation the load management system will continuously monitor the amount of power being imported from Con Edison and will have a load shedding solution ready for implementation should there be a loss of utility power.

In the event there is an unplanned complete loss of utility power, the load management system will immediately shed Level 2 loads to reestablish the generation/load ratio based on what DER assets were currently on-line. As additional generation is brought on line, the previously shed loads will be restored.

During island mode operation, the load management system will continuously monitor the microgrid load vs. online generating capacity, and will imitate starting of additional generation as necessary to maintain the required spinning reserve margin.

2.5.4: Data Historian

The data historian receives all operational parameters from the DER and switching equipment throughout the microgrid, all voltages, currents power flows, generator and inverter outputs etc. will be recorded on a continuous basis at 1 minute intervals.

The data historian also provides input to the economic dispatch controller for predicting the future demand profile. A report module within the PI software allows fully customizable reports of energy produced and consumed, generator run hours, fuel use emissions data, battery cycles and depth of charge etc..

2.5.5: Event recorder

The event recorder will provide a continuous time-synchronized electronic record of all normal and alarm events within the microgrid. This includes the opening and closing of primary and secondary isolation switches, breaker tripping and closing. Time of pick-up and drop out of protective relay functions, DER equipment alarms, telecommunication alarms etc.

2.5.6: Network and Communications

The following equipment forms the data network and communications backbone for the microgrid, integrating the protection, control and data collection functions into a secure and reliable system with integral redundancy and dedicated high speed communications paths for critical control functions:

- Multiplexers – SEL-ICON, dual protected line modules, dual Ethernet modules (8 LAN points ea.), (1) 125 VDC power supply, (1) 120 VAC power supply
- Time Synchronization – SEL-2047, IRIG-B output, 125 VDC, remote antenna
- RTU – for non-relay switchgear and load management I/O: SEL-2240 Axion RTAC, 10 or 4 module as needed, 125 VDC/120VAC power input.

2.6: Information Technology (IT)/Telecommunications Infrastructure Characterization

The primary telecommunications media for the microgrid control system will be the redundant, self-healing looped fiber optic network, running SONET protocol. Dedicated pathways will allow both TDM (high speed communications between time critical devices) and conventional packet switched Ethernet.

The communications backbone will only communicate with the outside world through a dedicated gateway that employs user authentication via Radius Server. There will be no open connection to the internet, and no use of common carrier fiber.

Communications with the utility (Con Edison) will be via this gateway. Con Edison will have full monitoring privileges as well as control functions that will be determined by a future operating agreement.

Outside vendor connections via the Web will not be allowed, but limited vendor access will be given to specific equipment through the secure gateway for remote troubleshooting and diagnosis. All communications through the gateway will be logged.

3: Microgrid's Commercial and Financial Feasibility

The proposed microgrid design is based on a business case that provides economic, environmental, and social benefits to the low to moderate income residents and business owners in one of the poorest census tracts in New York State. The issues faced by the Brownsville neighborhood inside the Brooklyn Queens Demand Management Zone are significant and diverse, affecting the local investor-owned utility, Con Edison, the local public housing authority, New York City Housing Authority (NYCHA), and hundreds of thousands of single family residential, multifamily residential, and commercial building owners and tenants. While creating an impediment to economic growth in the past, these issues represent an opportunity for the creation of tangible benefits through the implementation of the Brownsville Community Microgrid. The issues include: (1) a capacity-constrained electricity distribution infrastructure, (2) aging public housing building stock and a $17 billion capital repair backlog in the NYCHA budget, (3) the highest residential retail electricity rates and second highest commercial retail electricity rates of any zip code in the contiguous 48 United States[3], and (4) a history of blackouts due to both climate-change induced weather events, grid constraints, and poorly maintained building stock.

The business case for the Brownsville Community Microgrid is predicated on addressing each of these issues by deploying three distinct Distributed Energy Resources (DERs) and coordinating their development, integration, and deployment to maximize impact. The three DERs are: (1) 2.7 MW of solar PV installed on primary and secondary microgrid participants rooftops, (2) two 3.0 MW gas reciprocating engines, and (3) 4 MW of flow batteries that can provide 32 MWH of charge. The three DERs will: (1) deliver solar electricity to private sector commercial and residential building owners and occupants at a 10% - 40% discount to grid electricity, (2) provide islanding capability for the entire microgrid footprint, and (3) participate in DR programs offered by Con Edison.

3.1: Commercial Viability – Customers

3.1.1: Individuals Affected

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).

Microgrid Participant Summary		
Customer	**Facility Name**	**Individuals Affected**
NYCHA	NYCHA Van Dyke I	4,028
	NYCHA Van Dyke II	130
	NYCHA Brownsville	3,306
	NYCHA Tilden	2,628
	NYCHA Subtotal	**10,092**
NYC	Mother Gaston Branch Library	54,249
	PS 284 Lew Wallace School	495
	NYC Subtotal	**54,744**
Other	Brownsville Health Center	20,000
	Brownsville Baptist Church	TBD

[3] IOU rates by zip code database; http://en.openei.org/datasets/dataset/u-s-electric-utility-companies-and-rates-look-up-by-zipcode-2014

Aggregate Small Commercial on Perimeter	TBD
Aggregate Residential on Perimeter	TBD
Other Subtotal	**20,000**
Total	**84,838**

Table 9: Microgrid Participant Information

New York City Housing Authority

- Brownsville Development
  - 27 residential facilities
  - 3,306 residents
  - 819,997 sq ft
  - $447 average monthly gross rent

Brownsville NYCHA houses 3,306 residents in 1,338 apartments. Only 47% of households count employment among their sources of household income, with Social Security at 28% and Supplemental Security Income also at 28%. The Brownsville Houses also contain a senior center, which is designated by the NYC Office of Emergency Management as a “Cooling Center”. These Cooling Centers are meant to be a safe haven for residents particularly vulnerable to heat emergencies. The north block of Brownsville contains PS 284, the Wallace Lew public school, where many of the children living in Brownsville, Van Dyke, and Tilden attend school.

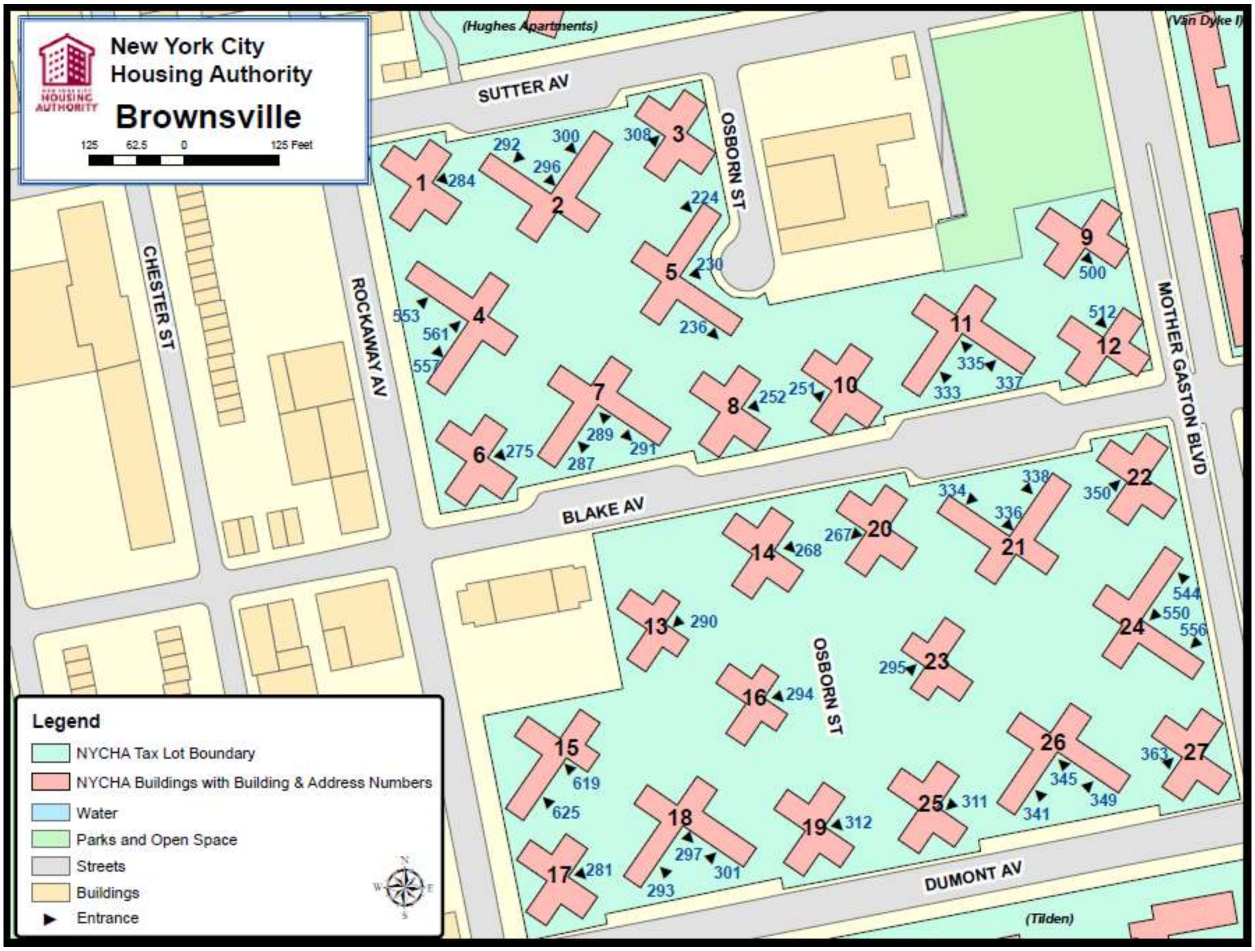

Figure 12: Brownsville Development Map

- Van Dyke I Development
  - 22 residential facilities, 1 non-residential
  - 4,028 residents
  - 911,494 sq ft
  - $447 average monthly rent

Van Dyke I NYCHA houses 4,028 residents in 1,603 apartments. Only 49% of households count employment among their sources of household income, with Public Assistance at 17, Social Security at 23% and Supplemental Security Income also at 27%. The Van Dyke I Houses also contain a senior center, which is designated by the NYC Office of Emergency Management as a “Cooling Center”, and a Community Center. The Community Center offers several programs for community benefit, including

- New York City Early Literacy Learning (NYCELL)
  The NYCELL Program seeks to strengthen language and prereading skills of children between the ages of one and four, so that they enter school ready to learn and to succeed. NYCELL is a collaborative effort between the Mayor's Office, the Department of

Education and NYCHA.[4]

- Cornerstone Program
  As part of the NYC Mayor's Action Plan for Neighborhood Safety, the Cornerstone Program is run by NYC Department of Youth and Community Development (DYCD) for children ages 5 and up, as well as adults. Child programming includes homework help, STEM activities, and high school and college prep; community beautification and mentoring; dance, music, singing, and photography; and healthy living activities. Adult programming designed to enhance skills and promote social interaction, community engagement, and physical activity.[5]

[4] NYCHA Resident Programs – Education Program, NYCELL; https://www1.nyc.gov/assets/nycha/downloads/pdf/RESIDENTS.PROGRAMS.EDUCATION.pdf
[5] NYC Mayor's Action Plan for Neighborhood Safety; http://www1.nyc.gov/assets/criminaljustice/downloads/pdfs/VanDyke_MAP3pgr_4-16-16.pdf

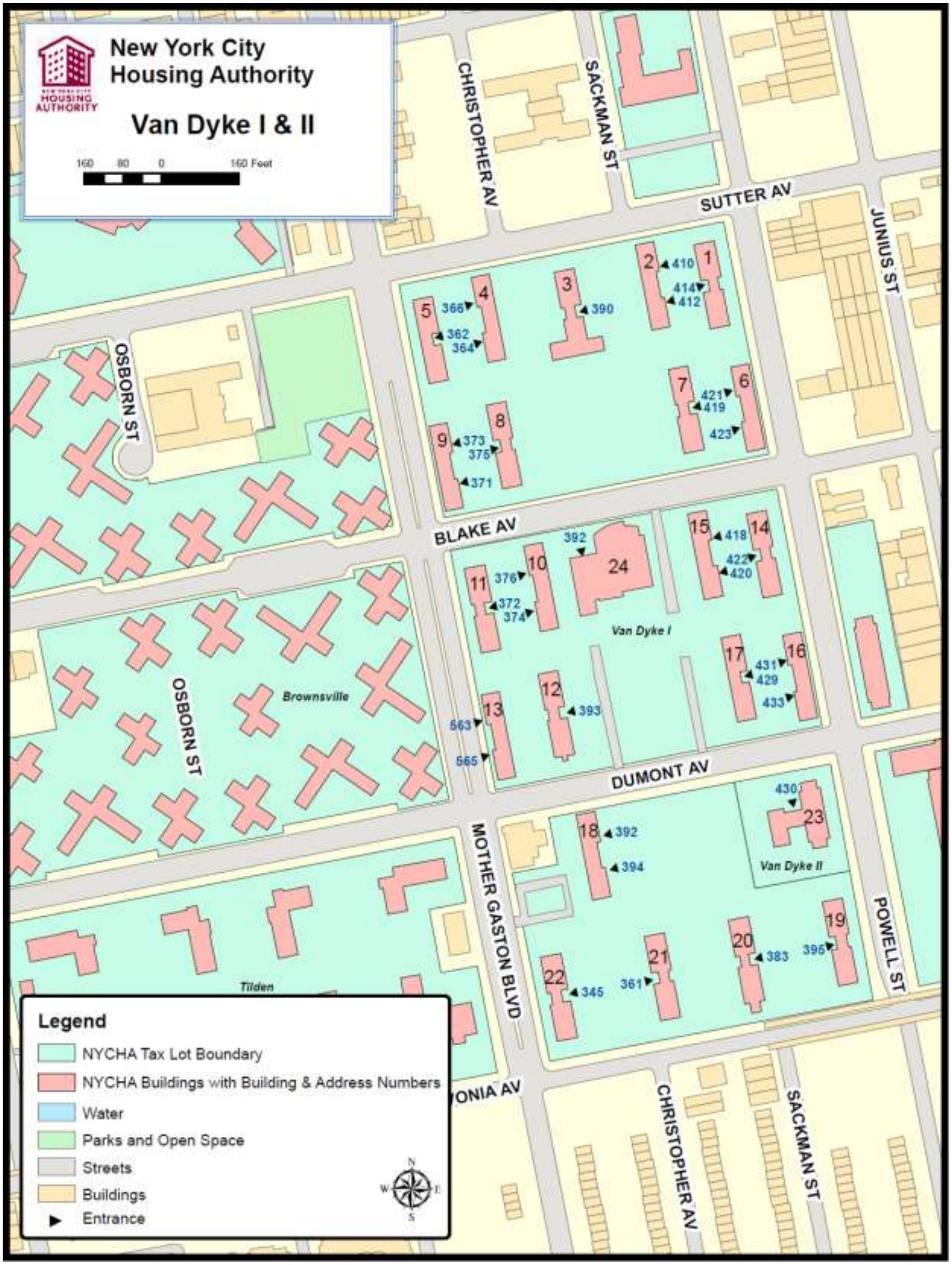
New York City Housing Authority
Van Dyke I & II
160 80 0 160 Feet
SUTTER AV
CHRISTOPHER AV
SACKMAN ST
JUNIUS ST
OSBORN ST
BLAKE AV
DUMONT AV
MOTHER GASTON BLVD
POWELL ST
Brownsville
Van Dyke I
Van Dyke II
Tilden
Legend
NYCHA Tax Lot Boundary
NYCHA Buildings with Building & Address Numbers
Water
Parks and Open Space
Streets
Buildings
Entrance

Figure 13: Van Dyke Development Map

- Van Dyke II Development
    - 1 residential facility (senior citizens)
    - 130 residents
    - 40,574 sq ft
    - $330 average monthly rent

Van Dyke II is an exclusively senior development, housing 130 residents in 112 apartments.

NYC Municipal Property

- K284 – The Gregory Jocko Jackson School of Sports, Art, and Technology
- Brooklyn Public Library – Stone Avenue Branch

The Stone Avenue Branch of the Brooklyn Public Library was opened on September 24, 1914 as the Brownsville Children's Library, the first public library in the world devoted to serving children. The branch was visited by librarians from around the world interested in learning about how to set up a children's library.

Figure 14: Brownsville Children's Library

Today the branch serves both adults and children, although many of the features that distinguished the branch as a place for children remain. Examples of children-centric educational programming include "Toddler time with Reading is Fundamental (RIF)", Kids Tech Time, and Chess for Teens. Expanded programming for adults includes job readiness and job skills trainings including Resume & Career Help and Computer Basics & Beyond. Located at 581 Mother Gaston Boulevard, it is a critical facility within the southern block of Van Dyke Housing.

Figure 15: Stone Ave Branch BPL

3.1.2: Direct Services

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 microgrid generates additional services for Con Ed and NYISO in two ways. The primary service is demand response, with 10 MW of callable capacity from batteries and gas fired generators that would be enrolled into the winter and summer NYISO DR programs and Con Ed's DLRP and CSRP summer programs. The secondary service is the improved reactive power characteristics, stable power quality, and optimized load shape on site enabled by timing charge and discharge of the battery to smooth on-site generation from the PV and match it with on-site load characteristics.

3.1.3: Customers

Identify each of the microgrid's customers expected to purchase services from the microgrid.

The primary customers for the microgrid will be the NYCHA buildings, NYC owned buildings, and privately owned buildings inside the microgrid footprint. These primary customers are physically connected to the microgrid and will take delivery of generation from microgrid DER assets specified below.

Secondary customers will be residential and small commercial customers in the surrounding neighborhood. Through the NYC Public Service Commission's Order Establishing Community Distributed Generation, these customers can receive a credit on their bill for rooftop solar generation on core microgrid rooftops.

"As described in the NEM Cap Order,2 community net metering would allow multiple customers to net meter from a single solar generation facility. The net metering credit the facility produced would be measured in conformance with Public Service Law (PSL) §66-j. Utilities would, as a billing service provided under PSL regulation, break up the credit into amounts offset against the utility accounts of the participating customers."[6]

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[6] STATE OF NEW YORK PUBLIC SERVICE COMMISSION, CASE 15-E-0082 - Proceeding on Motion of the Commission as to the Policies, Requirements and Conditions for
Implementing a Community Net Metering Program. ORDER ESTABLISHING A COMMUNITY DISTRIBUTED GENERATION PROGRAM AND MAKING OTHER FINDINGS

Figure 16: Microgrid Customers

The yellow box outlined in Figure 16 shows the buildings physically connected to the microgrid. This core microgrid area contains all Brownsville, Van Dyke I & II, and Tilden NYCHA developments. It also contains the elementary school K284, the Brownsville Baptist Church, and the Stone Avenue Branch of the Brooklyn Public Library. Core microgrid buildings will be given a PPA covering specific DER assets and power generation amounts. During grid parallel mode, core buildings would receive power from those DER assets only and receive additional power from the grid. In island mode, core buildings would receive 100% of their power from all the production and storage assets of the microgrid.

The purple areas in Figure 16 show the buildings not physically connected to the microgrid, but who would benefit from a Community Solar Agreement. These are residential and commercial areas in Brownsville where single family homeowners and small commercial building owners and tenants often pay higher $/kWh charges than larger buildings and would benefit financially from a reduced electricity bill. When the microgrid operates in island mode, these customers would not be supplied.

3.1.4: Other Stakeholders

Identify other microgrid stakeholders; what customers will be indirectly affected (positively or negatively)

NYCHA OEM Cooling Centers

In 2014, NYCHA facilities housed three separate cooling centers designated by the NYC Office of Emergency Management as cooling centers, "a facility, such as a senior center or community center, where people may go to enjoy air-conditioned comfort during a heat emergency." Since the heat wave in July and August of 2006 which claimed 46 lives and disrupted power throughout the city, cooling centers have played a major role in the lives of seniors and other citizens prone to heat-related illness. Within these 6 blocks of NYCHA housing, there are approximately 1,000 senior citizen residents. Brownsville Senior Center, Van Dyke Community Center, and Tilden Community Center were all OEM designated cooling facilities in 2014.

Heat waves continue to threaten the lives of seniors and other citizens in NYC. During summer 2016, Con Edison asked New Yorkers to switch from air conditioning to fans "as it struggles with electrical problems in several areas after demand reached a weekend record of 11,855 megawatts."[7]

Brownsville Multi-Service Family Health Center

Formed in 1982, BMS Family Health Center is a Federally Qualified Health Center. BMS operates out of ten (10) service sites throughout Brownsville and East New York. BMS Family Health Center is a Joint Commission Accredited medical practice in Brooklyn (which is the gold standard seal of approval for quality provision of health care) and a Patient Centered Medical Home Level 3 (the highest level). The practice uses state-of-the-art technology (Electronic Medical Records) to ensure cost effective, efficient, and high quality client-driven services. The main BMS facility opened in 1992, and is a 27,000 sq. ft. two-story building located at the corner of Rockaway & Blake Avenues in Brownsville.

3.1.5: Owner – Purchase Relationship

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

The project sponsors and the developer will set up a Special Purpose Entity (SPE) that will house the assets and operate the microgrid. The SPE will be an operating company with a 20-year energy services agreement with the host to operate the microgrid on its premises. The host will be the primary beneficiary of the energy and power performance characteristics, but it will not be the off-taker of the solar PV. The SPE will also be a sponsor entity to sell energy generated by the microgrid solar PV to members of the residential community immediately surrounding the host site, with no PV load being consumed by the host. Subscribers to the community solar component will be enrolled by the SPE on one-year contracts that automatically renew during the life of the microgrid.

[7] http://www.bloomberg.com/news/articles/2016-08-14/new-york-heat-overburdens-utility-as-authorities-urge-ac-use

3.1.6: Operation Type

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

During grid parallel mode, NYCHA will be the beneficiary of all energy savings and electricity generation attributed to the batteries and will purchase all energy produced by the generators, and the community solar subscribers will purchase all electricity generated by the PV.

During island mode, all resources will be diverted to support the full operation of the microgrid facilities, and NYCHA will purchase all electricity from the batteries, generators, and PV.

3.1.7: Contracts

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

	CDG	DER PPA	ESA
NYCHA	N	Y	Y
NYC K284 Public School	N	Y	Y
Brooklyn Public Library – Stone Ave Branch	N	Y	Y
Brownsville Baptist Church	Y	Y	Y
Brownsville Multi-Service Family Health Center	Y	Y	Y
Greg Jackson Community Center	Y	Y	Y
NYC K150 Public School	N	Y	Y
Small Commercial & Residential Customers Inside Microgrid	Y	N	N

Table 10: Planned Contracts

- CDG – Community Distributed Generation Subscriber Agreement
    - Offered to customers who pay more than $0.17/kWh average for electric utility service
    - Service only available during grid-parallel microgrid operation mode
    - Opportunity to own a small portion of 2.7 MW in Community Solar assets
    - Financed in SPE pool
- DER PPA – Distributed Energy Resource PPA
    - Offered to NYCHA and other core microgrid customers
    - Off-taker agreement for all non-solar generation including gas reciprocating engines and battery storage during grid-parallel mode microgrid operation
    - Financed in SPE pool
- ESA – Energy Services Agreement
    - Offered to all potential customers to provide energy efficiency services
    - Financed in SPE pool

3.1.7: Solicitation of Customers

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

BlocPower has already begun outreach to customers, having presented the proposed microgrid to NYC NYC Mayor's Office of Resiliency and Recovery staff and director, NYCHA Energy Capital Projects staff and director, the Brownsville Multi-Service Family Health Center board, local homeowners association, local business improvement districts, and local small commercial building owners.

For buildings in the core microgrid footprint, these discussions led to Letters of Support from NYCHA, Brooklyn Public Library, Con Edison, the New York Power Authority (NYPA), Brownsville Multi-Service Family Health Centers, and the Brooklyn Alliance for Sustainable Energy (a consortium of community-based organizations in Brooklyn advocating for sustainable energy implementation in Brooklyn's underserved neighborhoods)

Customers will also be solicited from homeowners and small commercial building owners that live and work in the Brownsville and East New York neighborhoods served by the same electric service feeder lines.

3.1.8: Energy Commodities

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

The microgrid could potentially switch from gas reciprocating engines to combined heat and power. In this alternative scenario, steam would be produced for NYCHA's steam boiler plants

3.2: Commercial Viability - Value Proposition

3.2.1: Benefits and Costs

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

Providing on-site generation and the ability to island critical facilities will deliver significant resiliency benefits for the community. The critical facilities identified in this proposal perform vital functions for the community during both weather-induced grid outages and other emergencies. Brownsville Multi-Service Family Health Center is a Joint Commission accredited medical practice in Brooklyn and a Level 3 Patient Centered Medical Home (the highest level). BMS provides several services that benefit the community and require continuous service including (1) an infectious disease practice, (2) a senior citizens specialty within the adult medicine practice, and (3) a pre-natal and post-natal nutrition program.

The proposed microgrid site is situated in category 4 NYS OEM hurricane storm surge zone as indicated by research conducted at NYC Environmental Justice Alliance (NYC-EJA).

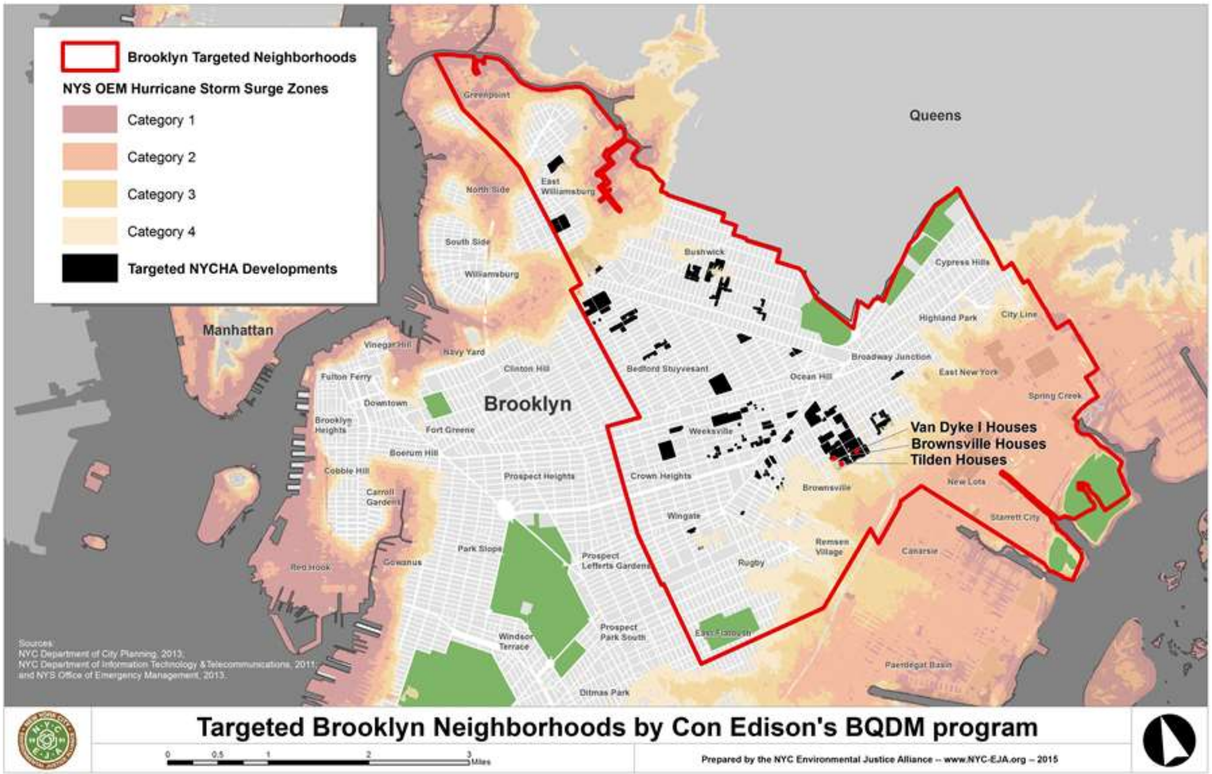

Figure 17: NYS OEM Hurricane Storm Surge Zones, Con Edison BQDM, and NYCHA Developments

The resiliency benefits for microgrids in storm surge zones was made evident by Hurricane Sandy.

The community in the 6-8 blocks of the proposed microgrid experience high rates of poverty and unemployment. According to 2013 data from the US Census Bureau, census tracts 910 and 912 (the 6 blocks of NYCHA housing) house 8,472 residents age 16 years and older. Of those, only 2,647 are employed (31%). A full 5,054 are considered “not in the labor force”. Of the 4,592 households, 55% fall below the national poverty line.

One of the primary benefits of the community-owned microgrid is to generate economic value for community members through equity ownership of energy-generating and energy-saving assets. Annual dividends paid from the SPV to the CBO owners would be distributed to heads of households through a debit card given to heads of household that participate in energy conservation outreach and sign up as potential microgrid co-owners. The amount, quantity, and frequency of projected dividends depends on the results of the feasibility assessment.

3.2.2: Impact to Utility

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?

This microgrid and the community solar subscribers are located entirely within the boundaries of Con Ed’s Brooklyn Queens Demand Management Program (BQDM). BQDM was developed as an alternative response to rapid load growth within local networks that is forecast to require major infrastructure upgrades to support continued growth. Rather than spend $1 billion on traditional transmission and distribution infrastructure upgrades, Con Ed plans instead to spend $200 million on a combination of non-traditional utility and customer side of the meter (CSM) demand reduction strategies to achieve a total of 52 MW of load relief by 2019. Those strategies could include efficiency and optimization strategies, solar PV, battery storage for peak shaving and load shifting, CHP and fuel cells, and enhanced demand response programs. The Brownsville Community Microgrid employs multiple CSM strategies to provide as much as 10 MW of load relief in emergency BQDM events, and as many 4 MW of summer peak capacity reductions in normal operations.

The cost Con Edison will incur will be paid out to the microgrid developer in the form of program incentives, which are modeled in this submission at $7.2 million. As a share of the $200 million allocated for achieving 57 MW of load reduction, this project represents $35 million of proportionate cost when measuring by full discharge in emergency events or $14 million when measuring by normal summer operations. In either case, the utility is getting a substantial discount to the unit cost of capacity reduction earmarked in the program.

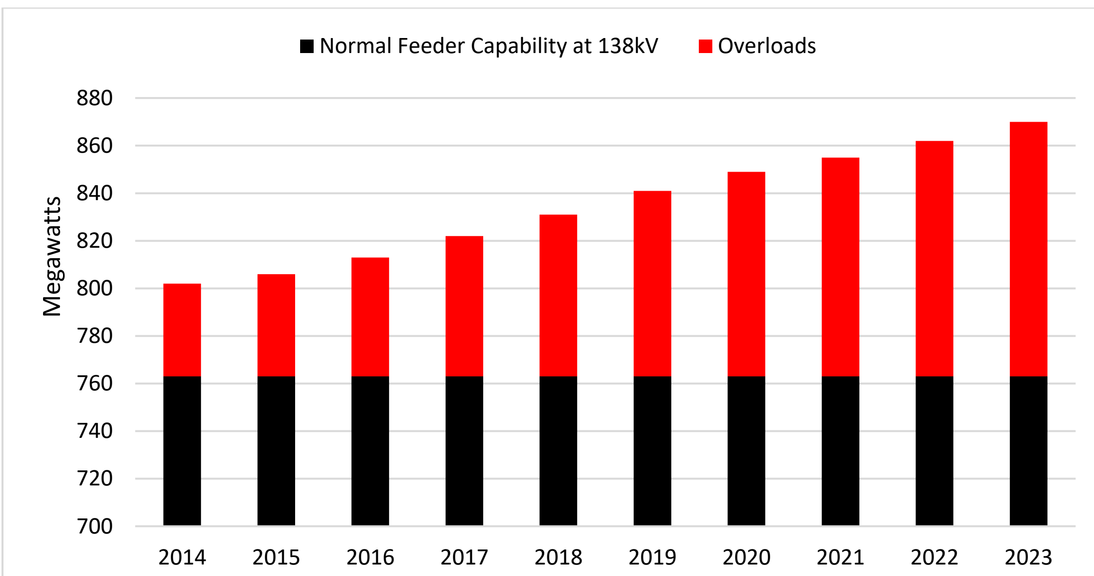

Figure 18: Con Edison Load and Feeder Overload Growth Projection

Con Edison would benefit from the microgrid in multiple ways. First, as a potential demonstration project for the PSC's "Reforming the Energy Vision" (REV) initiative, a community-owned microgrid in an LMI area with Con Edison as co-owner and partner to a collection of community-based organizations would be an strong example of the type of innovative and forward-thinking solutions Con Edison is able to execute as a Distributed System Platform Provider (DSPP). One of the key issues in REV revolved around the question of utilities owning distributed generation assets while also managing the platform that provided other non-utility parties an opportunity to own distributed generation. This new SPV structure would demonstrate that Con Edison could own generation as a partner to the community while acting as DSPP. The second benefit to Con Edison would be the reduction of demand for grid-based electricity within the Brooklyn Queens Demand Management (BQDM) Zone. On August 21, 2014, Con Edison filed its Brownsville Load Area Plan with the Public Service Commission to reduce load BQDM. The plan involves a combination of distributed generation, demand management, and energy efficiency implemented on the customer side to reduce demand by 41 MW and microgrid and storage on the utility side to reduce demand by 11 MW.

3.2.3: Proposed Business Model

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

The proposed business model is a Joint Ownership/Cooperative, where an SPE owns and operates the microgrid to serve the electric and/or thermal energy needs of its owners. Other customers may voluntarily join the microgrid and be served under contract. The system's wires and pipes may cross a public way/utility franchise. The microgrid will operate as a Public Private Partnership (PPP); it will be financed with private capital and public incentives to operate in a low-income community. Set forth below is a SWOT analyses for the proposed Community Microgrid.

Strengths

- Energy efficient system with low emissions
- Customers benefit from saving on their utility bills
- Provide resiliency to power vital services
- Cost competitive compared to Con Ed alternatives
- Flexible architecture: AC or DC
- NYCHA Repair Fund benefits from Peak shaving & shifting savings

Weaknesses

- Search for customers as off-takers of generated power
- Novel regulatory and business risks
- Required maintenance and operation costs over a 20 year period

Opportunities

- Provide Demand Response
- Scalable project across similar housing projects
- Tax equity benefits
- Lack of cost-competitive battery storage
- Business models not yet mature

Threats

- Inability to secure financing
- Damage to exposed solar equipment on rooftops
- Information deficits (such as pricing) can yield unrealistic expectations

- Inadequate market precedents

<table>
<tr><th colspan="8">Physical Microgrid Ownership & Control Options</th></tr>
<tr><th colspan="2">Utility Owner</th><th colspan="6">Non-Utility Owners</th></tr>
<tr><th colspan="2">Owns Wires</th><th colspan="3">Own Use</th><th colspan="2" rowspan="3">II(c): Own Use with Some Merchant Sales</th><th rowspan="3">II(d): Merchant Sales Only</th></tr>
<tr><th>I: Owns Generation</th><th>II: Non-utility generation</th><th colspan="2" rowspan="2">II(a): One Owner</th><th rowspan="2">II(b): Multiple Owners</th></tr>
<tr><th>Manages Control</th><th>May/may not manage controls</th></tr>
<tr><td>Vertically Integrated</td><td>Un-Bundled</td><td>Campus 1</td><td>Campus 2</td><td>JV/Co-op</td><td>Campus 3</td><td>JV/Co-op</td><td>Independent Provider</td></tr>
</table>

Vertically Integrated Utility Model: Con Ed owns the microgrid distribution infrastructure and generation and storage technologies operating on the system, providing electric and/or thermal energy services to NYCHA. Con Ed also operates the microgrid control system, determining which generating units run and directing DR

Unbundled Utility Model: Con Ed owns and maintains the microgrid distribution infrastructure, while generation and storage assets are owned by CBOs. Con Ed will accommodate the interests of CBO asset owners in scheduling by being an active partner with customers and generators to facilitate and manage the aggregation of loads and the deployment of generation

Landlord/Campus Model, Type 1: NYCHA operates the system and installs private wires and generation technologies on site, supplying electric and/or thermal power to multiple buildings also owned by the landlord-operator. The microgrid does not cross a right of way and only serves NYCHA residents.

Landlord/Campus Model, Type 2: This model is the same as Type 1, but wires/pipes may cross a public way or utility franchise. An example of a Type 2 Landlord/Campus model is New York University's (NYU) microgrid in Washington Square Park

Landlord/Campus Model, Type 3: This model is also the same as Type 1, but wires/pipes may cross a public way/utility franchise and previously unaffiliated neighboring customers may voluntarily join the micro-grid and be served under contract. The Burrstone Energy Center in Utica, NY is an example of this model.

<u>Joint Ownership/Cooperative</u>: An SPV owns and operates the microgrid to serve the electric and/or thermal energy needs of its owners. Other customers may voluntarily join the microgrid and be served under contract. The system's wires and pipes may cross a public way/utility franchise.

3.2.4: Unique Project Features

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

This project represents the adaptation of existing technologies that are deployed reliably in thousands of assets across the world, but combined and operated in a unique way to maximize revenue and make the project investable. Most use cases for these technologies examine them as individual technologies with discreet costs, operations, and revenue streams, but, by combining these assets into a single project, we are able to realize the cost efficiencies of overlapping infrastructure and operational needs and still direct the use of those assets to their highest revenue opportunity. This business model innovation, in combination with the intelligent site controls to automate the optimization of the operation of the assets in the microgrid, allow us to deliver the substantial energy, environmental, and social benefits to stakeholders while still making this a profitable project for potential investors.

3.2.5: Replicable

What makes this project replicable? Scalable?

This project is replicable because it uses existing technologies with proven performance track records to address energy and cost challenges in public housing, in which there is substantial consistency in building stock characteristics, operational characteristics, ownership structure, deferred capital maintenance needs, and opportunity for immediate social benefit within and around these communities. In public housing across the country, energy projects that not only deliver environmental and social benefits but also generate enough revenue and savings to be diverted back to the communities can create a robust new market-based funding stream to address massive capital needs in underserved communities, addressing the substantial needs of public housing stock at the same time as it drives the national carbon footprint down in a meaningful way.

The project is scalable because it provides returns high enough to attract private capital despite working in what has been considered a higher risk area of the market, with minimal public investment required to generate the returns required by the marketplace. As this model is replicated and proven out over time, competition for these assets will likely increase, driving down the costs and enabling a potential phase out over time of the incentives currently required to leverage private sector investment. At the same time, as public housing agencies start to see the substantial benefits these projects bring to their properties, their constituents, and their budgets, the appetite for these projects will likely also increase, providing tailwinds on the supply side to match the growth in demand.

3.2.6: Project Motivation

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.

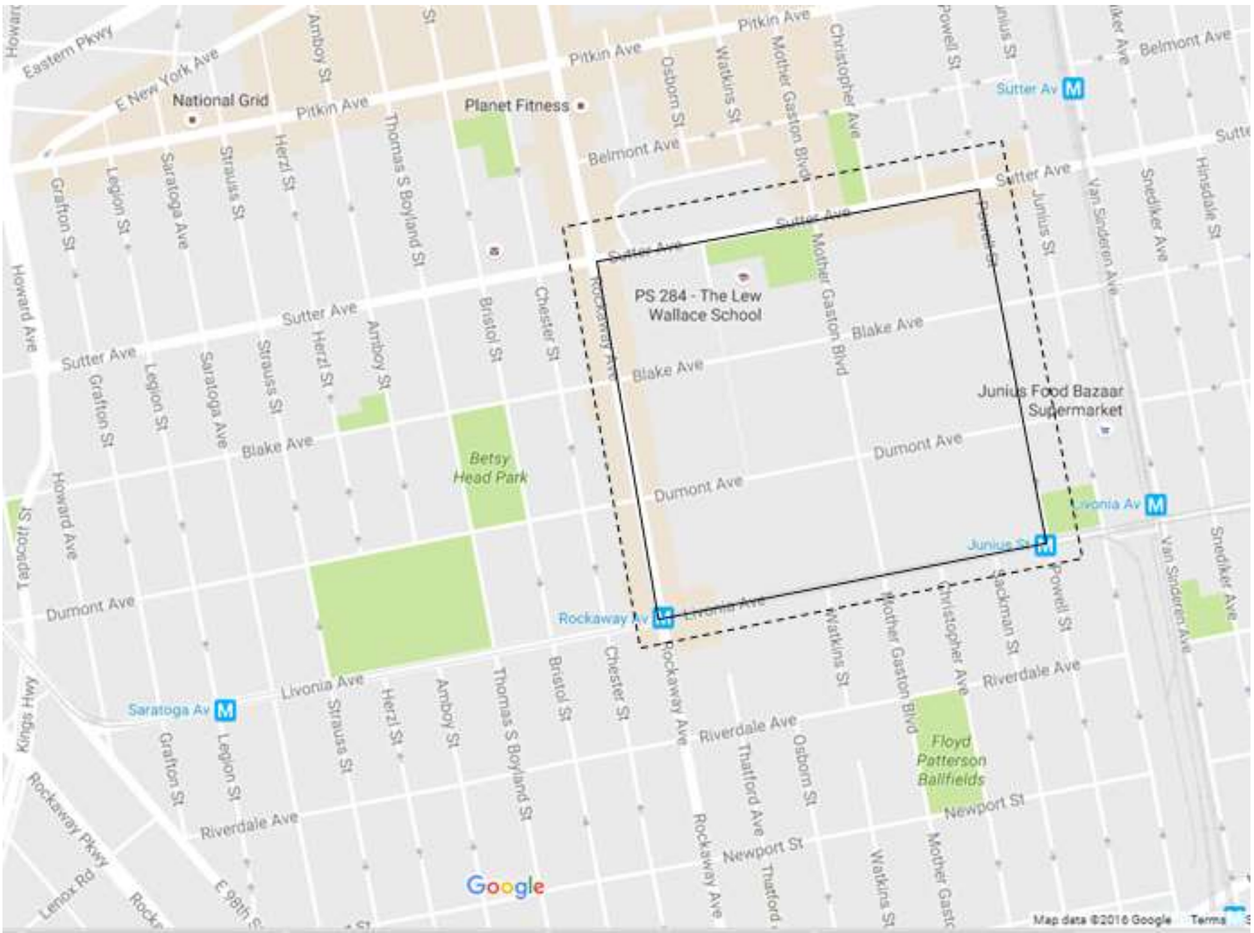

Figure 19: Core Microgrid Footprint

The microgrid will provide full power and electric utility services for the buildings included in Figure 19. The need for islanding capabilities is evident through two different type of grid disruptions:

- Outages caused by storm-related events

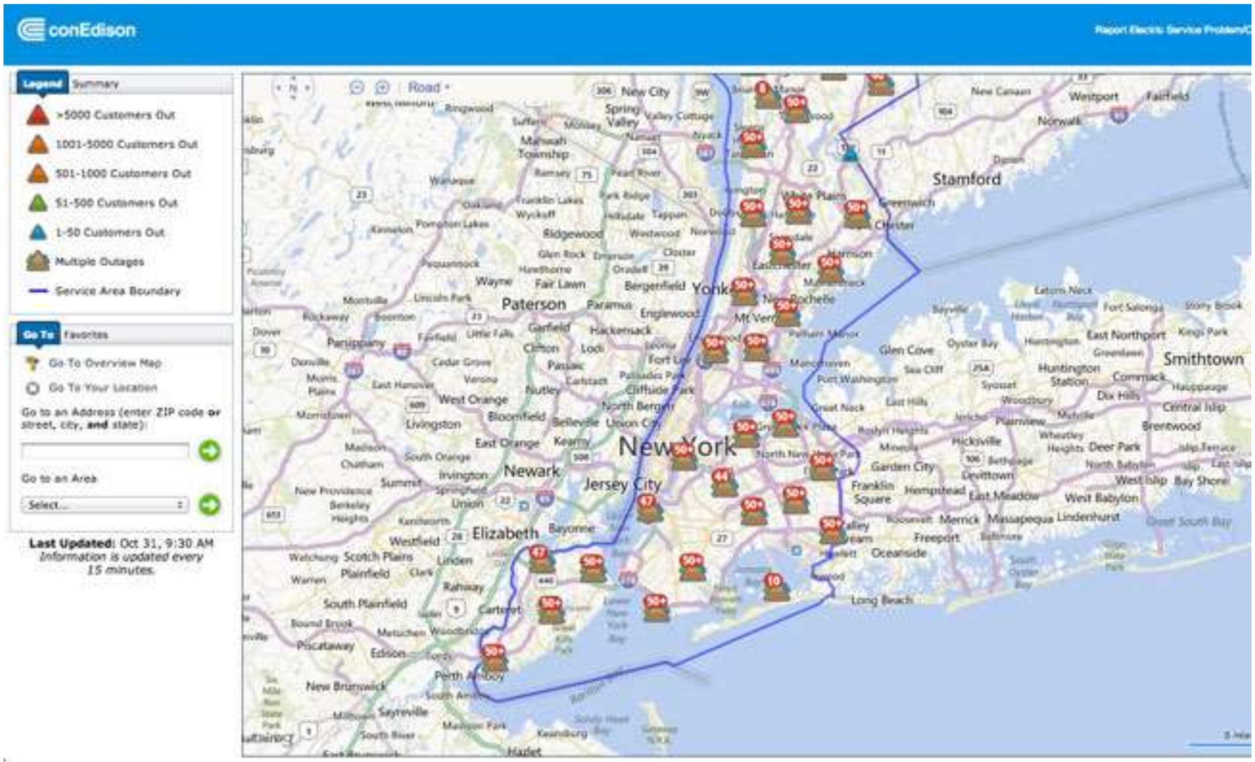

Figure 20: Con Edison Outage Map Following Hurricane Sandy

The map in Figure 20 shows power outages in Con Edison service territory two days after Hurricane Sandy made landfall in New Jersey. According to Con Edison, 900,000 in New York City and Westchester County had lost power due to the storm.[8]

Figure 21: Hurricane Sandy Shorefall Timeline

[8] http://newyork.cbslocal.com/2012/11/01/con-ed-says-vast-majority-will-have-power-restored-by-next-weekend-nov-10-11/

Figure 22: Hurricane Sandy Utility Service Recovery Efforts

- Outages caused by heat-related events

  Con Edison asks customers in several Brooklyn neighborhoods to conserve energy in midst of heat wave[9]
  BROOKLYN — Con Edison is asking residents in Brooklyn neighborhoods to conserve energy as they repair equipment problems on a day that temperatures are expected to reach over 100 degrees.

  People living in Sheepshead Bay, Marine Park, Gerritsen Beach, Midwood, Flatbush and East Flatbush are affected by this notice that was put out Saturday afternoon.

  The electrical company also reduced voltage by 5 percent in these neighborhoods to help repair electrical problems that have left about 200 residents in Brooklyn without electricity as of 1 p.m. The majority of the outages are in Flatbush, according to Con Edison's outage map.

  Customers are also asked not to use appliances such as washers, dryers, microwaves and air conditioners only if they have no health or medical issues, Con Edison said.

[9] http://pix11.com/2016/08/13/con-edison-asks-customers-in-parts-of-brooklyn-to-conserve-energy-in-midst-of-heat-wave/

Residents in several Queens neighborhoods were also issued the same notice Friday. That notice is still in effect.

Temperatures are expected to reach between 105 and 110 degrees all weekend, with a chance of showers and thunderstorms. The National Weather Service has issued an excessive heat warning that will remain in effect until 10 p.m. Sunday.

Though Con Edison has asked residents to reduce energy-intensive appliances, the city has asked people to turn on their air conditioners to stay cool. Cooling centers are available throughout the city for people without one.

3.2.7: Value Proposition

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 value proposition to the host is comprised of immediate cash flow benefits; electrical reliability and resiliency, including full electrical operational capacity during outages; upgraded electrical infrastructure at no cost; and the ability to provide clean power and contribute to a healthier environment for its residents and the surrounding community.

The value proposition for the residents within the microgrid is a new funding stream to support much needed and wanted capital improvements to their homes and common spaces, as well as direct connection to the clean power generated on site that will offset the need for drawing on dirty peaker plants, some of which are located in the immediate vicinity of the microgrid.

The value proposition for the surrounding community is reliable access to lower cost energy generated by local renewable assets.

The value proposition to the utility is a substantial reduction in capacity need for one of their most stressed distribution networks, at a far lower cost per unit than they are currently allocating.

The value proposition to the developer is a reasonable fee in exchange for the risk and cost of assembling a complex project.

The value proposition to the owner and investors is a satisfactory risk adjusted return.

3.2.8: Financial Impact to Purchaser

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

- Community residents will benefit from savings accruing from Peak Shaving and Peak Shifting. These savings can provide up to 40% of savings to residents.

- NYCHA stands to benefit from Peak Shaving and Peak Shifting savings that will fund a Tenant Repair Fund. NYCHA will control the Tenant Repair Fund that is estimated to receive $465k a year for 20 years.

3.2.9: State Objectives

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

This project promotes state energy policy objectives in two primary ways.

First, this project will attract private third party capital to invest in distributed energy assets that bring benefits both to the host property and surrounding community and also the wider utility network and NYISO grid. It represents a viable alternative, and much more cost effective approach, to the traditional utility solution for a forecasted major capacity shortfall in area of concentrated rapid demand growth.

Second, it brings the benefits of distributed clean energy assets to LMI communities that traditionally have high barriers to adoption and few opportunities to access the health and financial benefits of clean energy. Not only that, it leverages the substantial financial benefits of clean energy projects to pay for much needed capital improvements in taxpayer funded housing organizations with longstanding fiscal challenges.

3.2.10: New Technology

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

While all of the technologies employed in this microgrid have existed in the marketplace for a great deal of time and have proven track records of performance, the market for solar is just now approaching maturity, and is far from mature for batteries. This project would represent the single largest CSM battery deployment in New York City and play a significant role in demonstrating the value CSM battery storage projects in markets with clear price signals for the services that batteries provide to customers and utilities.

In addition, the use of intelligent controls for the integration of the assets enables what were once independent stand-alone assets to interact in a seamless manner for performance optimization and system flexibility. As much as this is a microgrid demonstration project, it’s also a demonstration of the power and scope of the Internet-of-Things to enable new business models and use cases for existing technologies. By networking distinct assets and controlling their operation through software that is responsive to real time data, the capabilities and flexibility of these assets increases at the same time as the cost to operate them decreases.

3.3: Commercial Viability - Project Team

The Contractor shall address no less than each of the following items below in describing the structure of the project team and the roles, strengths and resources of its members and other necessary partners.

3.3.1: Local Partners

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

BASE Coalition

The Brooklyn Alliance for Sustainable Energy (BASE) is a coalition of community-based planning organizations and local development corporations from Brooklyn that are working together to advocate for cleaner sources of energy; developing scalable and long-term equity business models; and building a more efficient and resilient energy infrastructure. Our efforts take place in the context of the New York State Public Service Commission's (PSC) Reforming the Energy Vision (REV) and Con Edison's Brooklyn - Queens Demand Management (BQDM) program. We are advocating for a transparent decision-making and implementation process: strong provisions to control the environmental justice impacts of projects on vulnerable communities; and a diverse and equitable energy market in compliance. Current BASE members include: Bedford Stuyvesant Restoration Corporation, Bridge Street Development Corporation, Brooklyn Movement Center, Cypress Hills Local Development Corporation, El Puente, Local Development Corporation of East New York, New York City Environmental Justice Alliance, and Make The Road New York.

Brownsville Multi-Services Health Center

Formed in 1982, BMS Family Health Center is a Federally Qualified Health Center. BMS operates out of ten (10) service sites throughout Brownsville and East New York. BMS Family Health Center is a Joint Commission Accredited medical practice in Brooklyn (which is the gold standard seal of approval for quality provision of health care) and a Patient Centered Medical Home Level 3 (the highest level). The practice uses state-of-the-art technology (Electronic Medical Records) to ensure cost effective, efficient, and high quality client-driven services. The main BMS facility opened in 1992, and is a 27,000 sq. ft. two-story building located at the corner of Rockaway & Blake Avenues in Brownsville.

3.3.2: Team Members

What role will each team member (including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners) play in the microgrid?

Team Member	Role	Notes
BlocPower	Project Developer	Administers SPE; raises debt raises and equity capital
TRC Solutions	Design Contractor	Feasibility assessment; preliminary design
BASE	Community Advocate	Environmental review; community organizing
NYPA	NYCHA/NYC Utility	Current NYCHA & school/library utility (O&M)
Con Edison	Non-NYCHA Utility	Current electric utility for Brooklyn
Private sector lenders	Capital Provider	NYPA, NY Green Bank, GS UIG, Generate Capital
NYCHA	Microgrid User	Off-taker for gas-fired power in parallel mode
Brooklyn Public Library	Microgrid User	Off-taker for gas-fired power in parallel mode
PS 284	Microgrid User	Off-taker for gas-fired power in parallel mode
BMS Health	Microgrid User	Off-taker for all power in parallel mode

Local Residents	Microgrid User	Off-taker for solar power in parallel mode

3.3.3: Public/ Private Partnerships

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

Public-private partnerships are a key feature of the project given that the off-takers for all of the power is a mixed group consisting of both public and private entities. The public entities have different utility service providers than the private entities, and pay different prices than the private entities. That allows the microgrid ownership entity, the Special Purpose Entity, to charge different prices for power from different sources. It also allows the SPE to provide power to different customers under different circumstances. Public entities that are considered critical facilities for the community can be offered resiliency services including, but not limited to, providing power during a grid outage. The microgrid is designed to support the largest number of critical facilities possible while running in island mode, and to create the largest amount of renewable energy possible for private off-takers in parallel mode.

3.3.4: Applicant Financial Strength

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.

The owner of the microgrid will be a Special Purpose Entity (SPE). Based on extensive financial analyses, the financial position of the SPE is very robust. Over the 20-year life cycle of the microgrid, the SPE will generate ~$158 million in revenue and $98 million in EBITDA. The SPE is also estimated to generate enough cash flows (with available revolver borrowing capacity) to cover debt service each year for the 20-year period. Returns to Cash and Tax Equity Investors clear a 15% hurdle rate and go up to 30+% depending on mix.

3.3.5: Qualifications

For identified project team members, including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners, what are their qualifications and performance records?

About BlocPower

Founded in December 2012, BlocPower markets and finances the installation of distributed generation and energy efficiency upgrades in multi-family, small business, non-profit, and other commercial properties in American inner cities. BlocPower creates micro-portfolios, or “blocs”, of shovel-ready clean energy projects and connects them to investors seeking social, environmental, and financial returns via an online marketplace. The company develops projects through community-based outreach, conducts engineering analyses to determine project feasibility and financial viability, and provides financing through an Energy Services Agreement (ESA) and a Special Purpose Vehicle (SPV). Our end-to-end “Energy Concierge” approach allows building owners in underserved communities to bypass the technology adoption, engineering, and financial barriers that traditionally prevent small businesses, non-profits, and multi-family building owners and tenants in underserved communities from accessing the savings and environmental benefits generated through clean energy. Aggregating the demand for retrofits allows BlocPower to negotiate the hiring of local unemployed residents to perform installations, which creates significant social value in underemployed communities. BlocPower aims to cut energy costs by an average of 20% for the property owners who live and work in the least efficient, oldest, and highest energy intensity buildings in New York City. BlocPower is the recipient of a $2.1 million investment from the Department of Energy, in addition to matching services and capital from NYSERDA, Emerald Cities, Wall Street investors such as George Soros, and Silicon Valley investors such as Andreessen Horowitz and Kapor Capital. In the past 6 months, the company has assisted several dozen clients representing hundreds of buildings in New York City, including small businesses, houses of worship, and educational institutions. In 2014, BlocPower was selected as a White House Champion of Change.

About TRC

TRC provides comprehensive services to the energy industry from generation to consumption including: energy generation, power transmission & distribution, energy efficiency, demand response, end-use energy management, renewable energy, and environmental protection. TRC has participated in three NY Prize Microgrid Feasibility Assessments: Endicott Community Microgrid, Brownsville-Van Dyke Community Microgrid, and Town of Huntington Microgrid and acts as the technical advisor to the State of Connecticut Microgrid Pilot Program.

TRC

- Incorporated in 1969
- 3,000 employees in 110+ U.S. offices
- Ranked 32nd in ENR's Top 500 Design Firms (2013)
- $434 Million annual revenue
- Proven track record resulting in a repeat business ratio of greater than 80%
- Award-winning Corporate Safety Program

TRC has deep project execution qualifications in the multi-disciplinary fields required to develop a successful micro-grid project. This section highlights specific projects that TRC has executed which highlight expertise in: microgrid development and community planning, power delivery engineering, distributed energy resources, and community engagement.

State of Connecticut Microgrid Pilot Program

TRC is a technical advisor to the Connecticut Department of Energy and Environmental Protection (DEEP), Connecticut Light & Power (CLP), and United Illuminating (UI) for the State of Connecticut Microgrid Pilot Program. The program awarded $24M in 11 microgrid projects through March 2015. The program is currently preparing to commence a third round of awards.

TRC helped establish the project feasibility application process and has supported the evaluation of project plans based on criteria including safety, technical feasibility, societal benefits, economic benefits, financial considerations, configuration of power distribution to customers, and project costs. TRC works closely with DEEP and the Connecticut utilities to select technically viable and economically justifiable microgrid projects for which funding is awarded by DEEP. Successful projects will leverage clean and green energy sources to maintain critical services for cities and towns across the state. Leveraging and developing its microgrid expertise, TRC has:

- Developed the program's technical standards

- Established project evaluation and scoring methods
- Supported the evaluation process
- Presented at educational seminars and webinars

Examples of projects that have received funding from the Connecticut microgrid program: Campus Microgrid Pilot, Wesleyan University, Campus Microgrid Pilot, University of Hartford, Campus Microgrid Pilot, Bridgeport University, Municipal Microgrid Pilot, Hartford Park Street, Municipal Microgrid Pilot, and Town of Woodbridge.

3.3.5: Contractors and Suppliers

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?

The project team including contractors are identified in section 3.3.2.

3.3.6: Financers and Investors

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 preliminary list of debt and equity financing sources has been identified. We have indications of interest from the identified sources of capital that have the balance sheet strength and appetite for the microgrid project. All the project financiers have a relationship with BlocPower as investors or partners in energy efficiency and clean energy projects where BlocPower is the developer. Members of the project team may participate in the partnership with equity investors.

3.3.7: Financers and Investors / Legal and Regulatory Advisors

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?

Yes, there are legal and regulatory advisors on the team and additional staff available with expertise as the project moves forward. The two advisors on the team are currently Shirly Anderson and Elizabeth Weatherby.

Shirly Anderson: Ms. Anderson has a Certificate in Regulatory Economics from the State University of NY at Albany. Ms. Anderson has 39 years of experience in the energy industry. Her background includes extensive program oversight; implementation and coordination experience for utility directed energy efficiency and demand side management programs; as well as deployment activities regarding NYSERDA sponsored programs targeting multifamily buildings and residential energy users. Ms. Anderson has developed effective negotiation, coordination and collaboration skills in her 30 years of progressively responsible Staff work at the NYS PSC. Commission. She has provided expert testimony, testifying as an expert witness before the NYS Public Service Commission in 10 utility rates cases and generic policy cases. She also testified as an expert witness in a proceeding before the Missouri Public Service Commission. Ms. Anderson was part of a panel that presented testimony to the Department of Energy in Washington, DC. Ms. Anderson testified before the New York City Council in favor of allowing electrical submetering in multifamily buildings to become eligible for J-51 tax credits.

Liz Weatherby: Ms. Weatherby is an environmental scientist with professional experience in environmental assessment and permitting coordination for power generation, electric transmission and infrastructure projects supporting a variety of clients in the power generation and transmission industry. Proven experience in environmental assessment and permitting services for power generation, electric transmission and renewable energy projects across many states, including New York, New Jersey, Pennsylvania and Connecticut.

3.4: Commercial Viability - Creating and Delivering Value

The Contractor shall describe the mechanics of ensuring that expected value is delivered to project participants, by addressing no less than the following items below:

3.4.1: Technology Selection

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

The Phase 1 project team is technology agnostic and developed the design approach based on the unique site requirements and opportunities. In order to develop realistic cost estimates vendor quotes were solicited for products that met the requirements of the specified technical approach. While these products represent viable solutions which demonstrate the technical and financial feasibility of the project, the project team retains the intention to compete technology and sourcing selection to provide an optimal technical and cost solution for the microgrid.

A primary benefit of the approach is that all technologies selected are currently commercially available and selection of specific products can be competed. This ensures that vendor selection can be competitive and that the solution is viable in the near term.

3.4.2: Existing Assets

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

NYCHA owns boiler and heating infrastructure that could be useful in a combined heat and power scenario. CHP would allow the microgrid off-takers to collectively lower their emissions footprint significantly versus both the status quo and the current reciprocating engine-based design.

3.4.3: Balance of Generation and Load

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

The microgrid architecture, technology selection, and design were based off of an in-depth analysis of historic load data to ensure right sizing of systems. The battery and natural gas engines can be operated for optimal economic dispatch which will assess the appropriate economic value and level of generation.

3.4.4: Permitting

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 base project does not require unique permitting that would not be required of any microgrid employing the same equipment. All equipment and infrastructure that will be installed will need to be reviewed and approved for safety and code compliance by the New York City DOB and the FDNY. All assets require an approved DOB application and FDNY Letter of No Objection before the DOB will issue electrical and construction permits for the job, and the interconnection plan must be reviewed and approved by Con Ed, as would any upgrades or changes to their distribution systems. In addition, to secure incentives, NYSERDA must review and approve the solar project for compliance with NY Sun rules and specifications, and Con Ed must review and approve the battery design and operation plan for compliance with BQDM. Both incentive programs include ongoing performance evaluation in the early years of the project to confirm expected system performance in order to distribute full contracted incentive amounts.

In addition to the DOB permitting process, the battery review and approval process requires additional analysis from the FDNY, the NYC Office of Technical Certification and Research (OTCR), the NYC Sustainability Review Board (SRB), and the NYC Innovation Review Board (IRB). The additional scrutiny for the battery is owed largely to its relatively recent adaptation for large-scale behind-the-meter applications and its chemical volatility and elevated risk of combustion, though this varies by chemistry. This process is evolving and the lengthy timeline compressing as more and more of these assets are reviewed and approved for installation in New York City. As a result, some of these requirements may be truncated or eliminated by the time the Brownsville Community Microgrid files for all requisite permits and approvals to begin installation.

3.4.5: Developing, Constructing, and Operating

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

BlocPower is the applicant and lead project developer at this stage in the process. Thus far the goal has been to develop a viable project that can be transitioned to private developers and third party investors as appropriate, which would likely take the form of a Master Developer for the site, with a series of development partners and/or vendors to develop, EPC, and operate the various components of the project.

The Master Developer would have site control and represent the project to the host client NYCHA as well as any financing entities with interest in the project. The Master Developer would also be responsible for engaging and enrolling subscribers for the community solar component of the project.

The EPC partners would be responsible for all engineering, procurement, permitting, construction, and commissioning of the microgrid systems.

Operation of the microgrid once functional would be handled by a single operating vendor with oversight of the technical operation of the systems and the settlement of financial transactions, to be largely handled through software, as well as the maintenance and repair of equipment.

3.4.6: Community Benefits

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

BlocPower will initiate a Community Solar Program and a NYCHA Tenant Repair Fund. Through the Community Solar Program, local residents on Con Edison's service classification number 1 and 2 (SC1 and SC2) who are currently paying an average of \$0.20 to \$0.30 per kWh for electric service will have an opportunity to participate in a program that allows them to receive credits on their utility bill for each kWh of solar power generated by the microgrid. These credits will lower their effective price per kWh significantly and provide economic benefits directly to low income households in need.

One of the costs for the community for the current microgrid design is a change in the emissions profile of the energy supply for microgrid participants.

	lb/MMBTU		Fuel input	Annual Emissions	
Pollutant	**uncontrolled[10]**	**controlled[11]**	**MMBTU**	**Pounds/yr**	**tons/yr**
NO_x	0.0422	0.038	48,980.88	1,861.27	0.93
PM_{10}	0.0001	0.0001		3.78	0.00
$PM_{2.5}$	0.0001	0.0001		3.78	0.00
SO_x	0.0070	0.0070		342.87	0.17
CO_2[12]	116.9000	116.9000		5,725,865.30	2,862.93

Table 11: Emissions from Operation of Proposed Caterpillar CG260-12 Generators

Compared with the baseline NY State emissions inventory, NO_x, PM_{10}, $PM_{2.5}$, and SO_x are reduced significantly, while CO_2 is increased slightly. BlocPower will independently evaluate the effect on emissions of shifting from Caterpillar reciprocating engines to fuel cells.

	Baseline NY State Emissions Inventory				Proposed Generation	Percent reduction
	Generation	Transmission	Total			
Pollutant	lb/MWh			tons/yr	tons/yr	

[10] NO_x emission factor from Caterpillar datasheet. PM_{10} and $PM_{2.5}$ from AP-42 Table 3.2-2. SO_X calculated from mass balance content of Ultra Low Sulfur Fuel specification

[11] Assumes 90% efficiency for NO_x control with SCR

[12] CO_2 emissions factor based on 40 CRF Part 98 Reporting Factors

No_x	0.333	0.031	0.364	1.08	0.93	-13.9%
PM_{10}	0.034	0.003	0.037	0.11	0.00	-98.3%
$PM_{2.5}$	0.024	0.002	0.026	0.08	0.00	-97.6%
SO_x	0.064	0.006	0.07	0.21	0.17	-17.5%
CO_2[12]	696.7	63.9	760.6	2,258.57	2,862.93	26.8%

Table 12: Comparison of Environmental Effect of power produced by proposed Gas Fueled Generators vs. Existing Sources

3.4.7: Utility Role

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

Con Edison, NYPA, and National Grid will be invited to bid on Operations and Maintenance contracts for the SPE.

3.4.8: Technology Readiness

Have the microgrid technologies (including but limited to: generation, storage, controls) been used or demonstrated before? If yes, describe the circumstances and lessons learned.

The microgrid technologies are commercially available products that have been demonstrated and validated. Specific selection of vendors and products will occur as the project matures. The senior engineer designing this project also acts as a technical advisor to the State of Connecticut Microgrid Pilot Program and has developed the program's technical standards, established project evaluation and scoring methods, and supported the evaluation process. This expertise has been used to develop a viable project. Some key design considerations have been: requirements based engineering, efficient system design, selection of requirements that can be competed, and cost effective technologies.

3.4.9: Operational Scheme

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 technical and financial operational approaches are fully described in the Section 2 and Section 3.1 – 3.2 of this report.

3.4.10: Billing and Metering

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

BlocPower is working with the New York Power Authority and Con Edison, who are the utility billing agents for all NYCHA and NYC municipal buildings. BlocPower has also engaged Acadia Micro to provide billing services for the Community Solar portion of the project.

Acadia Micro provides a turnkey, renewable energy asset management platform for distributed generation (DG) operators, retail energy suppliers, and utilities. They specialize in complex and highvolume utility back-office processes, and our software supports the requirements of renewable energy markets across the country. They also operate within a software as a service (SaaS) framework, developing and managing these systems on our clients' behalf.

Acadia Micro's background is as critical to our proposition as our software. They possess extensive retail energy experience performing back-office operations for energy providers. Collectively, they have billed billions of dollars for energy sold in every deregulated market in the US, providing critical data processing and utility API services for the leading energy companies in the country.

Acadia Micro's services manage back-office business processes for renewable energy assets. They monitor state regulations, utility tariffs, allocation agreements, program workgroups, standards organizations, and best practices to ensure that our systems, and your energy assets, are performing at their best capacity and within proper regulatory protocol.

At a high level, their systems and services help the SPE:

• Market our company's programs online.

• Enroll, engage, and service customers.

• Accurately and reliably monitor site production.

• Efficiently interface and comply with distribution companies.

• Optimize energy allocations and financial return.

• Establish a customer service system.

• Bill and process payments for residential, commercial, and industrial accounts.

• Adhere to regulatory requirements in every state and service territory.

They will provide us with both implementation and recurring services. Implementation services are the setup activities necessary for establishing the SPE's renewable energy site in Acadia's software platform. Recurring services are routine and commence once the Brownsville site is producing power, credits are being transferred, and Acadia services are billing customer accounts.

3.4.11: Business Replication

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

The project is highly scalable. As a Community Microgrid Public Private Partnership, there is not much precedent for this combined business model at this scale. The extensive design, engineering, financial and cost-benefit analyses performed provides a robust framework that once commissioned, can be highly replicable for this type of project.

3.4.11: Participant Barriers

How significant are the barriers to market entry microgrid participants?

There are high barriers to entry including, but not limited to, regulatory approval, engineering know-how, energy efficiency services track record, financing and environmental feasibility.

3.4.11: Barrier Busting

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

BlocPower has a track record of providing energy efficiency solutions in New York. BlocPower works with regulatory agencies, engineering firms and financing partners and consequently is very well-placed to overcome all the barriers outlined.

3.5: Financial Viability

The Contractor shall describe the case for financial viability for development and operation of the microgrid by addressing no less than the following items below:

3.5.1: Revenue Streams and Savings

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 revenue streams and their relative magnitudes are as follows:

- Gas generator production revenue: $43 million
- PV production revenue: $7 million
- Demand Response revenue: $108 million
- Incentives: Approximately $8 million
- Resiliency fee from NYCHA (indexed to Peak Shaving and Load Shifting Savings on NYCHA utility bill): Approximately 75% of resiliency fees will flow to the owner for debt service requirements of the microgrid. The estimated amount is $28 million over 20 years.

3.5.2: Project Incentives

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?

We are currently modeling two incentive sources for this microgrid.

First, for the solar component, we will apply for funding from NY Sun Commercial & Industrial program, including the bonus for solar projects that include storage. Because of the program structure, delay in the development cycle puts the incentive amount modeled at risk, as the megawatt block from which we took our incentive amounts, and subsequent blocks too, may fill up and move us to a block with a lower incentive amount. To date, the C&I program has had limited participation, so while the risk of delay here is real, it is not an existential threat to the project, as we expect there would still be a workable level of incentive for the project at the time of development, even with delay.

Second, for the battery component we will apply for funding from Con Ed's BQDM program. The risk of delay for this incentive is acute, as the program intends to lock up as much of the 52 MW by summer 2016, after which there will be no available incentive money for the battery. The battery is central to the function and revenue generation of the microgrid, and the capital cost of batteries is still quite high, so this incentive is critical and the project could not move forward with it, at current costs, even relative to the substantial revenue it generates. In the absence of similar levels of incentives for the battery, this project would not be viable.

3.5.3: Project Capital and Operating Costs

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?

Operating costs for the project include operation and maintenance expenses as well as equipment maintenance/replacement costs. The magnitude of these costs total approximately $60 million over the 20-year period.

3.5.4: Profitability

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

On average, the project generates 62% EBITDA margin and 29% Net Income margin over its 20-year cycle, ensuring it is very profitable. The mix of appropriate debt and equity financing ensures the project uses the optimal capital structure to operate. Additionally, contingencies have been built into the operating model that provides a level of cushion for sustained profitability.

3.5.5: Financing Structure

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

- Development financing: NY Prize
- Construction financing: debt and equity financing
- Operations financing: Project cash flows and a line of credit facility

3.6: Legal Viability

The Contractor shall describe the legal terms and conditions and other requirements necessary to develop and operate the microgrid by addressing no less than the items below:

3.6.1: Project Ownership Structure

Describe the proposed project ownership structure and project team members that will have a stake in the ownership.

SPE ownership shall be as follows:

- Tax Equity Investor [60%]
- Cash Equity Investor [40%]

3.6.2: Project Ownership

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?

Yes the project owner has been identified as a SPE owned by the equity investors.

3.6.3: Site ownership

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 SPE will arrange a lease agreement with NYCHA and NYC municipally-owned buildings for site access.

3.6.4: Customer Privacy

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

The standard privacy approaches of our billing partners, NYPA, Con Edison, and Acadia Micro

4: Microgrid's Cost Benefit Analysis

Benefit-Cost Analysis Summary Report

Site 19 – Brownsville Van Dyke Community (Brooklyn)

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the BlocPower Public Benefits Corporation has proposed development of a microgrid that would serve numerous facilities in and around Brooklyn's Brownsville Van Dyke Community. The microgrid would focus on maintaining service at three New York City Housing Authority (NYCHA) housing developments: Brownsville, Tilden, and Van Dyke I and II. In addition, the microgrid would provide power to a health care facility, a public elementary school, a library, a church, single-family residential homes, and small commercial entities in the surrounding community. Table 1 summarizes the specific residential and commercial facilities that the proposed microgrid would serve.

Facility Name	Facility Description
NYCHA Brownsville Housing Development	27 residential buildings with 1,337 apartments and 3,306 residents
NYCHA Tilden Housing Development	Eight residential buildings with 998 apartments and 2,628 residents
NYCHA Van Dyke I and II Housing Development	23 residential buildings with 1,714 apartments and 4,158 residents
NYCHA Tilden Building 9	Community center (no residents)
NYCHA Van Dyke I Building 24	Community center (no residents)
Brownsville Health Center	Health care facility
PS 284 Lew Wallace School	Public elementary school
Mother Gaston Branch Library	Public library
Brownsville Baptist Church	Church
Perimeter Residences	1,215 homes with approximately 3,329 residents
Perimeter Commercial Facilities	29 commercial entities in the surrounding community

Table 13: Facilities Served by Proposed Microgrid

The microgrid would combine gas-fired generators and solar capabilities to provide base load power. The system would be centered around two 3.0 MW natural gas generators. These distributed energy resources (DERs) would supply roughly 70 percent of the microgrid's power under normal operating conditions. Three photovoltaic (PV) arrays with a total nameplate capacity of approximately 2.7 MW would also contribute substantially to the system's output. In addition, the microgrid would incorporate a battery storage unit with 4.0 MW of nameplate capacity. The system as designed would have sufficient generating capacity to meet between 95 to 100 percent of average demand for electricity from the facilities the microgrid would serve during a major outage. The project's consultants also indicate that the system would be capable of providing ancillary services to the grid.

To assist with completion of the project's NY Prize Stage 1 feasibility study, IEc conducted a screening-level analysis of the project's potential costs and benefits. This report describes the results of that analysis, which is based on the methodology outlined below.

METHODOLOGY AND ASSUMPTIONS

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

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

This analysis relies on an Excel-based spreadsheet model developed for NYSERDA to analyze the costs and benefits of developing microgrids in New York State. The model evaluates the economic viability of a microgrid based on the user's specification of project costs, the project's design and operating characteristics, and the facilities and services the project is designed to support. 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.[13] 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

[13] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO_2 emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO_2, NO_x, and $PM_{2.5}$, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[14]

In addition to examining the two scenarios with the model's default assumptions, the BCA includes a sensitivity analysis. This analysis tests the sensitivity of the model's results to alternative assumptions about the value of the transmission capacity benefits the project would provide. The appendix to this report describes the methodological changes incorporated into the sensitivity analysis and summarizes its results.

RESULTS

Table 2 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 2.3 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES

[14] 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.

	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 2.3 DAYS/YEAR
Net Benefits - Present Value	-$16,700,000	$265,000
Benefit-Cost Ratio	0.8	1.0
Internal Rate of Return	1.2%	6.9%

Table 14: BCA Results (Assuming 7 Percent Discount Rate)

Scenario 1

Figure 23 and Table 15 present the detailed results of the Scenario 1 analysis.

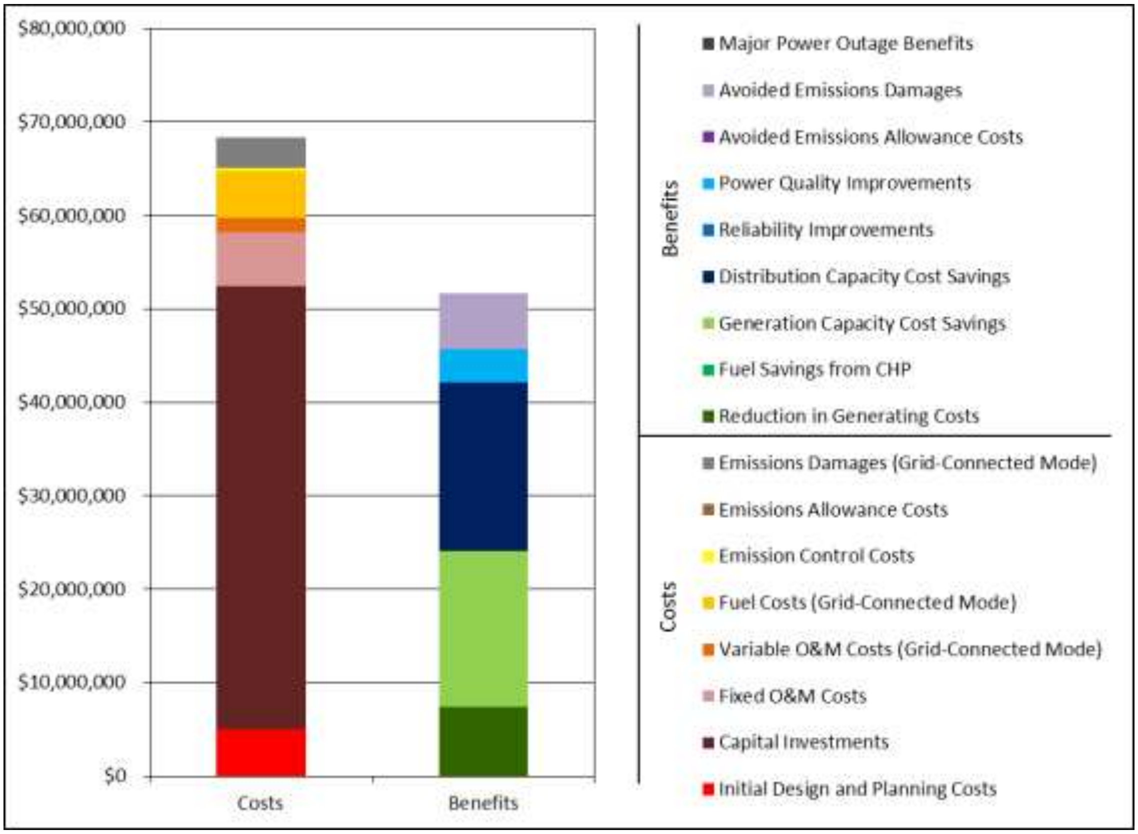

Figure 23: Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$5,000,000	$441,000
Capital Investments	$47,500,000	$3,560,000
Fixed O&M	$5,760,000	$508,000
Variable O&M (Grid-Connected Mode)	$1,490,000	$132,000
Fuel (Grid-Connected Mode)	$4,970,000	$438,000
Emission Control	$322,000	$28,400
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$3,350,000	$219,000
Total Costs	**$68,400,000**	
Benefits		
Reduction in Generating Costs	$7,400,000	$653,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$16,700,000	$1,470,000
Distribution Capacity Cost Savings	$18,000,000	$1,590,000
Reliability Improvements	$141,000	$12,400
Power Quality Improvements	$3,480,000	$307,000
Avoided Emissions Allowance Costs	$4,060	$359
Avoided Emissions Damages	$6,040,000	$394,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$51,700,000**	
Net Benefits	**-$16,700,000**	
Benefit/Cost Ratio	**0.8**	
Internal Rate of Return	**1.2%**	

Table 15: Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $5.0 million. The present value of the project's capital costs is estimated at approximately $47.5 million, including costs associated with installing the two 3.0 MW natural gas units; the 181 kW, 39 kW, and 2.5 MW photovoltaic systems; the 4.0 MW battery; distribution equipment; information technology equipment; and telecommunications equipment. The present value of fixed operation and maintenance (O&M) costs over a 20-year operating period is estimated to be approximately $5.8 million.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's generators. 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.[15] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $5.0 million.

The project will also have variable O&M costs associated with operating the natural gas units. The project team estimates these costs at approximately $10.98 per MWh of electricity produced by the system's DERs. Given the system's projected annual electricity production, this would translate to variable O&M costs of approximately $132,000 annually. The present value of the project's variable O&M costs over a 20-year operating period is estimated to be approximately $1.5 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the DERs 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. In this case, the damages attributable to emissions from the new natural gas units are estimated at approximately $219,000 annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $3.4 million.

Emission Control Costs

The microgrid project's emission control costs consist of a mix of fixed and variable costs. The project team estimates that emissions compliance tests for the natural gas generators will have a fixed cost of $15,000 per year. In addition, it will cost approximately $1.12 per MWh of electricity produced by the microgrid to operate and maintain the emissions control equipment. Given the microgrid's projected annual electricity production, this would translate to additional costs of approximately $13,400 annually. The present value of the project's emission control costs over a 20-year operating period is estimated to be approximately $322,000.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. In the case of the proposed microgrid, one of the primary sources 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 $7.4 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. The reduction in demand for electricity from bulk energy suppliers would also reduce emissions of CO_2 and particulate matter from

[15] 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.

these sources, and produce a shift in demand for SO_2 and NO_x emissions allowances. The present value of these benefits is approximately $6.0 million.[16]

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.[17] The project team estimates the project's impact on demand for generating capacity to be approximately 10.0 MW per year. Based on this figure, the BCA estimates the present value of the project's generating capacity benefits to be approximately $16.7 million over a 20-year operating period. Similarly, the team estimates that the project will help to avoid or defer an otherwise necessary investment in approximately 4.0 MW of distribution capacity. Based on this figure, the BCA estimates the present value of the project's distribution capacity benefits to be approximately $18.0 million over a 20-year operating period.[18]

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, including frequency support and voltage support, to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the markets for ancillary services are highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing 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 $12,400 per year, with a present value of $141,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[19]

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[16] Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model values emissions of CO_2 using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency (EPA). [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.] Because emissions of SO_2 and NO_x from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

[17] 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.

[18] This estimate of the project's distribution capacity benefit s is based on values for distribution capacity within Con Edison's underground network distribution system.

[19] www.icecalculator.com.

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.[20]

The estimate takes into account the number of residential customers the project would serve; the number of small and large commercial or industrial customers the project would serve; the distribution of commercial or industrial customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among commercial or industrial 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.[21] 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.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.8; i.e., the estimate of project benefits is approximately 80 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

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

[20] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Con Edison.
[21] http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1.

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.[22,23]

The proposed microgrid project would serve numerous facilities during an extended outage. In the BCA model, several factors influence the costs that facilities would incur during an outage, including the following:

- Whether or not a facility is equipped with a backup generator;
- Whether the facility would rent a backup generator to supply power during an outage;
- The ability of the facility to operate when using backup power;
- The ability of the facility to operate during a complete loss of power;
- The cost of operating any backup generators;
- The magnitude of any costs the facility would incur for emergency measures in the event of an outage (e.g., evacuation of patients); and
- The economic value of the services that the facility would cease to provide during an outage.

Table 4 summarizes these parameters for the different sets of facilities that would be served by the proposed microgrid. Additional detail on the methods employed to estimate the costs an outage would impose is provided below.

- **Electric Services**: The microgrid would serve 13,421 total residents, including 10,092 residents in NYCHA's Brownsville, Tilden, and Van Dyke I and II housing developments, as well as 3,329 residents in single-family homes in the surrounding community. The analysis calculates the impact of an outage on residential electric services using standard FEMA methodologies.
- **Emergency Medical Services**: The project team indicates that the microgrid would serve the Brownsville Health Center facility, which provides emergency medical services. This facility has no existing backup capabilities and would not maintain service during a power outage. The analysis calculates the impact of an outage on emergency medical services using standard FEMA methodologies.

[22] 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.

[23] 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.

- **Emergency Shelters**: Three of the facilities served by the microgrid would act as emergency shelters during a power outage: the PS 284 Lew Wallace School; the Mother Gaston Branch Library; and the Brownsville Baptist Church. For these facilities, the impact of a loss in service is estimated based on each shelter's capacity and a standard value from the Red Cross on the per capita cost of providing temporary shelter.[24,25] These three facilities do not have backup capabilities and would lose service during a power outage.

- **Community Centers**: NYCHA's Tilden Building 9 and Van Dyke I Building 24 both serve as community centers. These buildings do not have backup capabilities and would lose service during a power outage. The analysis uses the ICE calculator to estimate the collective value of service provided by these facilities.

- **Street Lighting**: The microgrid would provide power to streetlights in the local community. These streetlights do not have backup capabilities and would lose service during a power outage. The analysis uses the ICE calculator to estimate the collective value of service provided by the streetlights.

- **Aggregate Small Commercial on Perimeter**: The microgrid would also serve 29 small commercial entities in the local community. The analysis assumes that these facilities do not have backup capabilities and would lose service during a power outage. It uses the ICE calculator to estimate the collective value of service that these facilities provide.

[24] We estimate each shelter's capacity based on the project team's estimate of square footage available for shelter and a standard requirement of 40 square feet of floor space per person (for more than 72 hours). The floor space requirement is from: FEMA. 2010. Guidance on Planning for Integration of Functional Needs Support Services in General Population Shelters. Accessed March 17, 2016 at https://www.fema.gov/pdf/about/odic/fnss_guidance.pdf.

[25] The standard value from the Red Cross ($50 per person per day) is from: American Red Cross. 2014. Fundraising Dollar Handles for Disaster Relief Operations. Revised March 2014 based on FY14 figures. Accessed March 17, 2016 at http://www.redcross.org/images/MEDIA_CustomProductCatalog/m30240126_FY14FundraisingDollarHandles.pdf.

CATEGORY	FACILITIES INCLUDED	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
		VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY
Electric Services	NYCHA Brownsville, Tilden, and Van Dyke I and II Housing Developments; Single-Family Residential Homes	FEMA methodologies		n/a	100%	n/a	n/a	$0	$0
Emergency Medical Services	Brownsville Health Center	FEMA methodologies		n/a	100%	n/a	n/a	$0	$0
Emergency Shelters	PS 284 Lew Wallace School; Mother Gaston Branch Library; Brownsville Baptist Church	$143,250	Red Cross	n/a	100%	n/a	n/a	$0	$0
Community Centers	NYCHA Van Dyke I Building 24; NYCHA Tilden Building 9	$125,431	ICE	n/a	100%	n/a	n/a	$0	$0
	Street Lighting	$33,399	ICE	n/a	100%	n/a	n/a	$0	$0

CATEGORY	FACILITIES INCLUDED	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
		VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY
Street Lighting									
Aggregate Small Commercial on Perimeter	29 small commercial entities	$398,565	ICE	n/a	100%	n/a	n/a	$0	$0

Table 16: Summary of Major Power Outage Parameters, Scenario 2

Summary

Figure 2 and Table 5 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 2.3 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.

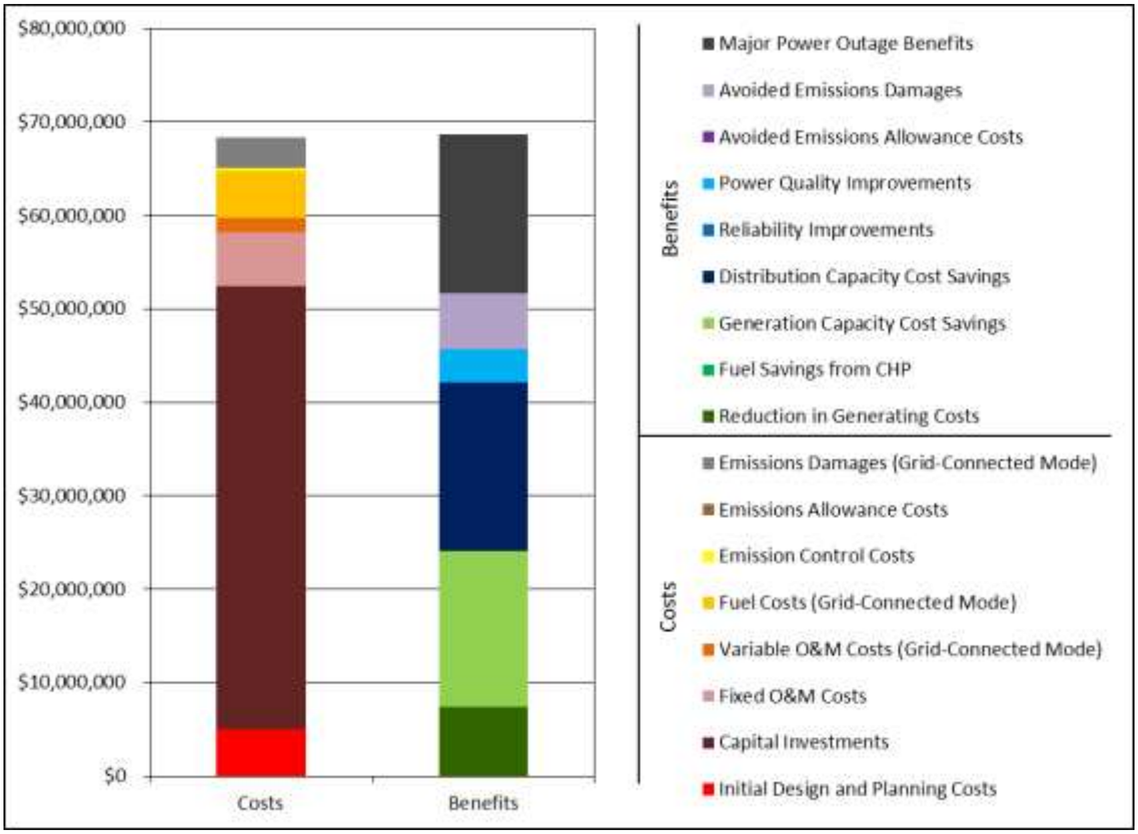


Figure 24: Present Value Results, Scenario 2 (Major Power Outages Averaging 2.3 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$5,000,000	$441,000
Capital Investments	$47,500,000	$3,560,000
Fixed O&M	$5,760,000	$508,000
Variable O&M (Grid-Connected Mode)	$1,490,000	$132,000
Fuel (Grid-Connected Mode)	$4,970,000	$438,000
Emission Control	$322,000	$28,400
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$3,350,000	$219,000
Total Costs	**$68,400,000**	
Benefits		
Reduction in Generating Costs	$7,400,000	$653,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$16,700,000	$1,470,000
Distribution Capacity Cost Savings	$18,000,000	$1,590,000
Reliability Improvements	$141,000	$12,400
Power Quality Improvements	$3,480,000	$307,000
Avoided Emissions Allowance Costs	$4,060	$359
Avoided Emissions Damages	$6,040,000	$394,000
Major Power Outage Benefits	$16,900,000	$1,500,000
Total Benefits	**$68,600,000**	
Net Benefits	**$265,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.9%**	

Table 17: Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 2.3 Days/Year; 7 Percent Discount Rate)

–BCA SENSITIVITY ANALYSIS

As designed, the BCA model does not estimate the value of a microgrid's impact on transmission capacity requirements. Standard assumptions about the value of these benefits are implicitly incorporated into the model's estimates of avoided generation costs and generation capacity cost savings. The Brownsville neighborhood, however, is located in the Brooklyn Queens Demand Management (BQDM) zone, an area that is already subject to blackouts due to transmission capacity constraints. To address this situation, Con Edison is currently offering a one-time incentive payment of $1,800 per kW for battery storage capacity. This figure may be more representative of the value of transmission capacity benefits in the BQDM area. In light of this information, the BCA examines an additional scenario that tests the sensitivity of the model's results to alternative assumptions about transmission capacity benefits. This scenario estimates the microgrid's transmission capacity benefits by applying the $1,800 per kW value to the microgrid's 4 MW of battery storage capacity and 6 MW of gas-fired generating capacity.[26]

Sensitivity Analysis Results

Figure 25 and Table 18 summarize the results of the sensitivity analysis. These results indicate, based on the assumptions described above, that the project's benefits would exceed its costs by approximately two percent, even if there were no major power outages over the 20-year period analyzed (Scenario 1). Since the results for Scenario 1 suggest a benefit-cost ratio greater than one, the report does not present a sensitivity analysis for Scenario 2. Consideration of Scenario 2 would further increase the positive benefit-cost ratio achieved when a value of $1,800 per kW is assigned to the project's potential transmission capacity benefits.

[26] This approach assumes that the Con Edison incentive of $1,800 per kW for battery storage capacity reflects the minimum value that Con Edison holds for additional transmission capacity; that the gas-fired generators the Brownsville Van Dyke project would incorporate would relieve demand for 6 MW of transmission capacity; and that the battery storage unit would relieve demand for an additional 4 MW of transmission capacity.

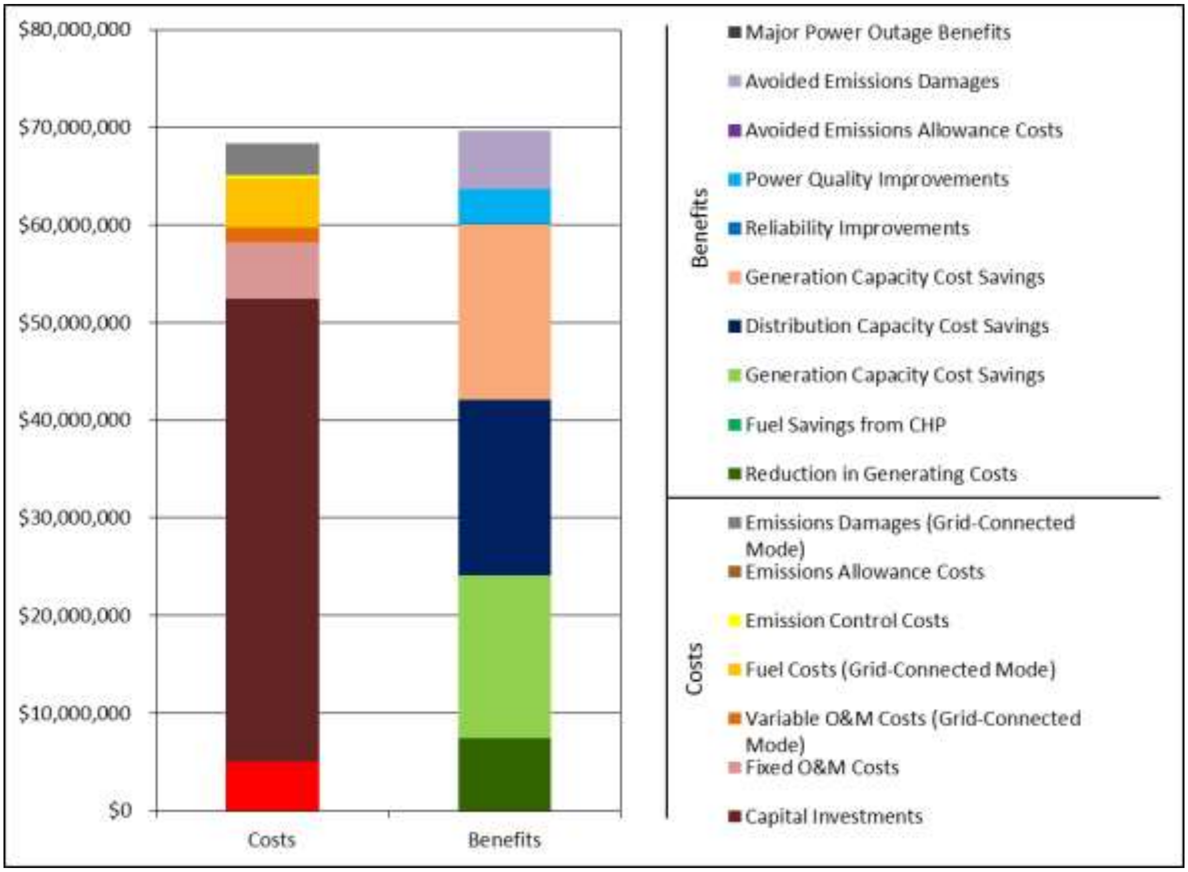
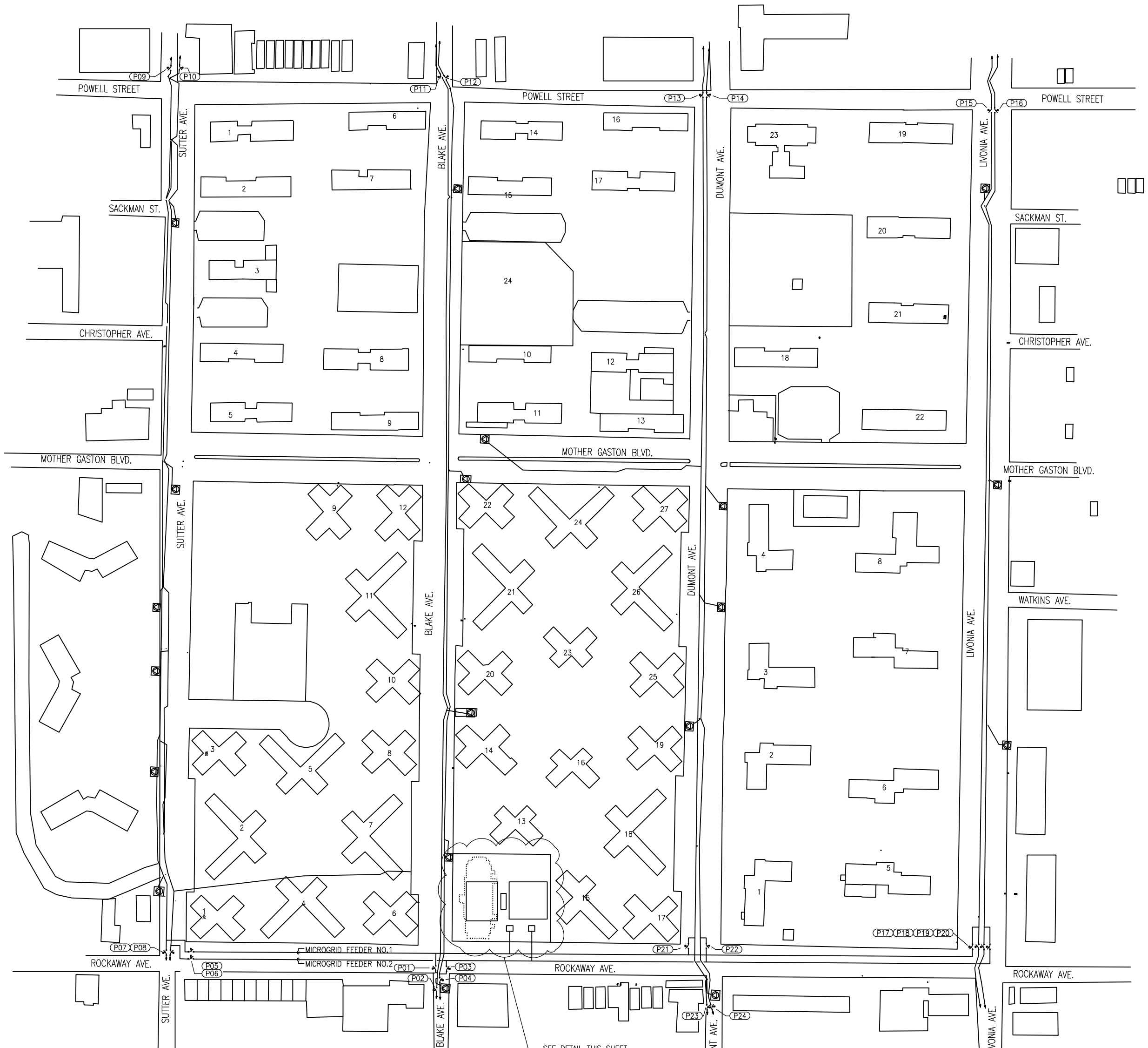


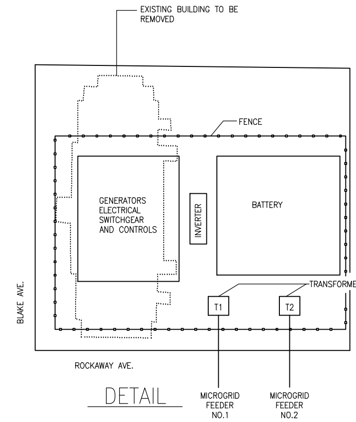
Figure 25: Present Value Results, Sensitivity Analysis for Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$5,000,000	$441,000
Capital Investments	$47,500,000	$3,560,000
Fixed O&M	$5,760,000	$508,000
Variable O&M (Grid-Connected Mode)	$1,490,000	$132,000
Fuel (Grid-Connected Mode)	$4,970,000	$438,000
Emission Control	$322,000	$28,400
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$3,350,000	$219,000
Total Costs	**$68,400,000**	
Benefits		
Reduction in Generating Costs	$7,400,000	$653,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$16,700,000	$1,470,000
Distribution Capacity Cost Savings	$18,000,000	$1,590,000
Transmission Capacity Cost Savings	$18,000,000	$1,590,000
Reliability Improvements	$141,000	$12,400
Power Quality Improvements	$3,480,000	$307,000
Avoided Emissions Allowance Costs	$4,060	$359
Avoided Emissions Damages	$6,040,000	$394,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$69,700,000**	
Net Benefits	**$1,320,000**	
Benefit/Cost Ratio	**1.02**	
Internal Rate of Return	**7.2%**	

Table 18: Detailed BCA Results, Sensitivity Analysis for Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

Appendix A: Layout Diagrams





DETAIL

LEGEND

- * MANHOLE
- * SERVICE BOX
- (PXX) MOTORIZED SWITCH
- TRANSFORMER

NOTES

1. ALL SERVICE CONNECTIONS, TRANSFORMERS, MANHOLES, SERVICE BOXES AND DISTRIBUTION FEEDERS ARE ARE EXISTING, UNLESS OTHERWISE NOTED.
2. MOTORIZED SWITCHES ARE NEW AND PROVIDE ISOLATION OF THE MICROGRID SECONDARY DISTRIBUTION WHEN IN ISLAND MODE.

TRC 125 GROVE ST SUITE 205
FRANKLIN MA, 02038

PROJECT NO: 243642

REV	DESCRIPTION	DATE	DES	CHK	APP
A	ISSUED FOR INTERNAL REVIEW	1/26/2016	WFM	.	.

WFM DESIGNED
WFM DRAWN
CHECKED
APPROVED
REVIEW 1
REVIEW 2

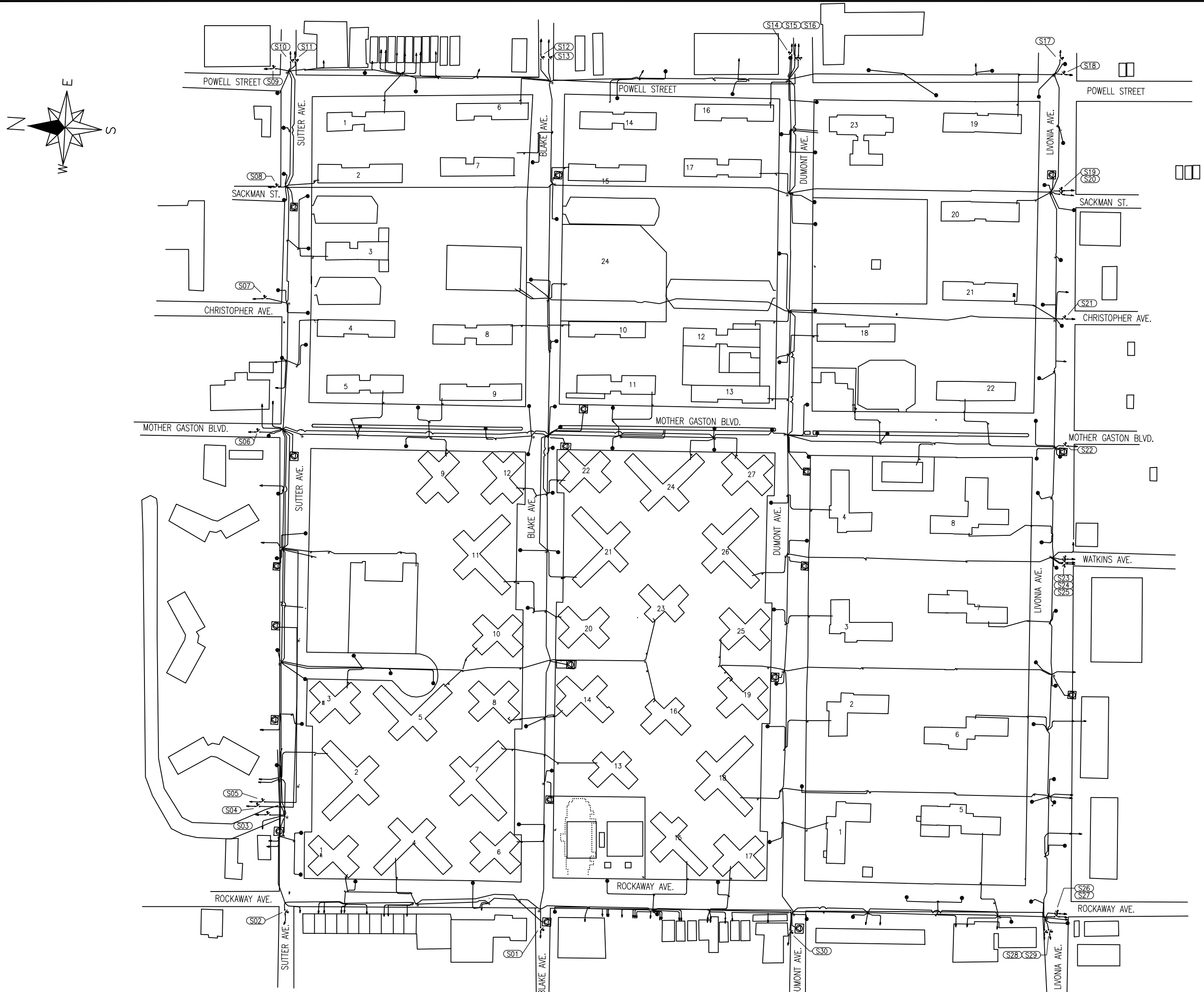
BROWNSVILLE MICROGRID
BROOKLYN NY
27 KV PRIMARY DISTRIBUTION SYSTEM
LAYOUT PLAN

1/26/2016 DATE
N.T.S. SCALE

TRC

LP-1

REV. A



LEGEND

- MANHOLE
- SERVICE BOX
- STREET LIGHT
- MOTORIZED SWITCH (SXX)
- TRANSFORMER

NOTES

1. ALL SERVICE CONNECTIONS, TRANSFORMERS, MANHOLES, SERVICE BOXES AND DISTRIBUTION FEEDERS ARE ARE EXISTING, UNLESS OTHERWISE NOTED.
2. MOTORIZED SWITCHES ARE NEW AND PROVIDE ISOLATION OF THE MICROGRID SECONDARY DISTRIBUTION WHEN IN ISLAND MODE.

TRC 125 GROVE ST SUITE 205
FRANKLIN MA, 02038

PROJECT NO: 243642

REV	DESCRIPTION	DATE	DES	CHK	APP
A	ISSUED FOR INTERNAL REVIEW	1/26/2016	.	.	.

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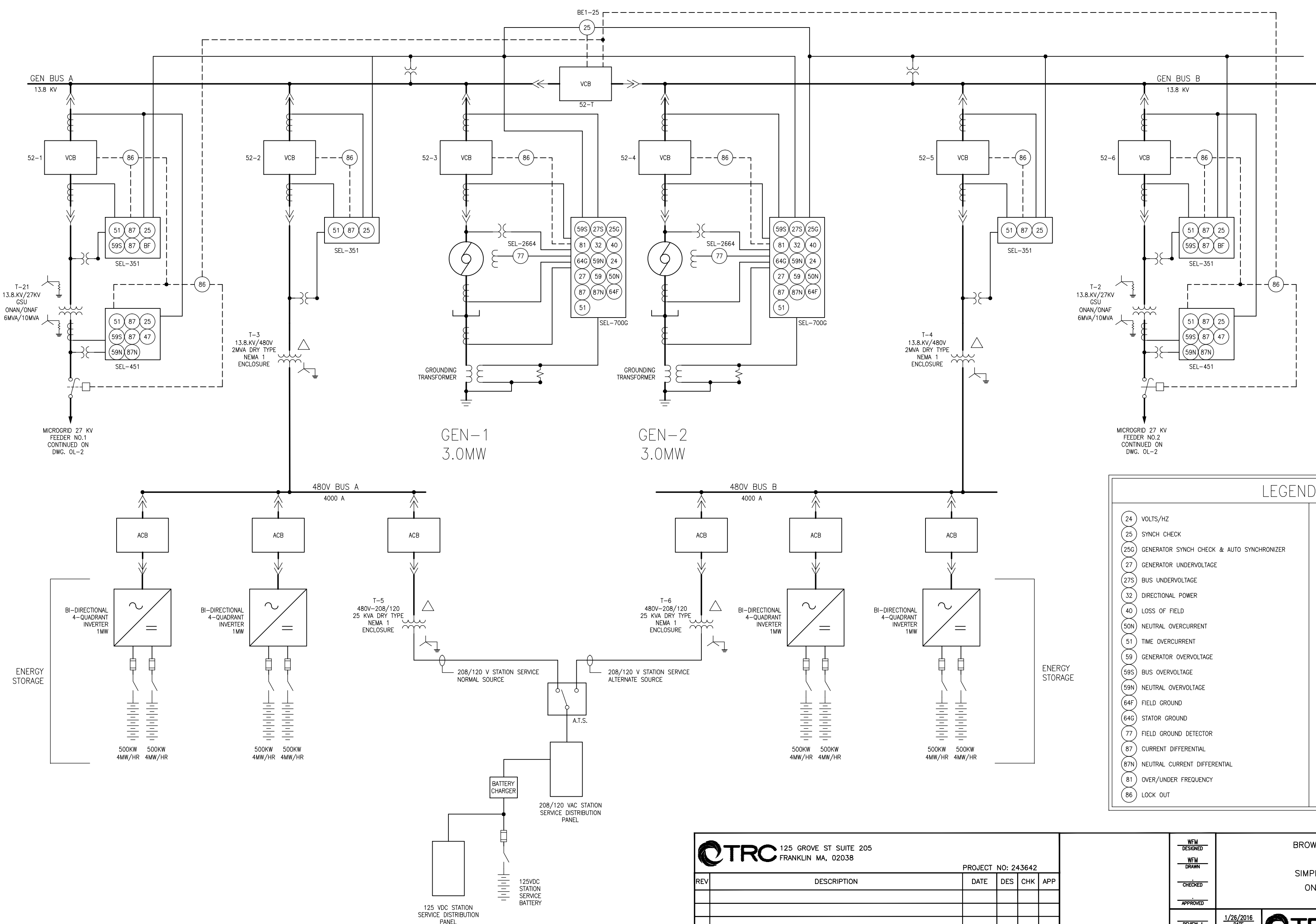
REVIEW 2 N.T.S. SCALE

BROWNSVILLE MICROGRID
BROOKLYN NY
208V/120V SECONDARY DISTRIBUTION SYSTEM
LAYOUT PLAN

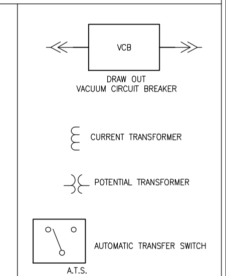
TRC LP-2 REV. A

Appendix B: Electrical Single Line Diagrams



LEGEND

- 24 VOLTS/HZ
- 25 SYNCH CHECK
- 25G GENERATOR SYNCH CHECK & AUTO SYNCHRONIZER
- 27 GENERATOR UNDERVOLTAGE
- 27S BUS UNDERVOLTAGE
- 32 DIRECTIONAL POWER
- 40 LOSS OF FIELD
- 50N NEUTRAL OVERCURRENT
- 51 TIME OVERCURRENT
- 59 GENERATOR OVERVOLTAGE
- 59S BUS OVERVOLTAGE
- 59N NEUTRAL OVERVOLTAGE
- 64F FIELD GROUND
- 64G STATOR GROUND
- 77 FIELD GROUND DETECTOR
- 87 CURRENT DIFFERENTIAL
- 87N NEUTRAL CURRENT DIFFERENTIAL
- 81 OVER/UNDER FREQUENCY
- 86 LOCK OUT



TRC 125 GROVE ST SUITE 205
FRANKLIN MA, 02038

PROJECT NO: 243642

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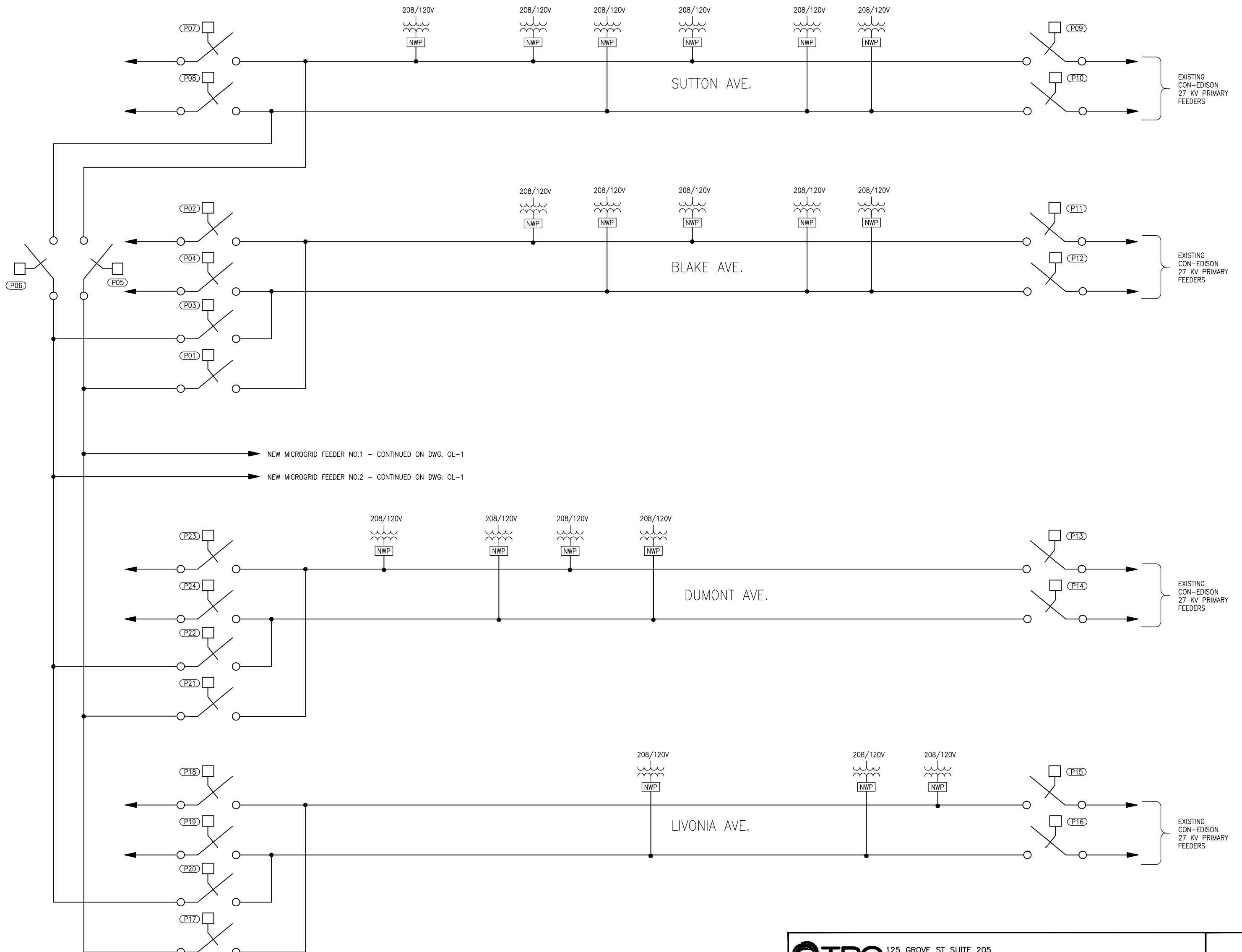
BROWNSVILLE MICROGRID
BROOKLYN NY
SIMPLIFIED ELECTRICAL
ONE-LINE DRAWING

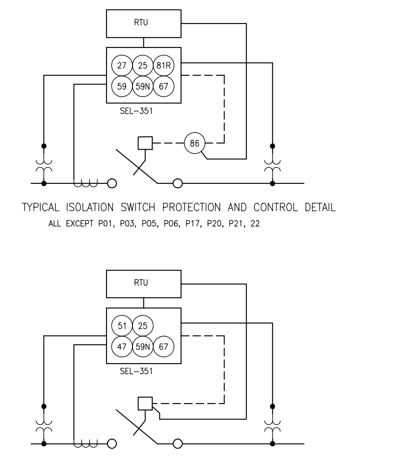
1/26/2016 DATE
N.T.S. SCALE

TRC

OL-1

REV. A





TRC 125 GROVE ST SUITE 205
FRANKLIN MA, 02038

PROJECT NO: 243642

REV	DESCRIPTION	DATE	DES	CHK	APP
.A	ISSUED FOR INTERNAL REVIEW	1/26/2016	WFM	.	.

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. APPROVED
REVIEW 1
REVIEW 2

BROWNSVILLE MICROGRID
BROOKLYN NY
SIMPLIFIED ELECTRICAL
ONE-LINE DRAWING

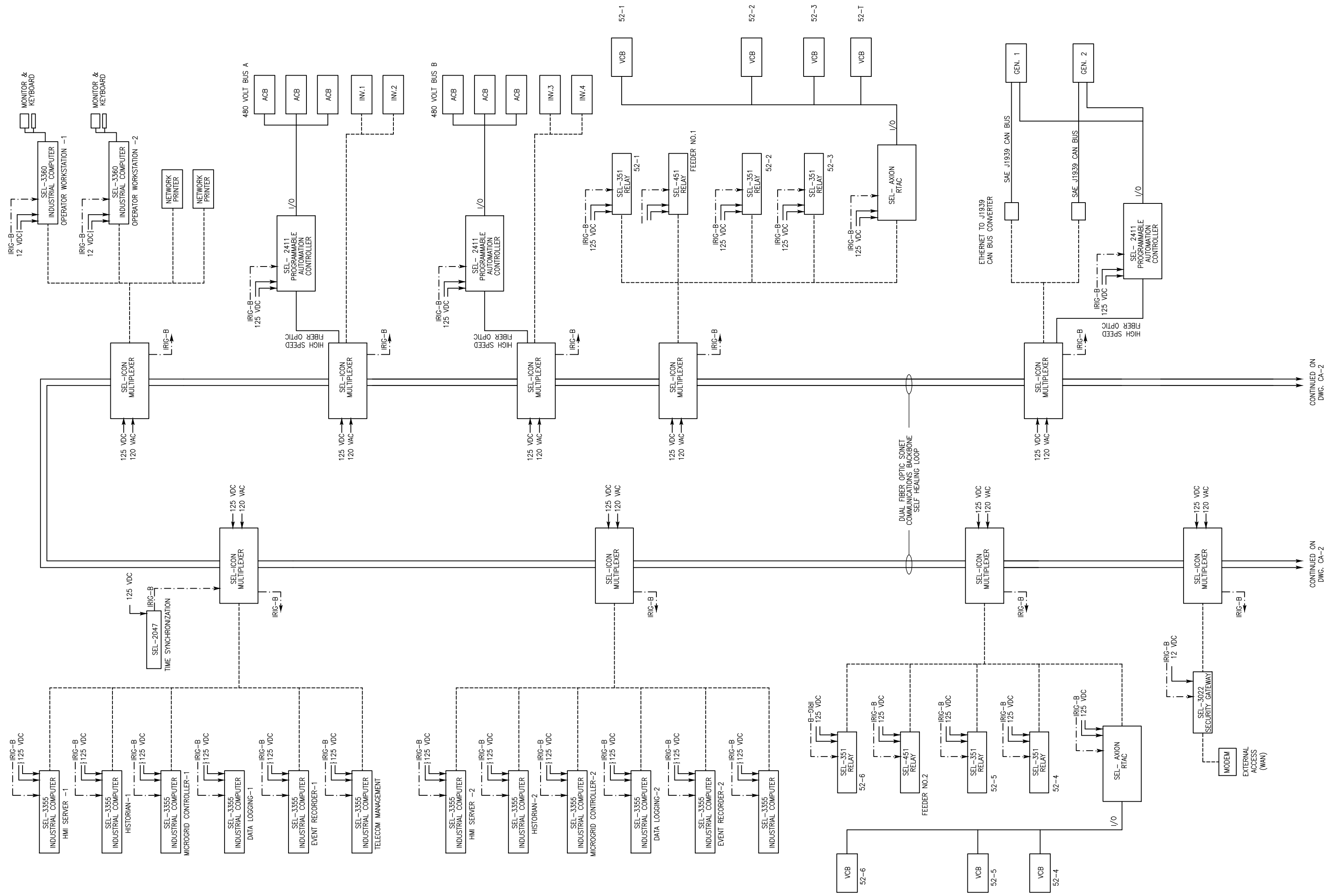
1/26/2016 DATE
N.T.S. SCALE

TRC

OL-2

REV. A

Appendix C: Control Architecture Diagrams



TRC 125 GROVE ST. SUITE 205
FRANKLIN MA 02038

PROJECT NO: 243642

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WFM DRAWN
CHECKED
APPROVED
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REVIEW 2

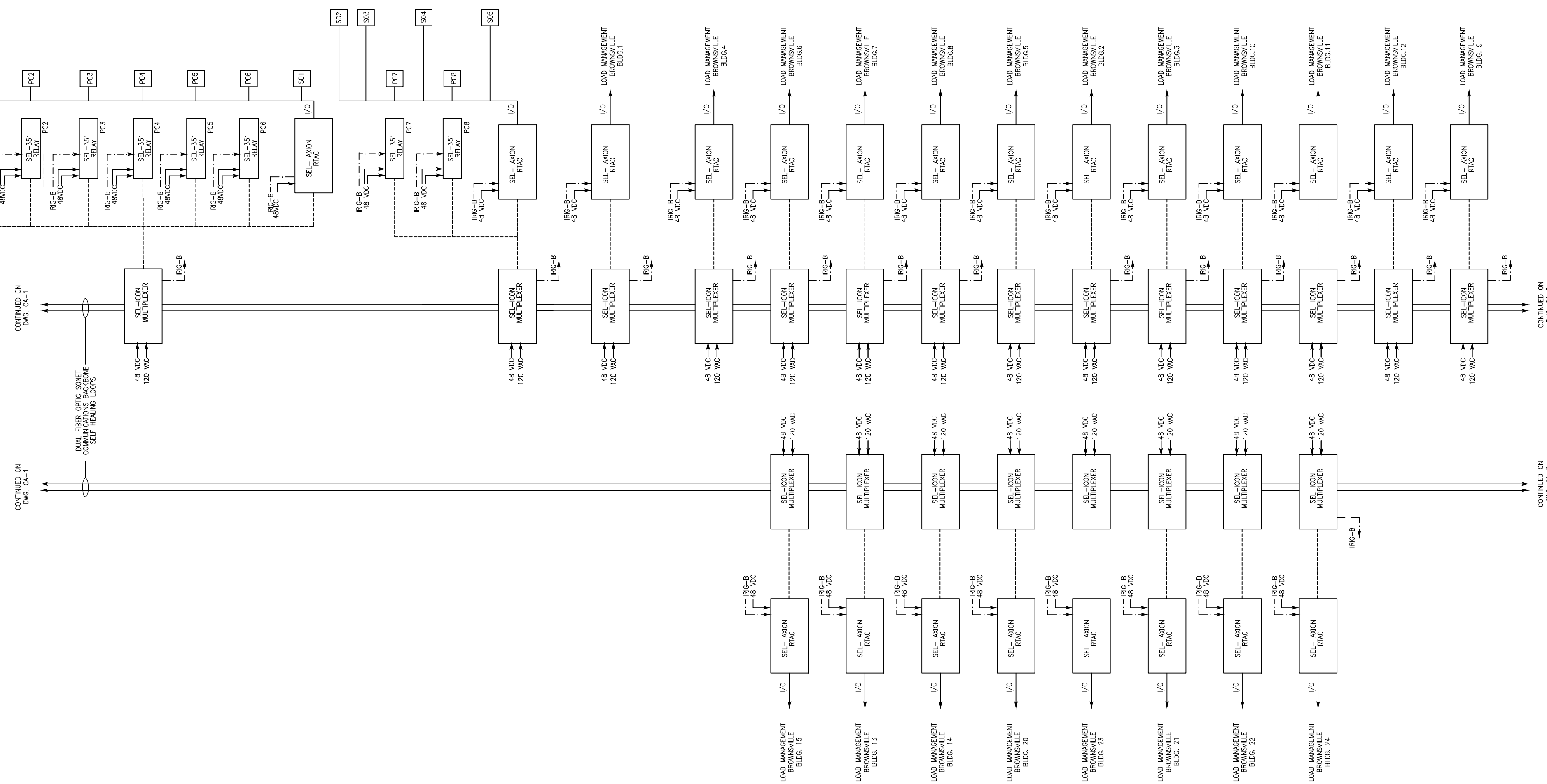
2-1-2016 DATE
NOT TO SCALE SCALE

BROWNSVILLE MICROGRID
BROOKLYN NY
CONTROL SYSTEM ARCHITECTURE
ONE-LINE DIAGRAM

TRC

CA-1

REV. A



TRC 125 GROVE ST.
FRANKLIN MA 02038

PROJECT NO: 243642

REV	DESCRIPTION	DATE	DES	CHK	APP
A	FOR INTERNAL REVIEW	2/1/2016	WFM	.	.

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REVIEW 1
REVIEW 2

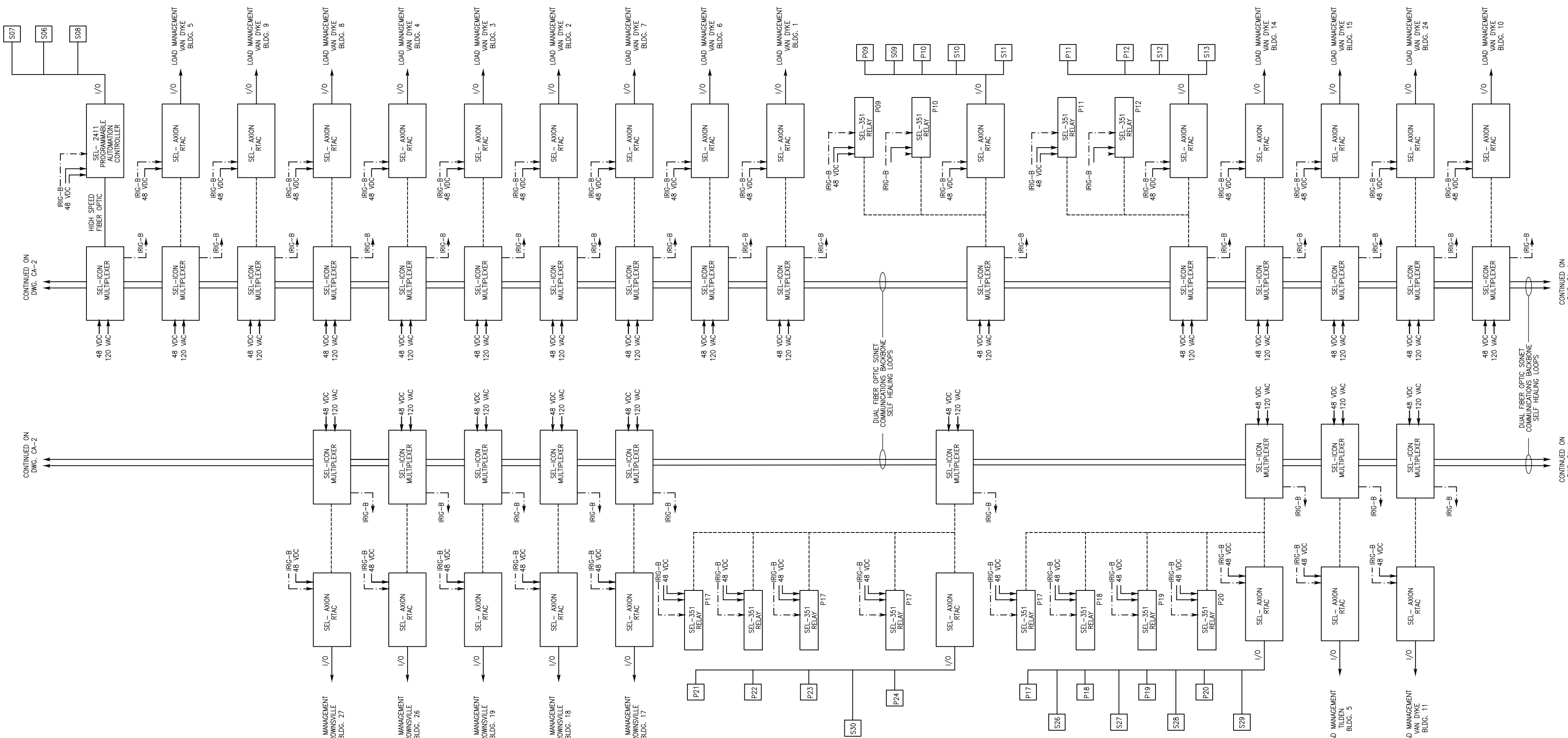
BROWNSVILLE MICROGRID
BROOKLYN NY
CONTROL SYSTEM ARCHITECTURE
DIAGRAM

2-1-2016 DATE
NOT TO SCALE SCALE

TRC

CA-2

REV. A



TRC 125 GROVE ST. FRANKLIN MA 02038

PROJECT NO: 243642

REV	DESCRIPTION	DATE	DES	CHK	APP
A	FOR INTERNAL REVIEW	2/1/2016	WFM	.	.

WFM DESIGNED

DRAWN

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APPROVED

REVIEW 1

REVIEW 2

BROWNSVILLE MICROGRID
BROOKLYN NY
CONTROL SYSTEM ARCHITECTURE
DIAGRAM

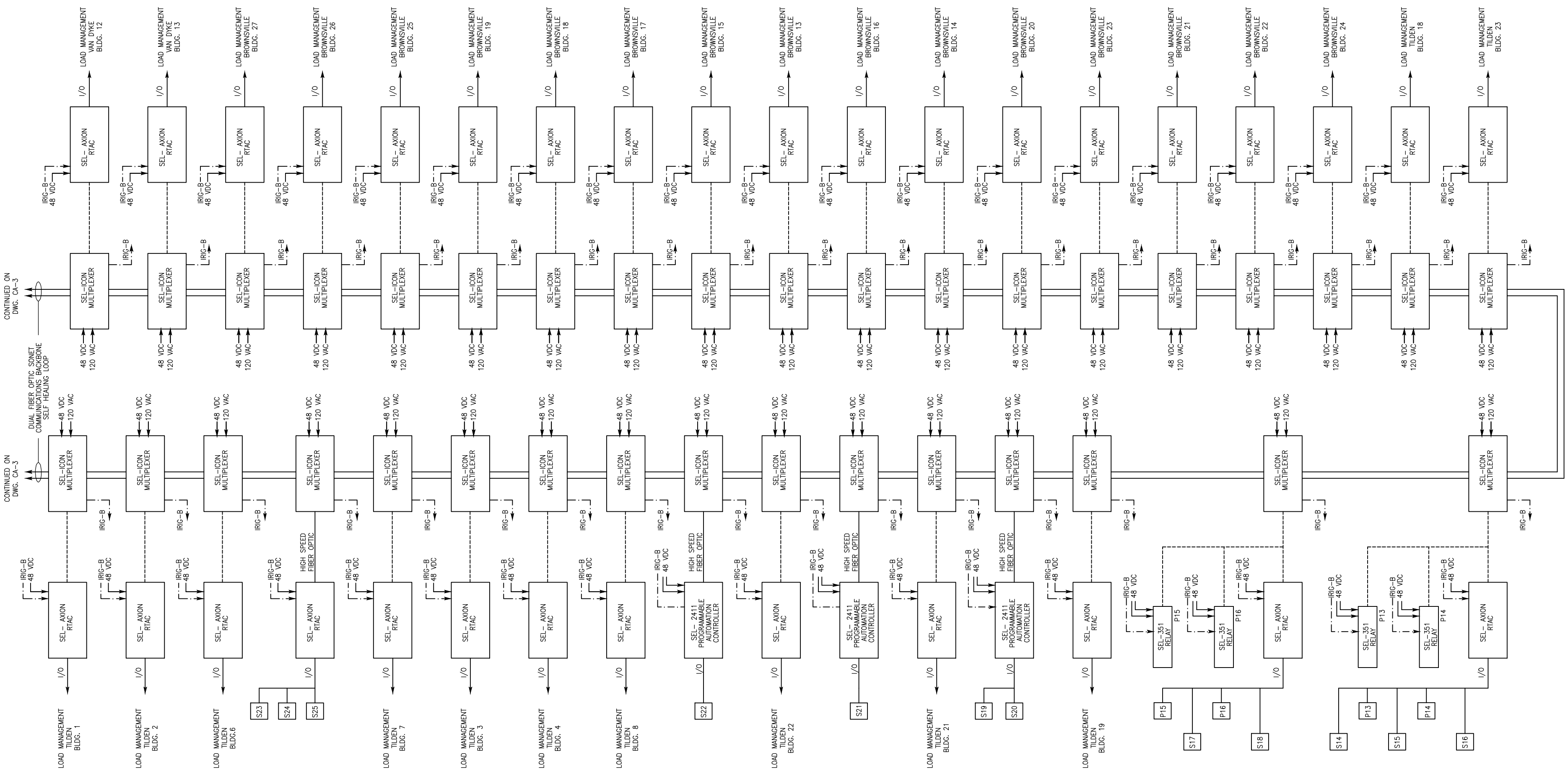
2-1-2016 DATE

NOT TO SCALE SCALE

TRC

CA-3

REV. A



TRC 125 GROVE ST. FRANKLIN MA 02038

PROJECT NO: 243642

REV	DESCRIPTION	DATE	DES	CHK	APP
A	FOR INTERNAL REVIEW	2/1/2016	WFM	.	.

WFM DESIGNED
DRAWN
CHECKED
APPROVED
REVIEW 1
REVIEW 2

BROWNSVILLE MICROGRID
BROOKLYN NY
CONTROL SYSTEM ARCHITECTURE
DIAGRAM

2-1-2016 DATE
NOT TO SCALE SCALE

TRC

CA-4

REV. A

Appendix D: Grid Parallel Model Results

January

Energy Storage

Maximum Discharge rate	(2,318)	kW
Maximum Charging rate	3,068	kW
Total kWh discharged	(18,158)	
Total kWh charged	18,159.64	
Net balance	1	

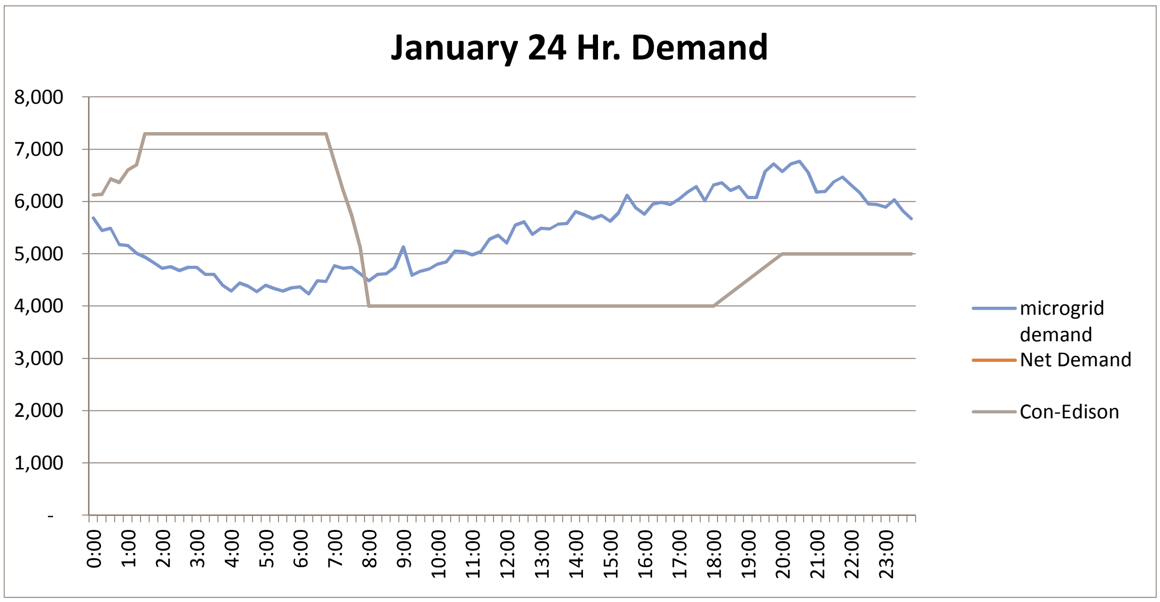
Demand kW

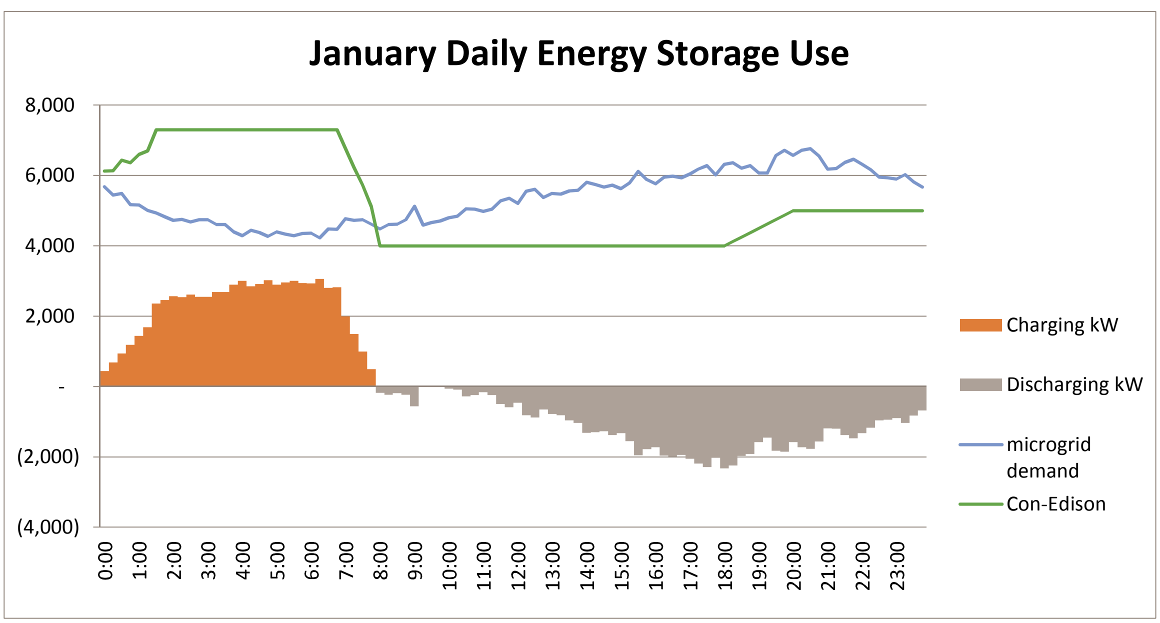
Microgrid peak	6,768
Microgrid Avg.	5,385
Net Peak	7,300
Net Average	5,191

On Peak Hours 0800 - 1600	
Microgrid Demand	6,318
Con-Edison Demand	4,000

Generators

Gen.1 kWh	-
Gen2 kWh	-
Total kWh	-





February

Energy Storage

Maximum Discharge rate	(2,288)	kW
Maximum Charging rate	2,623	kW
Total kWh discharged	(14,571)	
Total kWh charged	14,574	
Net balance	4	

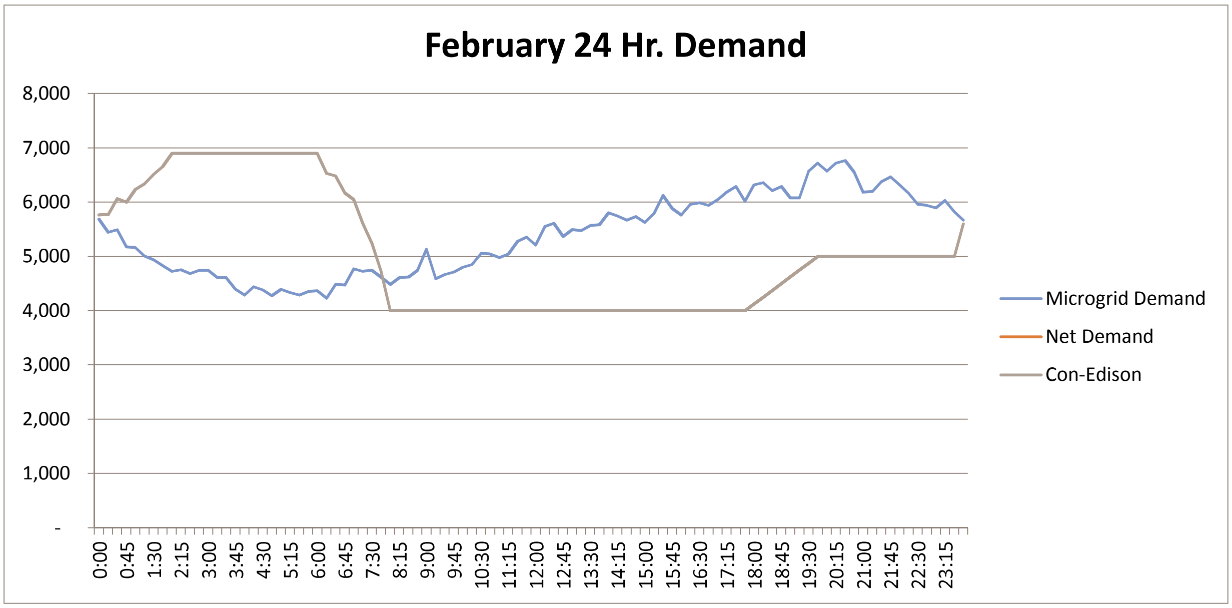
Demand kW

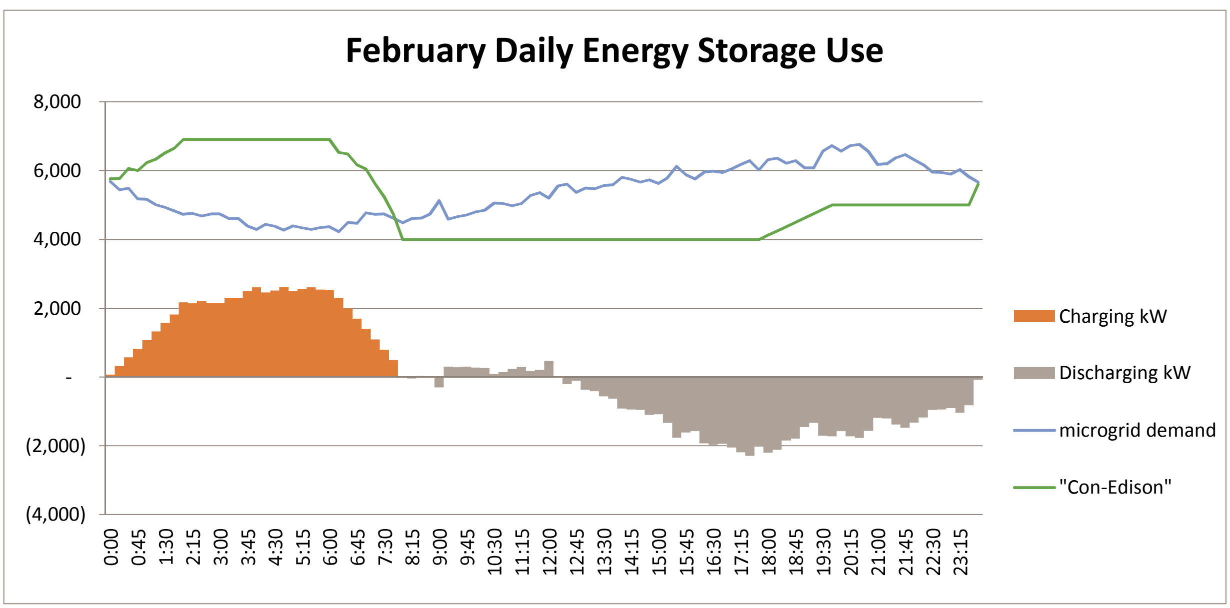
Microgrid peak	6,768
Microgrid Avg.	5,385
Net Peak	6,900
Net Average	5,048

On Peak Hours 0800 - 1600	
Microgrid Demand	6,318
Con-Edison Demand	4,125

Generators

Gen.1 kWh	-
Gen2 kWh	-
Total kWh	-





March

Energy Storage

Maximum Discharge rate	(2,984)	kW
Maximum Charging rate	3,317	kW
Total kWh discharged	(18,324)	
Total kWh charged	18,333	
Net balance	9	

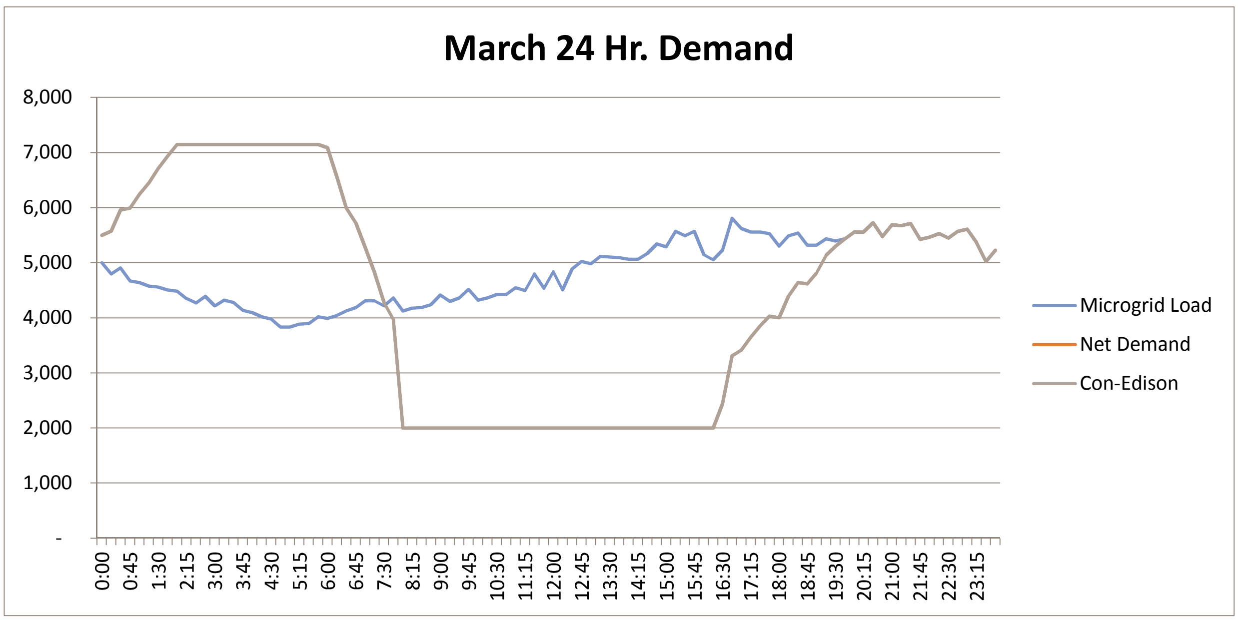
Demand kW

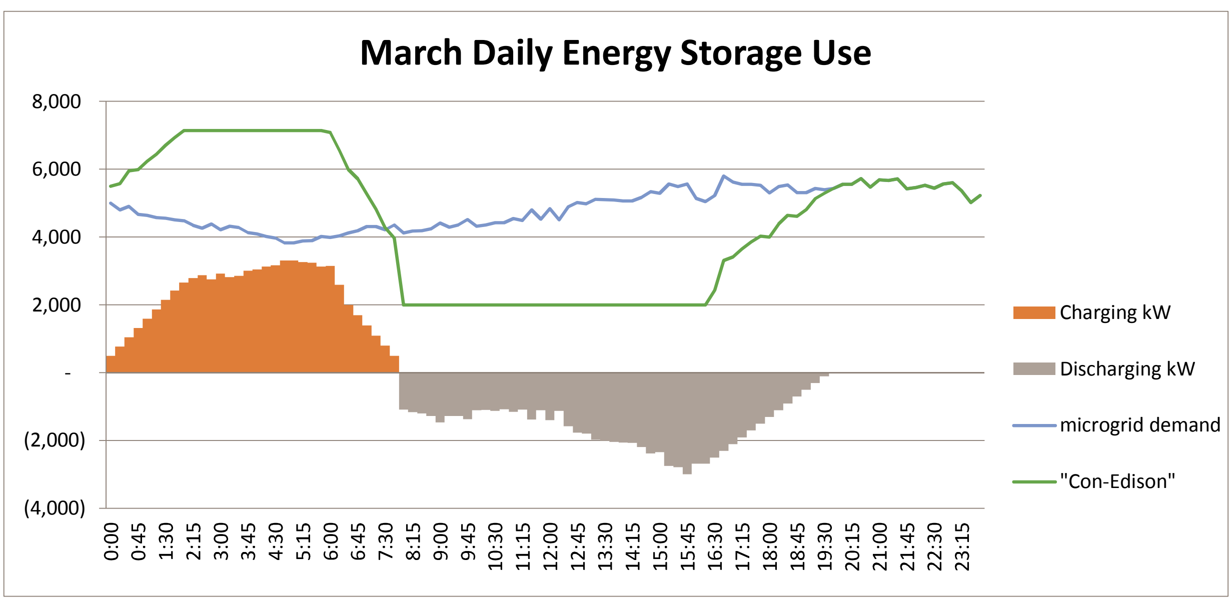
Microgrid peak	5,810
Microgrid Avg.	4,839
Net Peak	7,150
Net Average	4,402

On Peak Hours 0800 - 1600	
Microgrid Demand	5,810
Con-Edison Demand	4,031

Generators

Gen.1 kWh	-
Gen2 kWh	-
Total kWh	-





April

Energy Storage

Maximum Discharge rate	(2,689)	kW
Maximum Charging rate	3,154	kW
Total kWh discharged	(17,929)	
Total kWh charged	17,924	
Net balance	(5)	

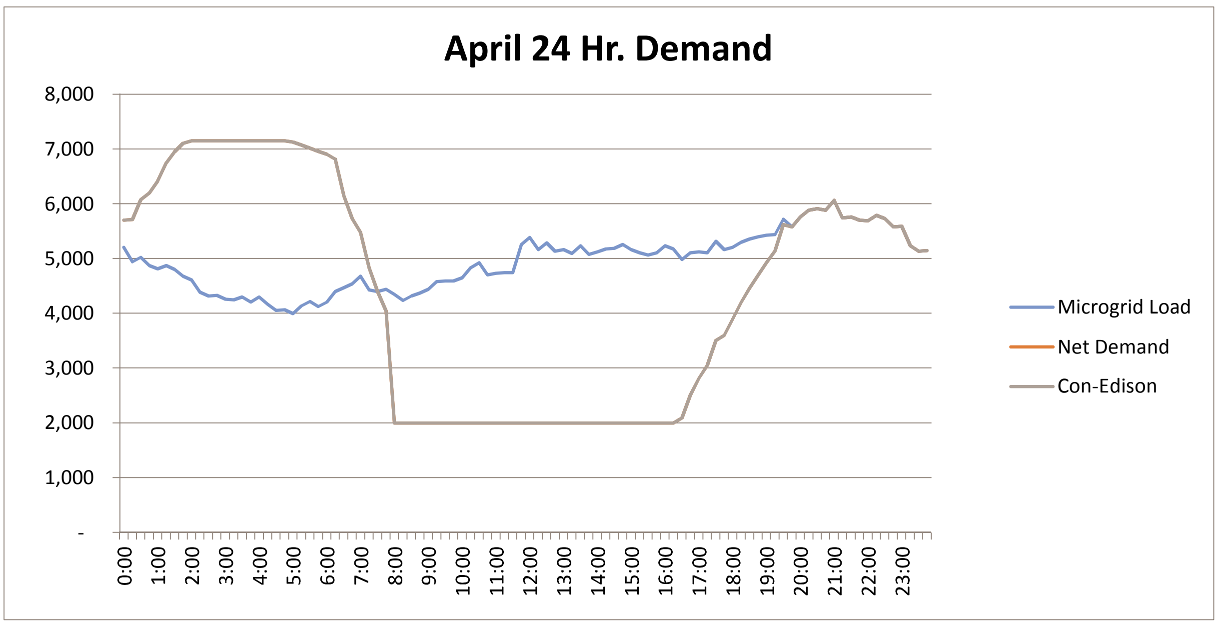
Demand kW

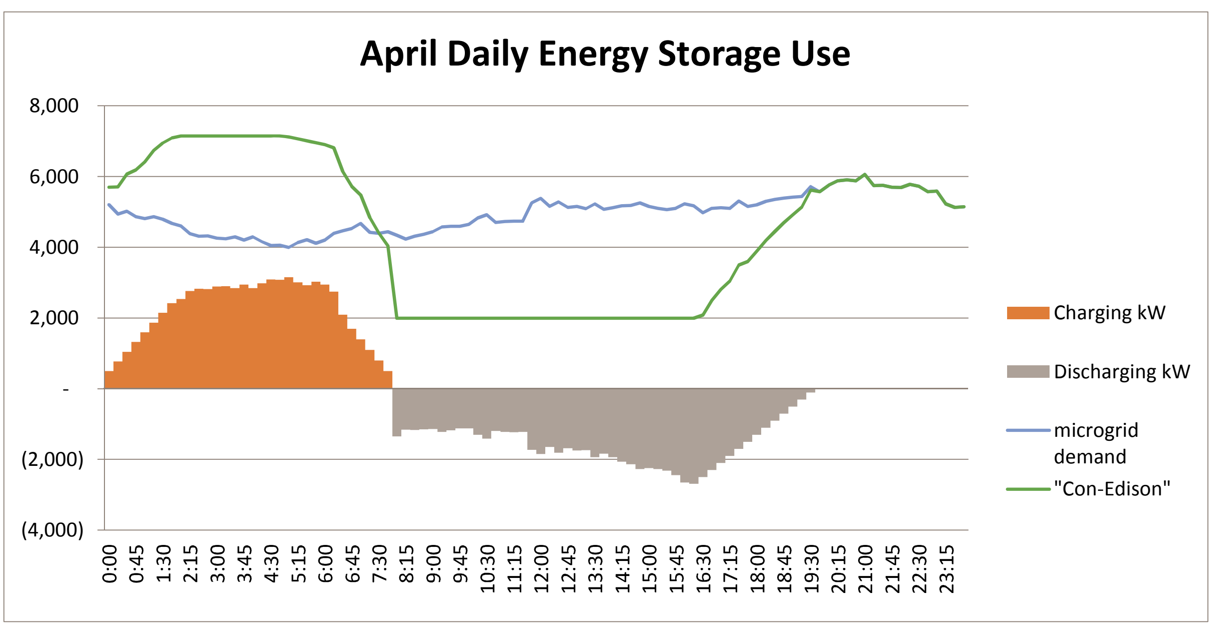
Microgrid peak	6,064
Microgrid Avg.	4,942
Net Peak	7,150
Net Average	4,416

On Peak Hours 0800 - 1600	
Microgrid Demand	5,384
Con-Edison Demand	3,890

Generators

Gen.1 kWh	-
Gen2 kWh	-
Total kWh	-



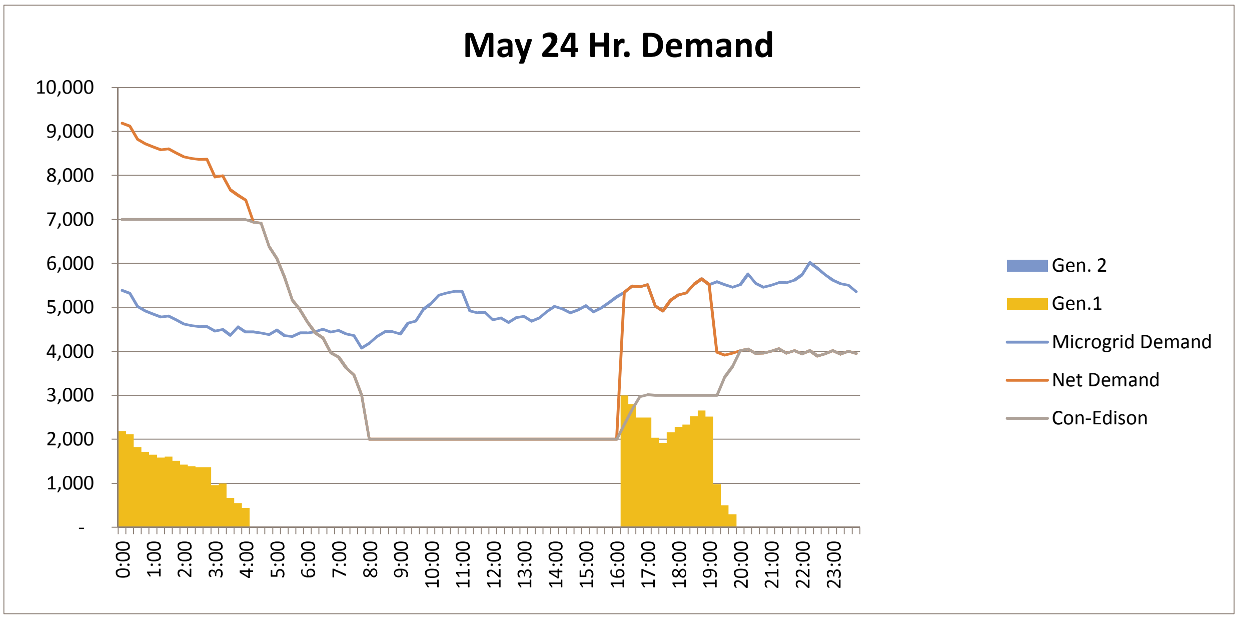


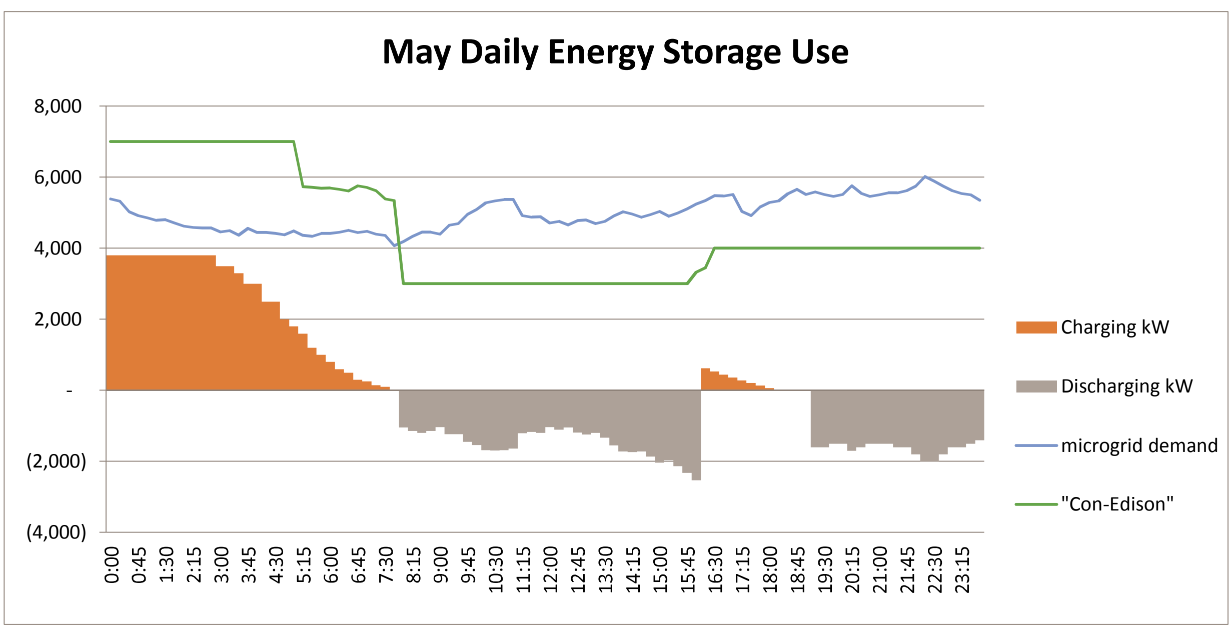
May

Energy Storage		
Maximum Discharge rate	(2,529)	kW
Maximum Charging rate	3,800	kW
Total kWh discharged	(19,969)	
Total kWh charged	19,967	
Net balance	(2)	

Demand	kW
Microgrid peak	6,020
Microgrid Avg.	4,975
Net Peak	9,190
Net Average	4,394
On Peak Hours 0800 - 1600	
Microgrid Demand	5,516
Con-Edison Demand	3,016

Generators	
Gen.1 kWh	13,603
Gen2 kWh	-
Total kWh	13,603



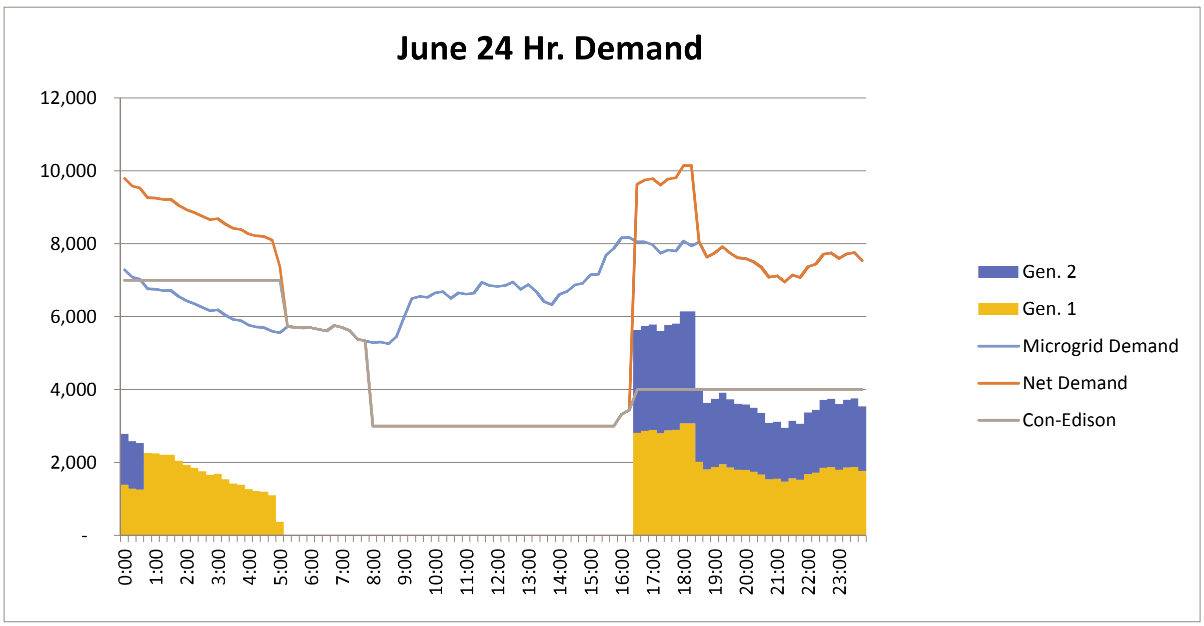


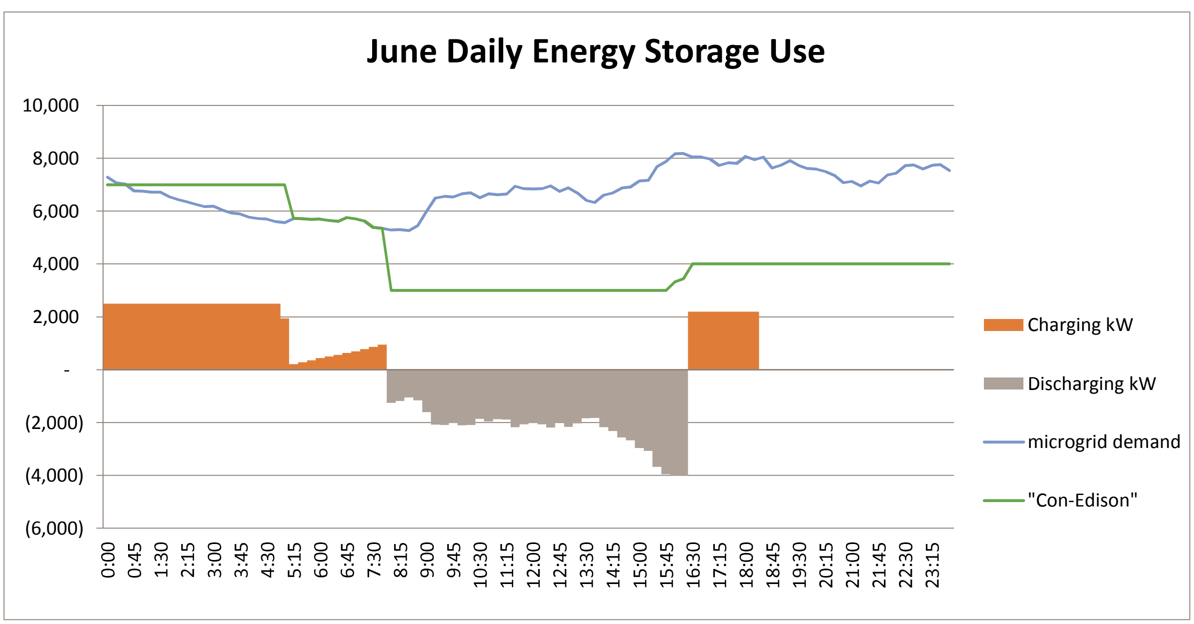
June

Energy Storage		
Maximum Discharge rate	(4,000)	kW
Maximum Charging rate	2,500	kW
Total kWh discharged	(18,963)	
Total kWh charged	18,966	
Net balance	4	

Demand	kW
Microgrid peak	8,178
Microgrid Avg.	6,781
Net Peak	10,149
Net Average	6,179
On Peak Hours 0800 - 1600	
Microgrid Demand	8,178
Con-Edison Demand	4,000

Generators	
Gen.1 kWh	23,871
Gen2 kWh	16,509
Total kWh	40,380





July

Energy Storage

Maximum Discharge rate	(4,086)	kW
Maximum Charging rate	4,000	kW
Total kWh discharged	(30,918)	
Total kWh charged	30,925	
Net balance	7	

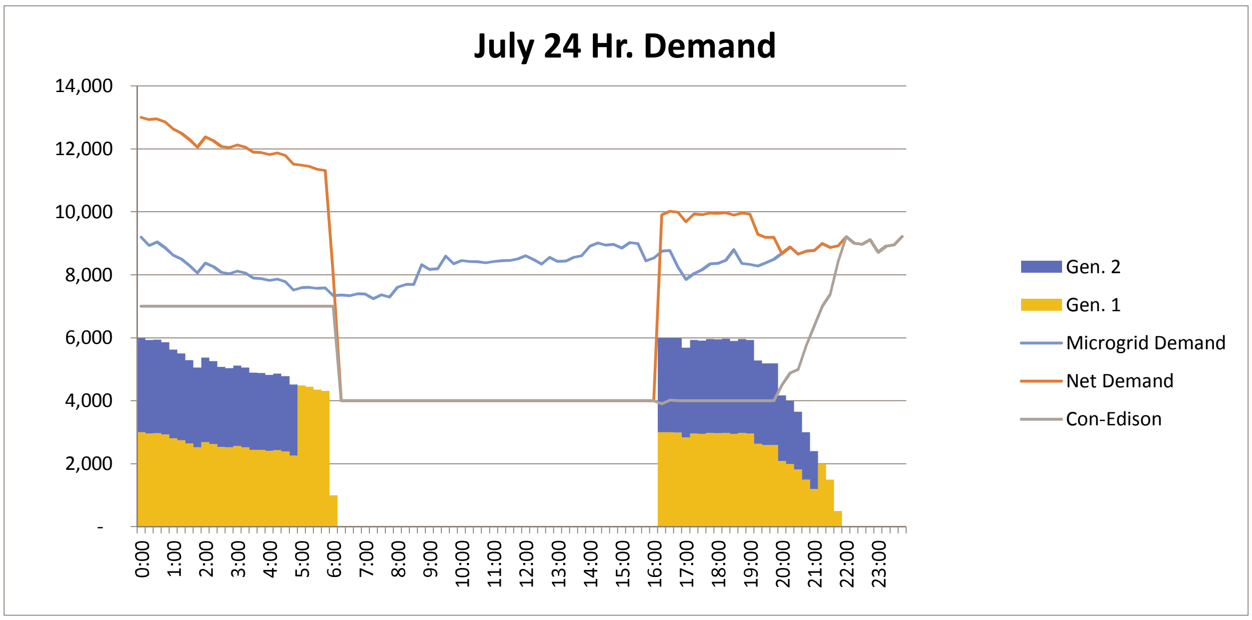
Demand kW

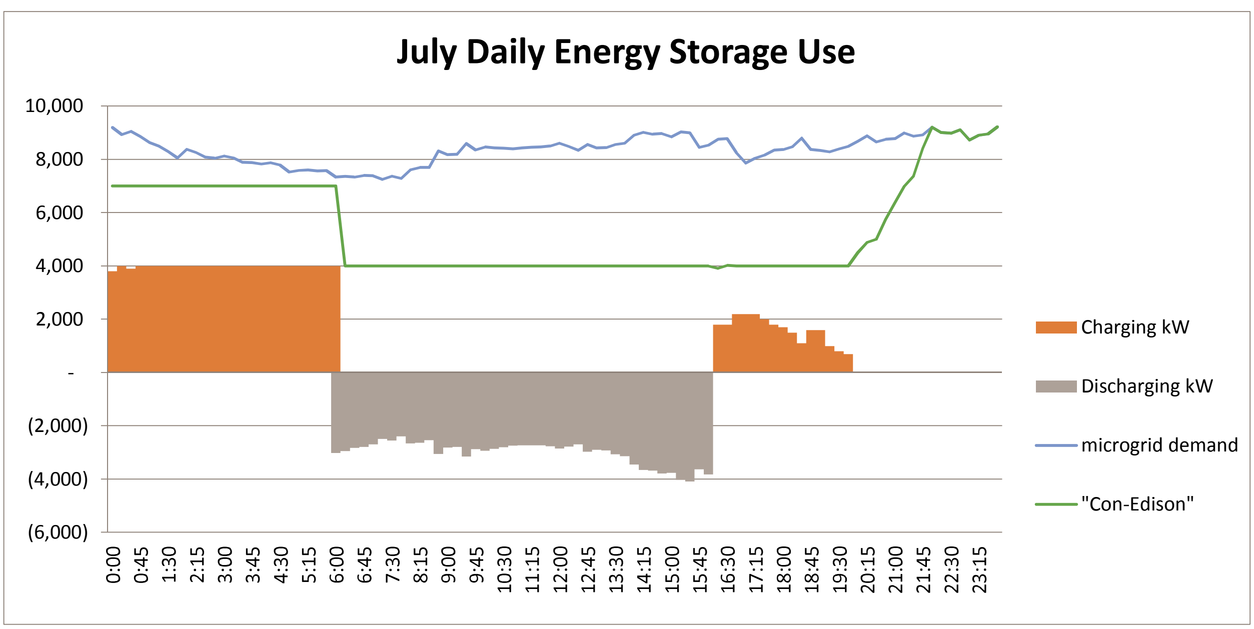
Microgrid peak	9,222
Microgrid Avg.	8,360
Net Peak	12,999
Net Average	7,792

On Peak Hours 0800 - 1600	
Microgrid Demand	9,026
Con-Edison Demand	4,026

Generators

Gen.1 kWh	31,788
Gen2 kWh	26,137
Total kWh	57,925





August

Energy Storage

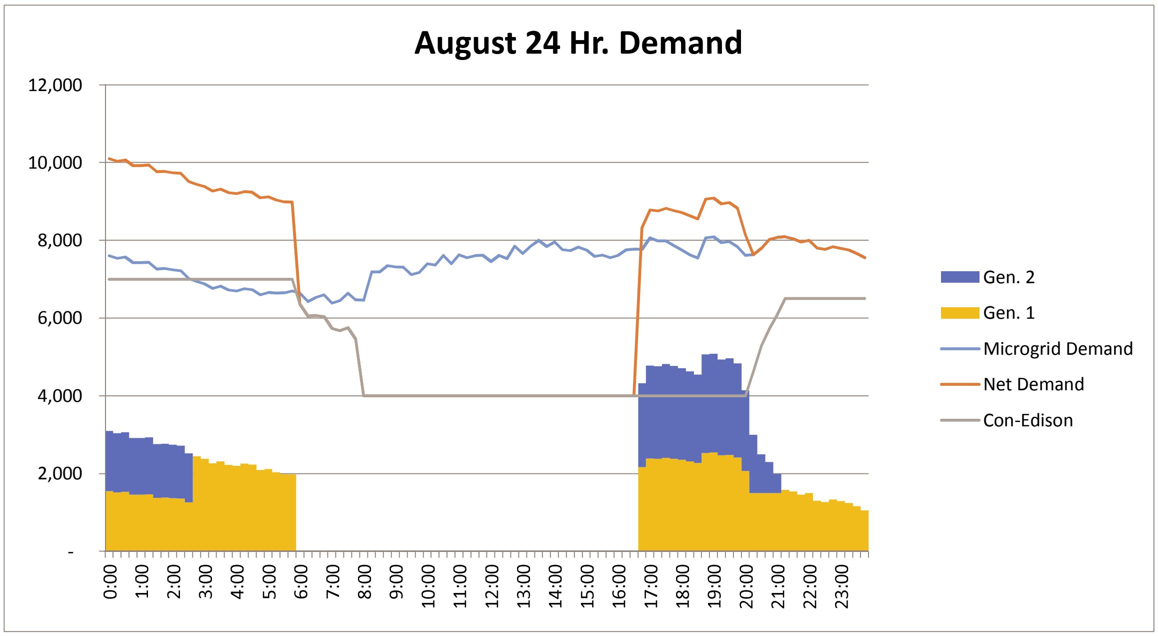
Maximum Discharge rate	(3,176)	kW
Maximum Charging rate	2,500	kW
Total kWh discharged	(18,380)	
Total kWh charged	18,383	
Net balance	3	

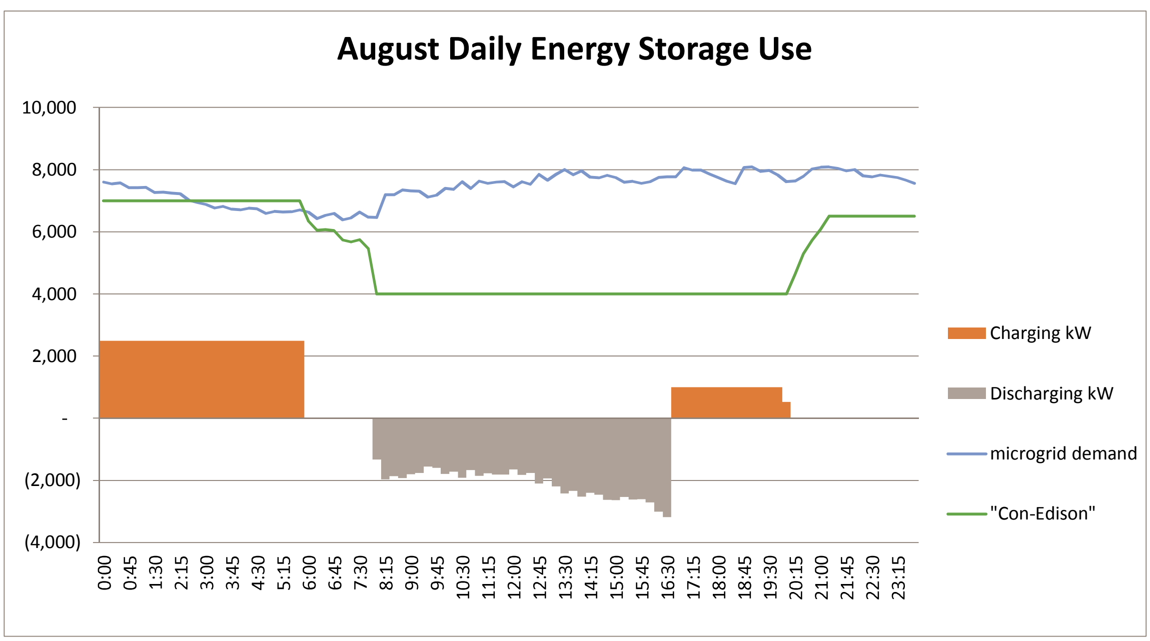
Demand kW

Microgrid peak	8,089
Microgrid Avg.	7,424
Net Peak	10,102
Net Average	6,828
On Peak Hours 0800 - 1600	
Microgrid Demand	8,067
Con-Edison Demand	4,000

Generators

Gen.1 kWh	24,576
Gen2 kWh	13,191
Total kWh	37,767





September

Energy Storage

Maximum Discharge rate	(3,858)	kW
Maximum Charging rate	1,800	kW
Total kWh discharged	(28,662)	
Total kWh charged	24,400	
Net balance	(4,262)	

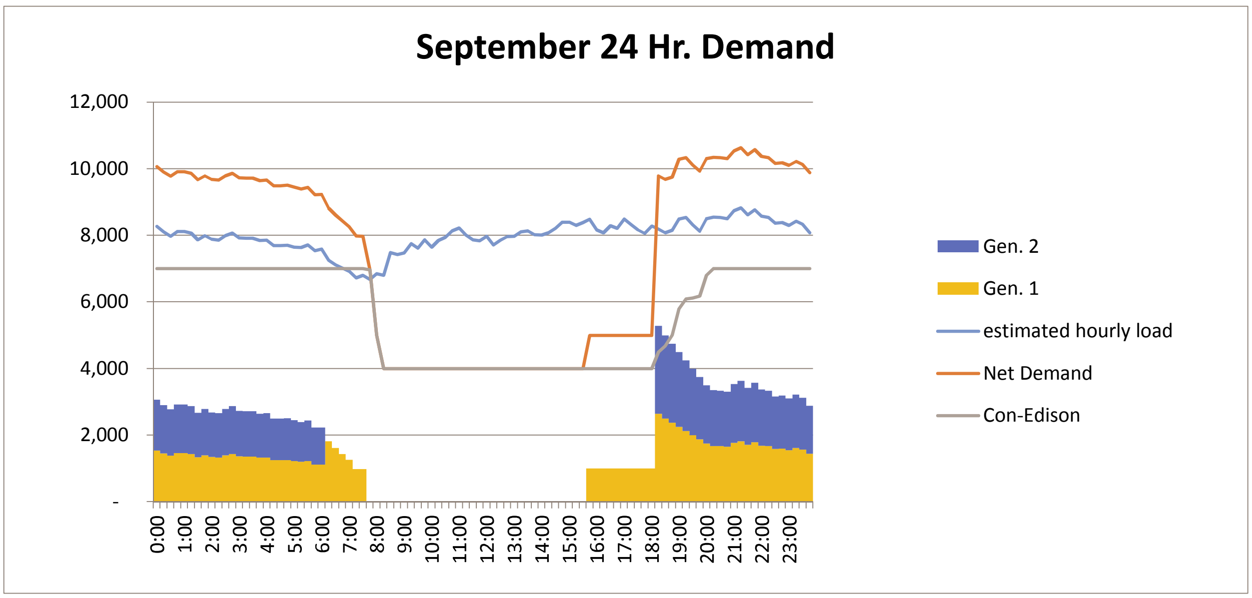
Demand kW

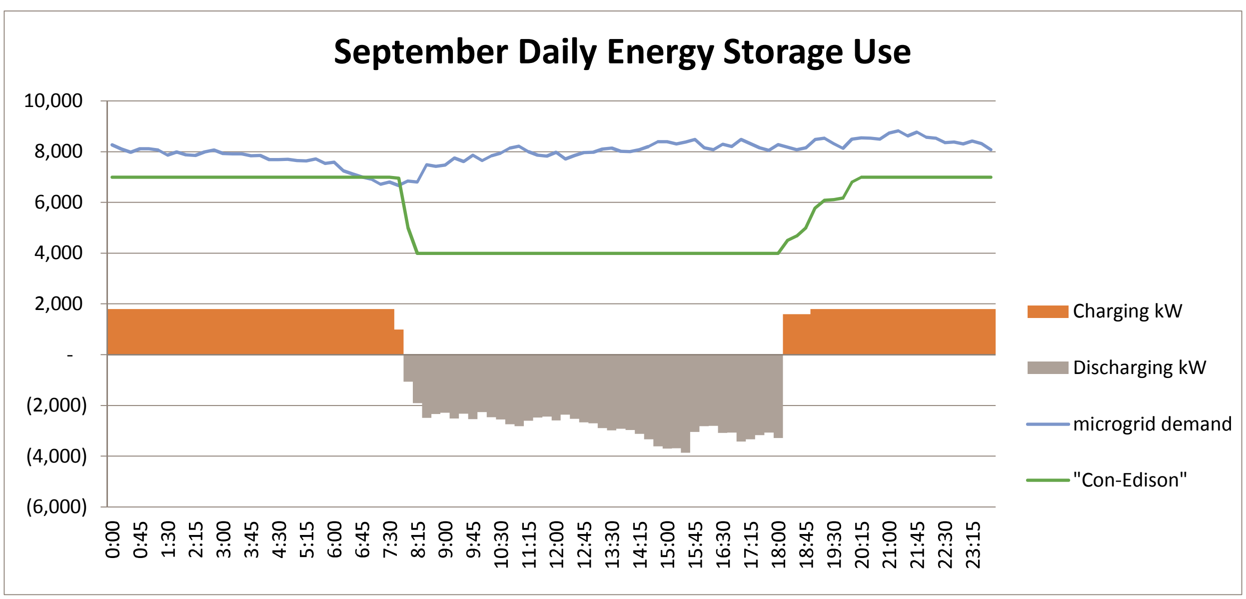
Microgrid peak	8,831
Microgrid Avg.	7,983
Net Peak	10,631
Net Average	7,379

On Peak Hours 0800 - 1600	
Microgrid Demand	8,491
Con-Edison Demand	5,000

Generators

Gen.1 kWh	23,420
Gen2 kWh	18,900
Total kWh	42,320



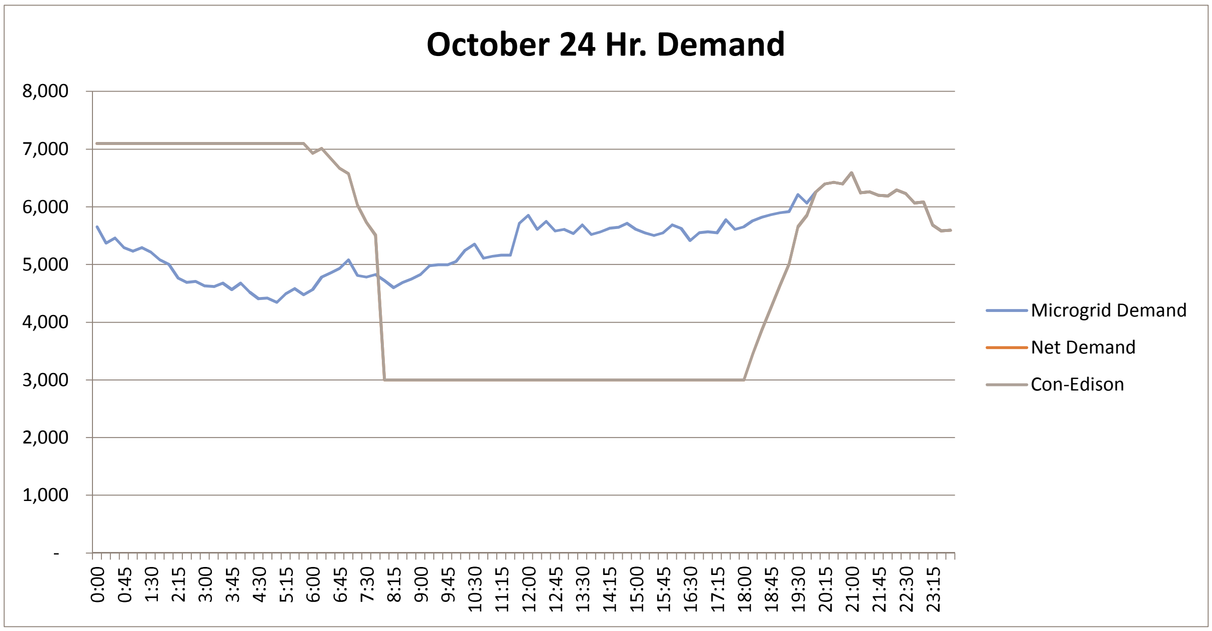


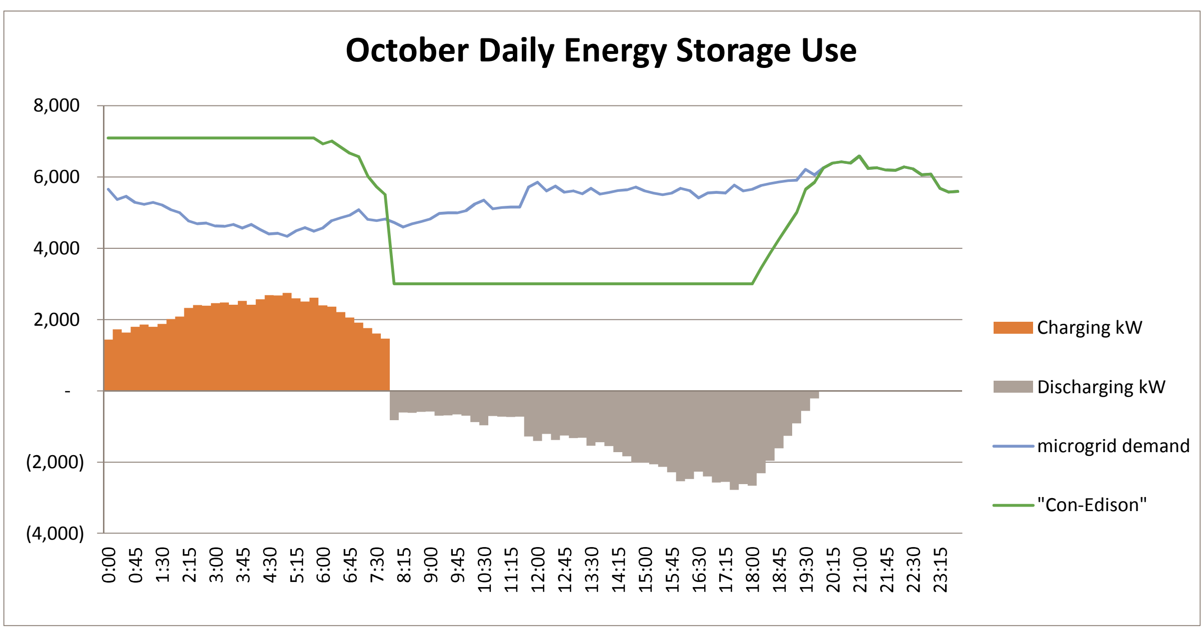
October

Energy Storage		
Maximum Discharge rate	(2,779)	kW
Maximum Charging rate	2,754	kW
Total kWh discharged	(17,492)	
Total kWh charged	17,490	
Net balance	(2)	

Demand	kW
Microgrid peak	6,594
Microgrid Avg.	5,374
Net Peak	7,100
Net Average	4,958
Con-Ed demand	7,100
On Peak Hours 0800 - 1600	
Microgrid Demand	5,854
Con-Edison Demand	3,000

Generators	
Gen.1 kWh	-
Gen2 kWh	-
Total kWh	-





November

Energy Storage

Maximum Discharge rate	(3,594)	kW
Maximum Charging rate	2,749	kW
Total kWh discharged	(20,298)	
Total kWh charged	20,298	
Net balance	(0)	

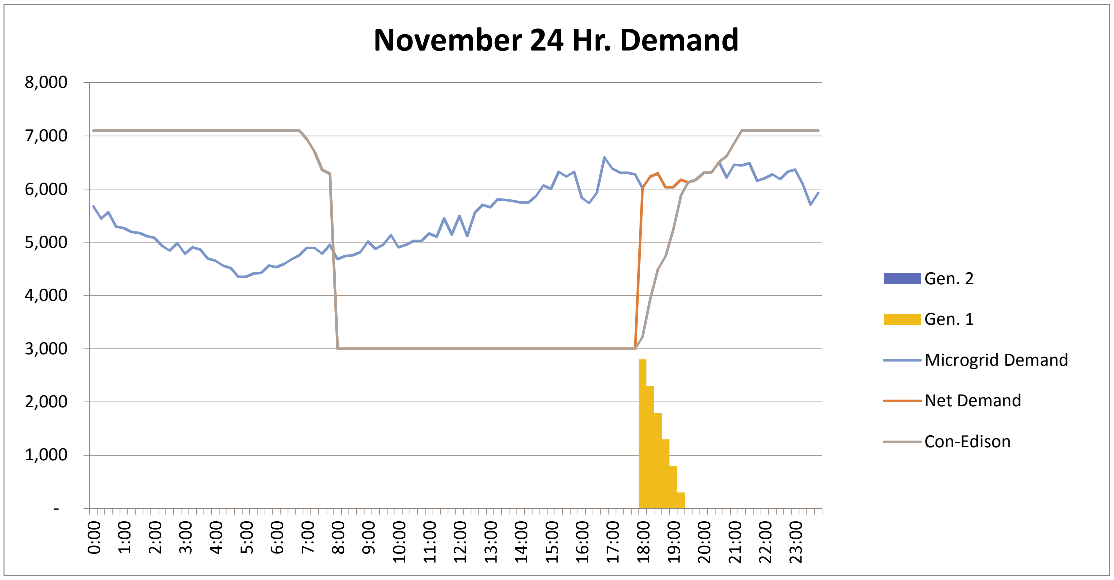
Demand kW

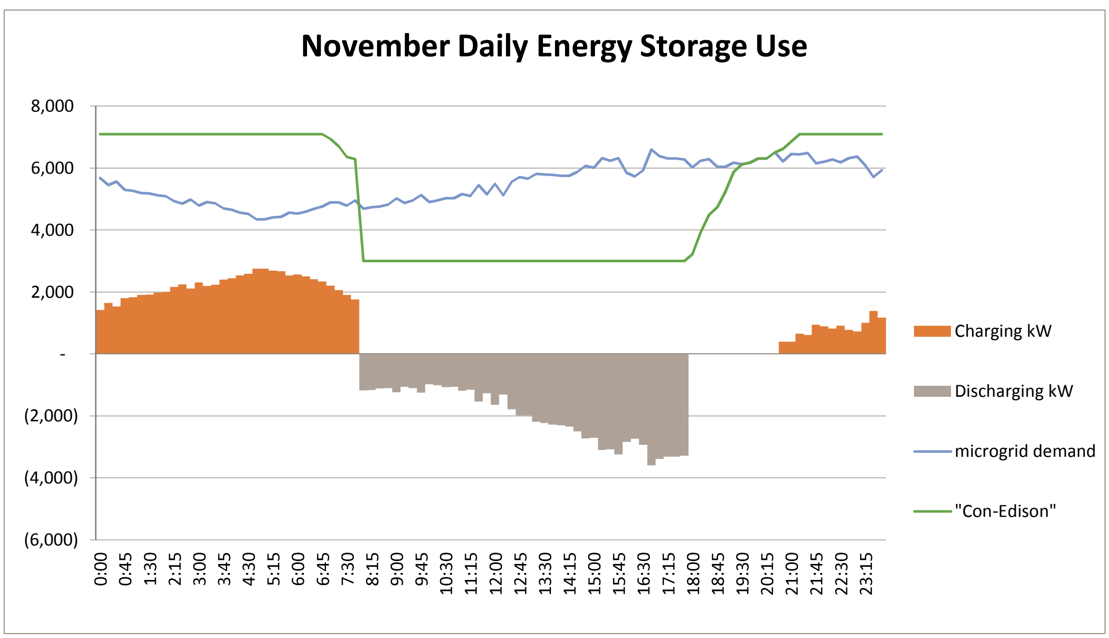
Microgrid peak	6,594
Microgrid Avg.	5,492
Net Peak	7,100
Net Average	5,259

On Peak Hours 0800 - 1600	
Microgrid Demand	6,594
Con-Edison Demand	3,222

Generators

Gen.1 kWh	2,325
Gen2 kWh	-
Total kWh	2,325





December

Energy Storage		
Maximum Discharge rate	(2,000)	kW
Maximum Charging rate	1,656	kW
Total kWh discharged	(12,208)	
Total kWh charged	12,210	
Net balance	1	

Demand	kW
Microgrid peak	3,749
Microgrid Avg.	2,982
Net Peak	4,000
Net Average	2,792
On Peak Hours 0800 - 1600	
Microgrid Demand	3,500
Con-Edison Demand	1,500

Generators	
Gen.1 kWh	-
Gen2 kWh	-
Total kWh	-