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Notice

City of Yonkers
Community Microgrid

August 12, 2016

Microgrid Feasibility Study

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

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Section 1 – Project Summary and Description of Microgrid Capabilities

Executive Summary

The proposed microgrid project includes multiple buildings near each other in the downtown area of Yonkers at South Broadway and Nepperhan Avenue / Vark Street. The project involves two islandable areas, which include City of Yonkers government buildings and a justice center (plus the Yonkers Police Department Headquarters and U.S. HUD-subsidized residential housing) to the east of South Broadway and St. Joseph's Medical Center (Hospital and Nursing Home) to the west of South Broadway. The geographical location is 40.931210 (N) longitude and -73.898747 (W) latitude.

The project team sees an opportunity to deploy a mix of cleaner, more efficient distributed energy resources ("DER") to provide an economic benefit but to also provide a more reliable optional standby power to serve customer needs during outage events. Under the concept design discussed in this report, 2.9MW of high efficiency natural gas-fueled engines will be installed at the sites with the highest potential for combined heat and power (CHP) operation: Justice Center, Griffin House and St. Joseph's Hospital. 300kW of renewable solar PV is planned for the City parking garage. The DER generation will also provide grid support for electrical grid system under normal grid-connected operation to allow for more utility capacity. A microgrid solution that addresses the issues described above would advance the objectives of the NY Prize Community Grid Competition, as well as align with the Yonkers Five Cities Energy Plan, supported by the New York Power Authority and guided by Governor Cuomo's landmark BuildSmart NY program, and the Yonkers NY Rising Community Reconstruction Plan, supported by the Governor's Office of Storm Recovery and funded with grants from U.S. HUD's CDBG-DR program.

Hurricane Irene and Superstorm Sandy hit Yonkers with full force, causing widespread and long-lasting damage to public and private property as well as serious physical, economic, and safety hardships to Yonkers residents and businesses. Superstorm Sandy left more than 20,000 Yonkers residents without electricity and caused physical damage to homes, businesses, and City infrastructure, including storm surges that destroyed a lot of equipment at the Yonkers Wastewater Treatment Plant. In the Yonkers NY Rising Community Reconstruction Plan from December 2014, the needs identified include generators at facilities providing services that are critically needed after storms and preservation of electrical service during storms, and one of the opportunities is to "explore alternative power opportunities such as renewables and micro-grids for improved access to power and increased flexibility during/after storms."[1] A reliable, resilient, and efficient microgrid in Yonkers will help the city move into the next phase of sustainable

[1] Yonkers NY Rising Community Reconstruction Plan, December 2014. <http://stormrecovery.ny.gov/sites/default/files/crp/community/documents/yonkers_nyrcr_combined_full_plan_akrf_3.30.15_0.pdf>.

development, and NY Prize offers an extraordinary opportunity for Yonkers to address its energy challenges, promote revitalization downtown in a severely distressed area, and build a stronger, greener city. The proposed microgrid facilities are in the best position to serve the City and the community during and after disaster events.

Project Background

NRG Energy, Inc. ("NRG"), the City of Yonkers, St. Joseph's Medical Center ("SJMC"), and Griffin House have partnered to study the feasibility of a resilient, multi-customer microgrid in Yonkers. As envisioned, the project will deploy an optimized mix of clean, reliable, resilient, and efficient on-site generation, coupled with distributed energy storage and an integrated control system and management technology platform. The project team consists of the following members:

NRG is a Fortune 200 company, the largest competitive power producer in the U.S., and one of the nation's largest developers and owners of renewable generation. NRG is a competitive energy solutions provider with a proven track record of developing and implementing microgrids incorporating multiple generation and storage technologies under an integrated control and optimization platform at locations such as Princeton HealthCare System's University Medical Center of Princeton at Plainsboro.

Consolidated Edison Company of New York ("ConEd") is the local distribution company serving 349,000 residential and commercial electric customers and 232,000 residential and commercial gas customers in Westchester County.

The City of Yonkers is New York State's fourth largest city, with 195,976 residents as of 2010 and behind only NYC, Buffalo, and Rochester. It is the largest city in Westchester County and the Hudson Valley. The New York Power Authority ("NYPA"), the nation's largest state power organization and a national leader in promoting energy efficiency, is the electricity supply provider for the City's facilities.

SJMC, founded by the Sisters of Charity of New York, has served the city and community of Yonkers since 1888. In 2013, more than 55,000 individuals were touched by St. Joseph's and/or its St. Vincent's Westchester Division in Harrison. SJMC's healthcare facilities in Yonkers primarily consist of a 194-bed inpatient acute care hospital and a 200-bed nursing home. SJMC also sponsors two affordable senior housing facilities, including Griffin House.

Griffin House is a 10-story, 81-unit residence for very low income senior citizens. It is sponsored by SJMC Senior Development Fund Corp., managed by H.H. Management Corp., and federally subsidized by the U.S. HUD.

The facilities under consideration include:

1. Yonkers Government Administration Buildings:

- City Hall at 40 South Broadway
- City Offices at 87 Nepperhan Avenue
- City Parking Garage at 118 New Main Street

City Administration Buildings
Figure 1

The following is information on the electrical systems:

City Hall – Main Service: old CB SWBD: 208Y/120 VAC 1000 amp – 3-500 MCM per phase.

City Offices – Main Service: rusty Bolted Pressure Switch feeds – 2 section distribution board rated 208/120 VAC; 1200 amp.

City Parking Garage – No information obtained – six lighted levels with one elevator – estimation 208Y/120 VAC; 400 amp.

2. Justice Center Complex (including Police HQ) and Senior Housing:

- Robert W. Cacace Justice Center at 104 South Broadway
- Yonkers Police Department Headquarters also at 104 South Broadway
- Outdoor city-owned parking lot for municipal complex
- Griffin House at 122 South Broadway

Justice Center Complex and Senior Housing
Figure 2

The following is information on the electrical systems:

Robert W. Cacace Justice Center – Main Service : A 208Y/120 VAC – 4000 amp service feeds three distribution switchboards, Bolted pressure switch mains on Normal and Equipment boards and an Emergency board with Bolted Pressure Switch feeding source 1 of ATS with 500 kW Emergency Generator connected to the second source.

Yonkers Police Department Headquarters and Outdoor Parking Lot lights feed from switchgear in Robert W. Cacace Justice Center.

Griffin House – This apartment building has 81 individual utility owned tenant meters and one building meter for common areas. 208Y/120 VAC 3200 amp utility max with 3-800 amp switches feeding meter stacks with 27 meters installed in each (81 total) and one three section 800 amp rated bus SQD Breaker distribution boards (rough total is 4 x 800 amp sources = 3200 amp). Roof has wide area for solar and has significant wind on the roof. A room is available for battery storage on roof and larger rooms in the basement.

3. St. Joseph's Medical Center

- SJMC Hospital building at 127 South Broadway
- SJMC Nursing Home at 115 South Broadway

St. Joseph's Medical Center
Figure 3

The following is information on the electrical systems:

SJMC Hospital building – Main Service : A 480Y/277 VAC – 2500 amp service feeds the main hospital building there are three ATS with 750 kW Standby Emergency Diesel Generator. Parking garage across Vark Street is fed electrically from the main hospital building.

SJMC 1934 building – 480Y/277 VAC; was shown an ATS with 250 kW Standby Emergency Diesel Generator. Estimated 300 amps at 480Y/277 VAC. This building is the one in front of the center main hospital building in the picture above, and electrical systems are mixed in the main hospital building's Emergency Room.

SJMC Nursing Home building – 1976: 480Y/277 VAC – saw no utility meter; was shown an ATS with 250 kW Standby Emergency Diesel Generator. Estimated 300 amps at 480Y/277 VAC.

The Yonkers subject facilities above have separate electric utility services delivered from ConEd. Certain buildings have natural gas utility service also provided by ConEd, while others have fuel oil for heating, as shown in the table below. The Justice Center and St. Joseph's Medical Center facilities have existing emergency diesel generators (1.75 MW in aggregate), listed in Task 3.4.3, to provide reliable electrical power as mandated by building codes for life safety. Present use of the other subject buildings does not require emergency or standby power generation systems.

PRESENT HEATING ENERGY SOURCE	
City Hall	Fuel Oil*
City Offices	Fuel Oil
City Parking Garage	No Heating
Justice Center	Natural Gas
Griffin House	Natural Gas
SJMC Hospital	Fuel Oil**
SJMC Nursing Home	Fuel Oil

* Future plans for City Hall include conversion to natural gas, as also noted in Task 3.2.3
** Fuel oil is major source for St. Joseph's Medical Center. Some natural gas is available, although not for primary heating purposes

Facilities in the proposed microgrid are shown in the following table, as listed in the Community Asset Inventory in the Yonkers NY Rising Community Reconstruction Plan from December 2014. All are considered FEMA critical facilities, providing vital health and social services to the Yonkers community or housing services to senior citizens.

Asset Name	Asset Class	Asset Subcategory	Critical Facility	Community Value	Socially Vulnerable Populations
Yonkers City Hall	Health and Social Services	Government and Administrative Services	Yes, FEMA	High	No
Yonkers Police Dept. Headquarters	Health and Social Services	Emergency Operations/Response	Yes, FEMA	High	No
St. Joseph's Medical Center	Health and Social Services	Healthcare Facilities	Yes, FEMA	High	No
St. Joseph's Nursing Home/Aging	Housing	Senior Housing	Yes, FEMA	High	Yes

Task 1.1 – Description of Minimum Required Microgrid Capabilities

Grid-Parallel Generation and Fuel Mix

In order to satisfy the Minimum Required Capabilities for the Yonkers microgrid, the project team proposes a mix of new generation assets, to work in conjunction with new electrical infrastructure upgrades and energy conservation measures. Existing backup generators may be incorporated for additional robustness.

Potential for new generation is described in Table 1 below. A total of seven (7) separate facilities will be included in the proposed microgrid. Total energy required by the facilities was estimated from monthly billing demand where billed energy usage was not available. Based on available data, the total annual energy usage is estimated at 14,031 MWh/year for the facilities combined. During grid-parallel operation, the CHP systems will follow the load of the facility where required by sensing the electric load requirement at the customer's electric service entrance or main switchgear.

Facility	Planned Baseload Generation Size	Planned Solar PV Generation	Description
City Hall	N/A	N/A	Primary path is to combine electrical services so that facilities are fed by Justice Center utility and CHP
City Offices		N/A N/A	
City Parking Garage		300kW ~ 525 MWh/year	
Robert W. Cacace Justice Center and Police HQ	250kW/750kW 1,884 MWh/year	N/A	2 Engines (Solar PV potential at Justice Center parking lot and surrounding City-owned property)
Griffin House	300 kW 1,248 MWh/year	N/A	Assumes conversion to master meter with submetering, (2) 150kW engines
St. Joseph's Hospital	1,600 kW 7,500 MWh/year	N/A	Microturbine System (Canopy Solar PV potential in south parking lot)
St. Joseph's Nursing Home	N/A	N/A	Fed from Hospital during island mode
Total Nameplate (kW):	**2,900 kW**	**300 kW**	
Total Energy Potential from Grid-parallel Generation (MWh/year):	**24,134 MWh/year**	**525 MWh/year**	
Estimated Total Energy Required by All Facilities (MWh/year):	**14,031 MWh/year**		
Total Energy Potential from Grid-parallel Generation (% of Total Annual Energy Usage):	**172%**		

Potential for Grid-Parallel Generation
Table 1

Solar PV generation potential was estimated by total available space for solar panels on the top level of the City Parking Garage. To estimate base load generation, the lowest monthly billing demand for the period available (Jan. 2013 – Feb. 2015) was multiplied by 0.6 when electric interval data was not available. Electric interval data was available from ConEd for the SJMC Hospital (127 South Broadway), Cacace Justice Center (104 South Broadway), and City Offices (87 Nepperhan Avenue). City facilities get electric supply from NYPA under Service Tariff No. 200

for Westchester County Governmental Customers (Service Classification No. 69, General Large), with delivery from ConEd under PSC No. 12 "Schedule for PASNY Delivery Service."

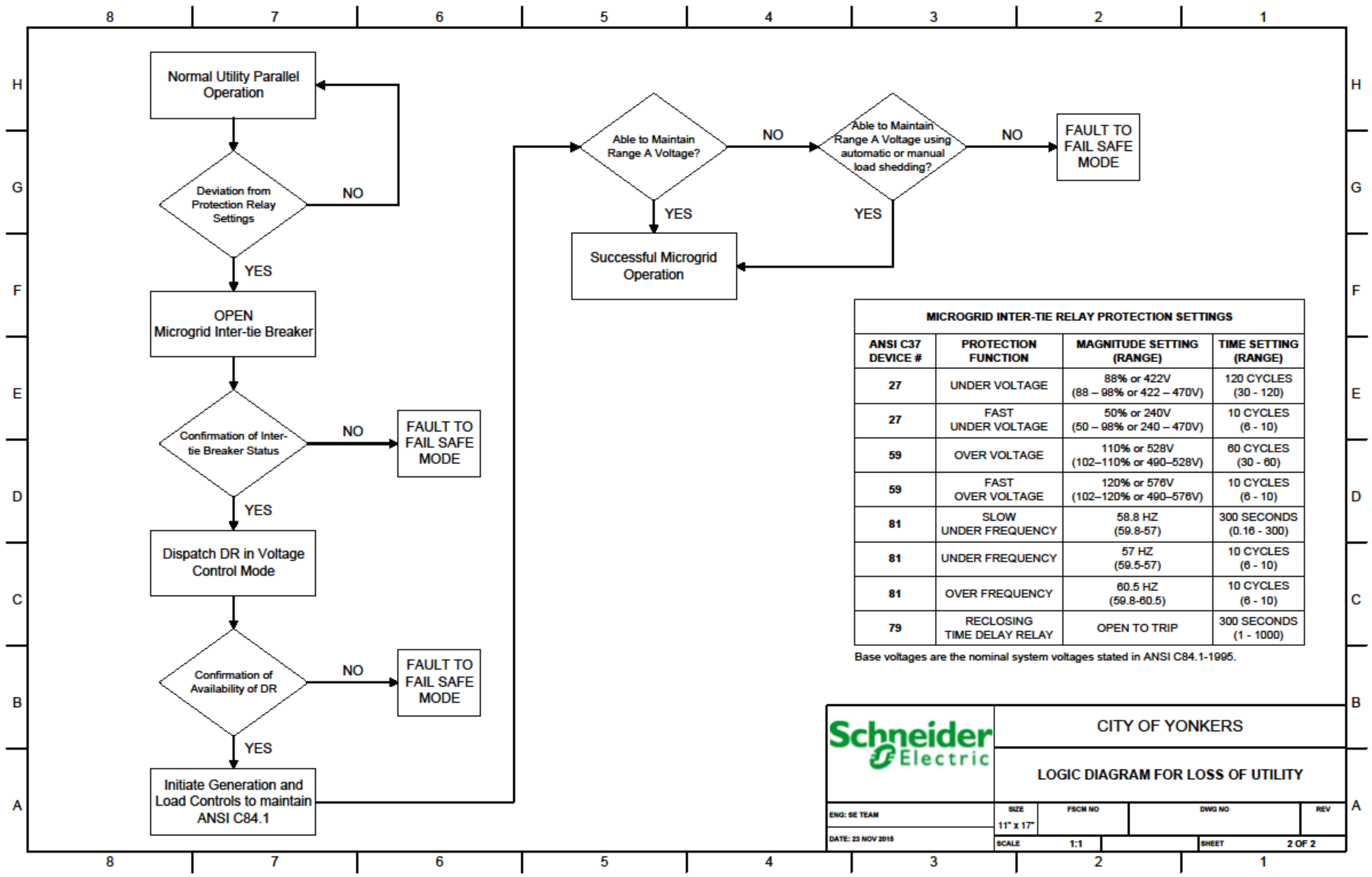
The City-owned facilities will be electrically tied together on the ConEd system during grid-parallel operation so that they are serviced with a single ConEd meter, with the exception of the solar system on the garage which may be separately metered in order to facilitate net metering or remote net metering as necessary to maximize its financial performance. The connected system will enable larger base load generation to be deployed, maximizing economies of scale and minimizing the number of generators that will need to be operated in tandem during Island Mode. This is likely possible for facilities that have the same owner (such as the City buildings). For facilities with different owners, they will be tied together only during Island Mode. Cross connections for improved reliability will be further considered during detailed design work. The City Parking Garage electrical system is fed from a different ConEd network, and the solar PV system will operate stand-alone utilizing net metering.

The proposed plant generation is sized for aggregate peak load and could provide up to 172% of the facilities' total annual energy usage in grid-parallel generation, as shown in Table 1. Energy during grid-parallel mode will come primarily from the base load generation sources, which includes natural gas reciprocating engines and microturbines and will be configured to recover heat in Combined Heat and Power ("CHP") operation. There is not enough thermal load to account for all generation and for all generation sources to operate during normal mode. The additional capacity is provided for islanded/emergency operation.

These resources are sized for maximizing payback/financial performance for the City of Yonkers, SJMC, and Griffin House, while still allowing for adequate generation during Island Mode operation. Tax credits, incentive funds, and other applicable financial assistance (e.g. NYSERDA Program Opportunity Notices, programs at NYPA, or programs through ConEd) is assumed in the current design and will increase the financial performance of the grid-parallel generators. In addition to federal and state incentives, solar PV is expected to take advantage of net metering or remote net metering to maximize the value of its electrical output. Other generators are sized to match the thermal load requirements of the buildings and will be configured to follow the facility loads and avoid power export. Base load generation sources will be maintained at regular intervals, according to manufacturers' requirements and will likely be maintained under long-term service contracts in order to minimize risk to the facility owners. Typical availability for base load generators is expected to be 90-97%. Generators will be configured for black-start capability.

Island Mode Capability and Operation

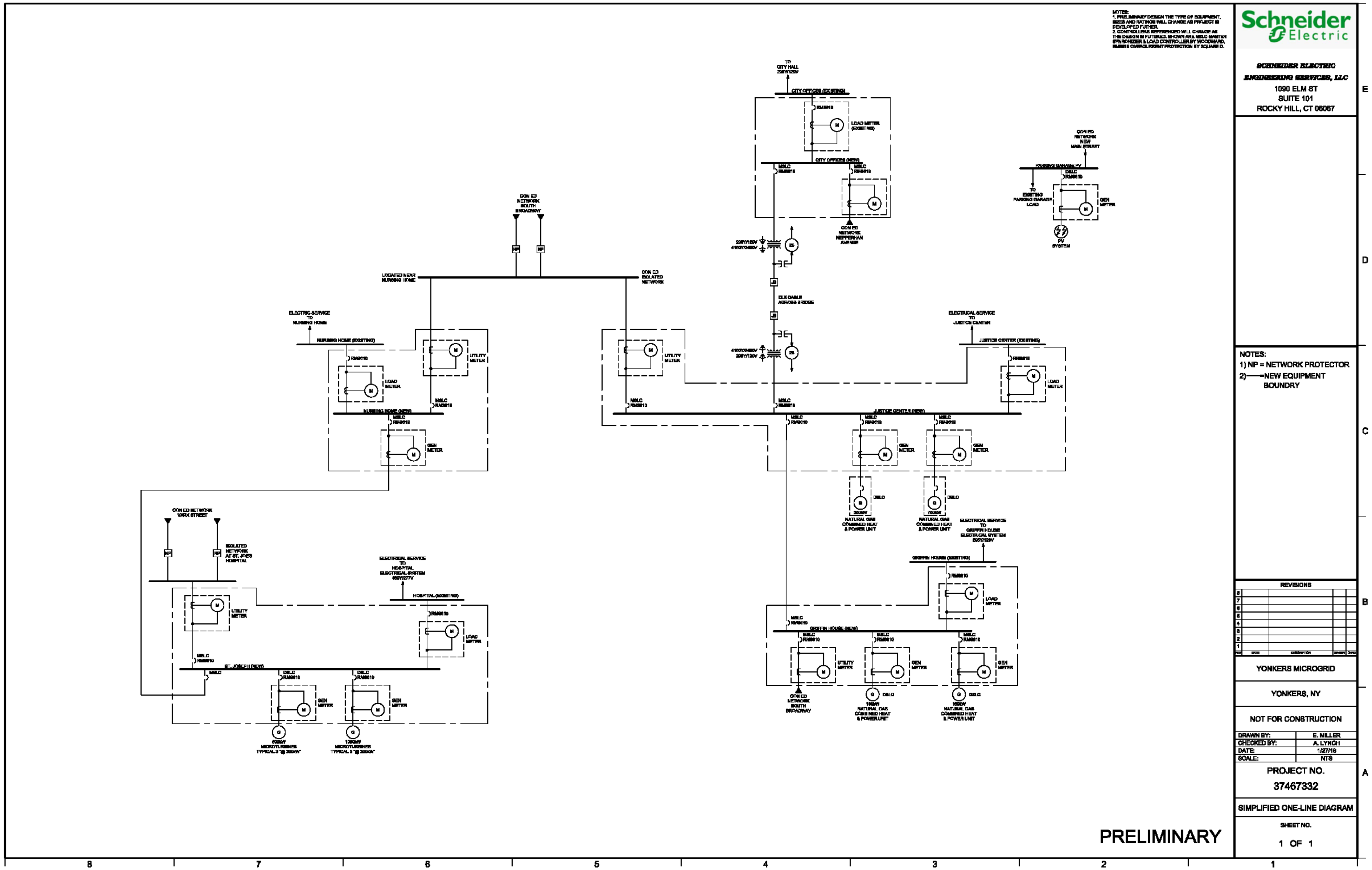
During Island Mode, the natural gas-fueled engines will "black start" in order to supply the all or most of the electric supply to the facilities in the absence of the utility supply. This distributed generation would become the backbone of the microgrid. Existing diesel generators will be operated in parallel with the natural gas-fueled systems in case additional supply is necessary during peak periods. Or, the existing transfer equipment will remain and the diesel gensets will come on line for load shedding purposes. During Island Mode, a portion of the solar PV will supplement the natural gas-fueled generators where possible. The microgrid controller will allow the generation sources to operate in tandem during Island Mode and enable the facilities to automatically disconnect from the grid during times of grid outage. When grid power is restored (or Island Mode ended), each base load generator and solar PV system will parallel to the grid once again.



MICROGRID INTER-TIE RELAY PROTECTION SETTINGS

ANSI C37 DEVICE #	PROTECTION FUNCTION	MAGNITUDE SETTING (RANGE)	TIME SETTING (RANGE)
27	UNDER VOLTAGE	88% or 422V (88 – 98% or 422 – 470V)	120 CYCLES (30 - 120)
27	FAST UNDER VOLTAGE	50% or 240V (50 – 98% or 240 – 470V)	10 CYCLES (6 - 10)
59	OVER VOLTAGE	110% or 528V (102–110% or 490–528V)	60 CYCLES (30 - 60)
59	FAST OVER VOLTAGE	120% or 576V (102–120% or 490–576V)	10 CYCLES (6 - 10)
81	SLOW UNDER FREQUENCY	58.8 HZ (59.8-57)	300 SECONDS (0.16 - 300)
81	UNDER FREQUENCY	57 HZ (59.5-57)	10 CYCLES (6 - 10)
81	OVER FREQUENCY	60.5 HZ (59.8-60.5)	10 CYCLES (6 - 10)
79	RECLOSING TIME DELAY RELAY	OPEN TO TRIP	300 SECONDS (1 - 1000)

Sequence of Operations
Figure 4



Preliminary 1-Line Diagram

(see Appendix C for enlarged diagram)

Figure 5

The facilities selected for the City of Yonkers microgrid include a wide range of types of facilities and multiple critical facilities. The microgrid will allow for continuity of business/operation of existing facilities as well as enhanced community services during storms and crises causing wider grid outage. The table below describes facility usage during Normal Operation and Island Mode.

Facility	Description/Normal Usage	Usage During Grid Outage
City Hall	Houses multiple offices for normal City business and governance. Includes: - Office of the Mayor - City Clerk - Department of Public Works - VOIP Servers (being installed)	Crisis and Storm Management, some sheltering possible
City Offices	Houses multiple offices for normal City business and governance. Includes: - Dept. of Housing and Buildings - Dept. of Planning and Development - Management Information System (MIS) admin servers that support the City's IT infrastructure	Crisis and Storm Management, some sheltering possible
City Parking Garage	Multi-level parking for City Buildings	Crisis and Storm Management and Equipment Staging, some sheltering possible
Robert W. Cacace Justice Center and Police HQ	Law Enforcement Headquarters and Dispatch (24/7 facility). Includes: - Yonkers criminal court (and jail) and small claims court - YPD HQ including detectives division, police communications (Radio System)	Continuity of Law Enforcement, Emergency Response and Dispatch
Griffin House	Residential housing for very low income senior citizens	Shelter in place of tenants
St. Joseph's Medical Center – Hospital	Healthcare services for community (194-bed inpatient acute care)	Continuity of healthcare services
St. Joseph's Medical Center – Nursing Home	Elder care (200-bed, typically at > 90% occupancy)	Shelter in place of occupants, some community sheltering may be possible

Usage during Normal Operation and Island Mode
Table 2

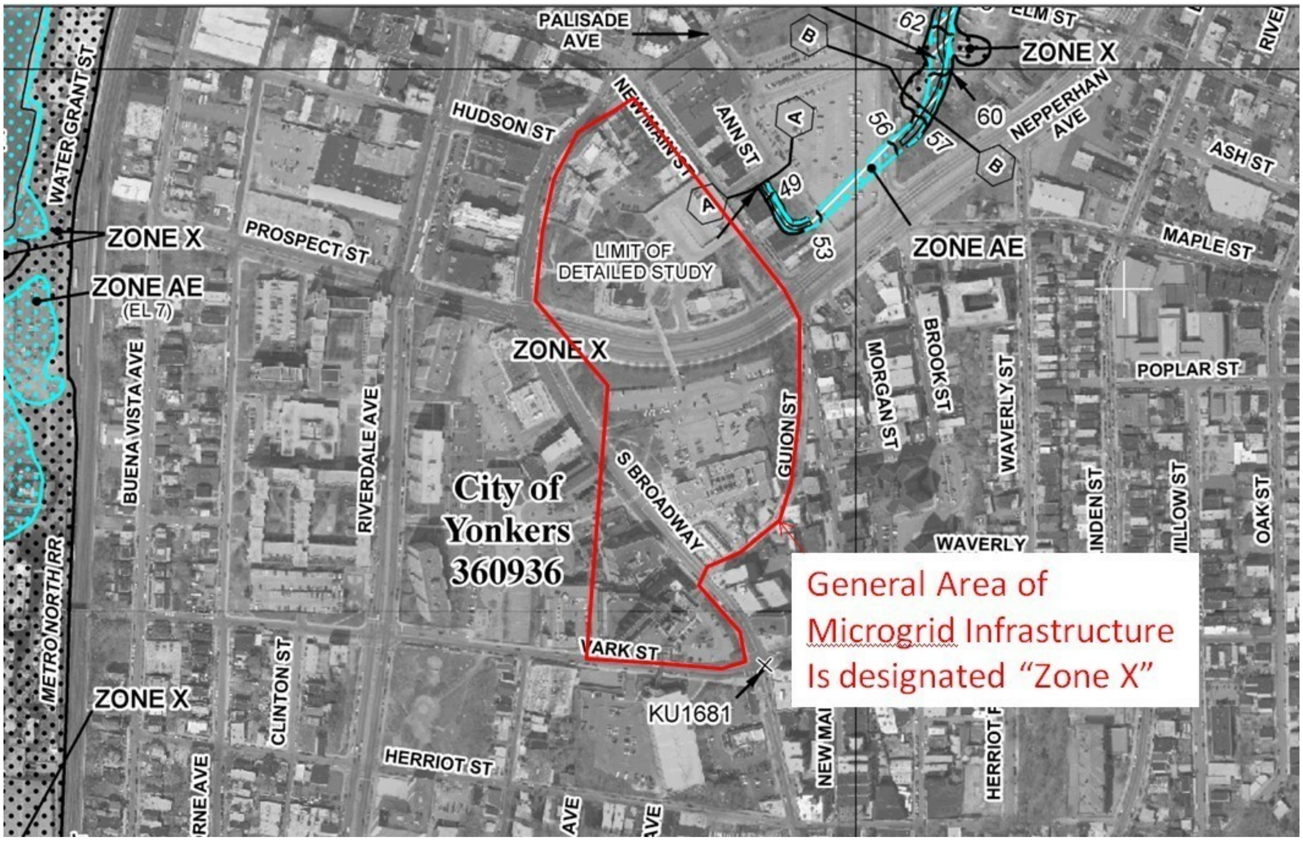
Interaction with Grid and Equipment Resiliency

Level of communication between the Yonkers microgrid and ConEd will vary depending on the final configuration of the system and size of installed generators. The planned grid-parallel generators are each less than 2 MW nameplate. All grid-parallel generators will follow ConEd's interconnection process and will comply with New York State's Standardized Interconnections Process for 50 kW-2 MW generator interconnections.[2] Although telemetering is not expected to be required for generators of the size proposed, automated communications with ConEd will be beneficial so generation operational status indication will be provided. The method of communicating the status information to ConEd will be developed in the next stages of the project. In the proposed microgrid configuration, some ConEd owned infrastructure will be used to tie the facilities together, when crossing the public streets. In this scenario, it is anticipated that ConEd will be able control of portions of the microgrid infrastructure in order to maintain safe operating conditions on their equipment. This may include remote monitoring and control of actual generation equipment or controls of disconnect switches tying the customer owned electrical gear to ConEd electrical gear. All communications between customer- or third party-owned equipment and ConEd will follow standard security protocol to protect privacy and ensure safe operability of the microgrid.

During adverse weather events, it is imperative that microgrid equipment and generators continue to be operable. During detailed design, a risk assessment will be performed on each building's critical infrastructure and on location and tie-in points of the various generators. Risks to equipment during storms include: flooding, tree strike, high winds and driving rain/snow/ice. Mitigation steps will vary depending on the physical site conditions. Appropriate mitigation will be used throughout the microgrid. Examples of mitigation steps include use of elevated equipment pads, installation of redundant equipment, installation of sump basins and pumps, robust weather-proof enclosures for generation and electrical equipment or installation of equipment indoors and moving of equipment to elevated floors of buildings. The risk of flooding for the general area of the microgrid appears to be low, based on the available FEMA flood map.[3] The area of the microgrid is designated as "Zone X," indicating that it is an "area determined to be outside the 0.2% chance floodplain," per FEMA's analysis.

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

[3] Interactive FEMA flood map for Yonkers, NY can be downloaded here:
https://msc.fema.gov/portal/search?AddressQuery=87%20Nepperhan%20Ave%20%23%20319%2C%20Yonkers%2C%20NY%2010701



FEMA Flood Map and General Area of Proposed Yonkers Microgrid
Figure 6

Task 1.2 – Description of Preferable Microgrid Capabilities

Control Systems and Energy Conservation Measures

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

Energy conservation measures (ECM) will be addressed during the detailed design phase. Formal energy audits will be conducted where there appears to be energy savings opportunities, in order to identify the best ECM to address. Typical ECM include lighting retrofits, HVAC controls and equipment upgrades. While energy savings ECM will focus on energy cost savings for the City of Yonkers, SJMC, and Griffin House, particular attention will be paid to ECM which lower demand, since those items will add stability to the microgrid control when in Island Mode in addition to energy cost savings during normal grid-connected operation. Significant potential for energy savings was identified during the initial site walk, particularly at the SJMC Hospital, where some aging equipment exists.

Microgrid Architecture and Flexibility

The proposed microgrid architecture will include two separate, segmentable areas comprising electrical generation plants, as shown in the figure below. Area#1 includes three City-owned facilities defined by the blue outline, City-owned public safety buildings defined by the green outline, and privately-owned very low income senior housing defined by the purple outline. Area #2 is comprised of St. Joseph's Medical Center (Hospital and Nursing Home buildings) defined by the red outline. Each of these two areas is generally defined by the public streets and in particular by being located east or west of South Broadway. Combining these areas electrically likely requires use of ConEd infrastructure; however, during the detailed design phase, the project team will also evaluate a direct electrical connection from SJMC (west of South Broadway) to

Cacace Justice Center / Griffin House (east of South Broadway) without having to use ConEd infrastructure. The proposed design uses ConEd infrastructure to combine both areas during Island Mode. In the event of damage or other issue with ConEd infrastructure, each area may be islanded on its own.

AREA 1

City Hall (40 South Broadway), City Offices (87 Nepperhan Ave), and Parking Garage (118 New Main Street)

- City Hall: Office of the Mayor, the City Clerk, the Department of Public Works, and VOIP servers (being installed)
- 87 Nepperhan Ave: Department of Housing and Buildings, Planning and Development, and admin servers that support City's IT infrastructure (Management Information System)

Robert W. Cacace Justice Center, Yonkers Police Department HQ, and outdoor parking lot (100-104 South Broadway municipal complex)

- Criminal court (and jail), small claims court, and police headquarters (including detectives division and police radio communications)

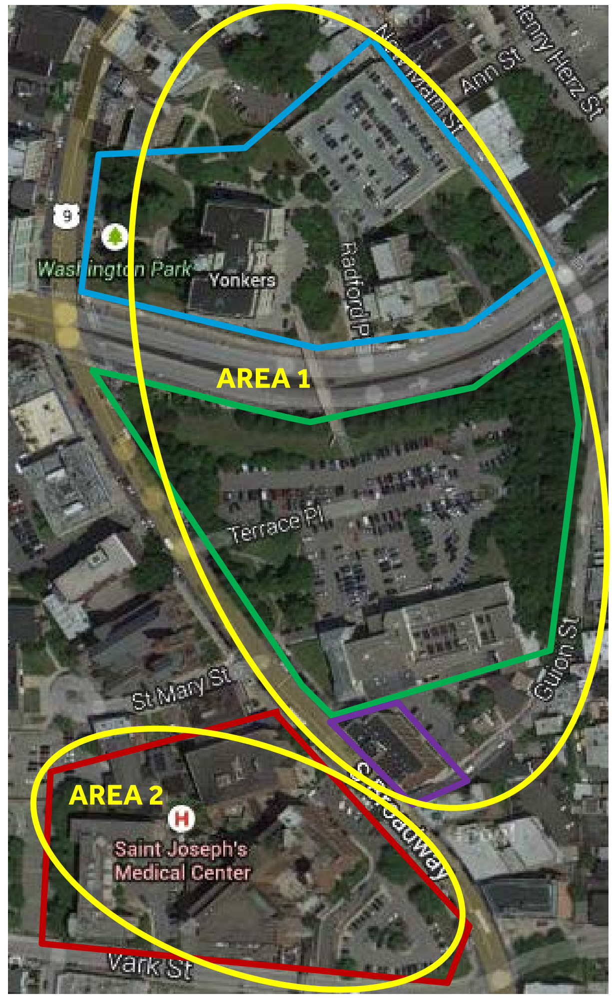
Griffin House (122 South Broadway)

- Total of 81 1-bedroom units for very low income senior citizens (U.S. HUD-subsidized)
- Sponsored by SJMC Senior Development Fund Corp. (non-profit housing corporation)
- Managed by H.H. Management Corp.

AREA 2

St. Joseph's Medical Center (115 & 127 South Broadway)

- Consists primarily of a 194-bed inpatient acute care hospital (127 South Broadway) and a 200-bed nursing home (115 South Broadway)



Two Islandable Areas Covering Seven Facilities Served by Yonkers Microgrid
Figure 7

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

The existing switchgear in each building will be modified to accommodate a connection to a new intertie circuit breaker. The intertie circuit breaker will be provided with the lock out and tag out provisions to allow for safe maintenance of the new plant and the buildings electrical equipment. The interconnection circuit breaker will include power monitoring and synchronizing controls. The monitoring and controls information will be communicated back to plants control system. Each plant will have an independent control system that will sequence the power output based on the generation availability and the demand load. The control system can provide individual plant information to the local building manager and building maintenance personnel. The controls system will be accessible via secure encrypted communications with two passwords levels of controllability. ConEd will also have access to the facilities' on-site generation information. The electrical and thermal interconnection methods from the new plant to the existing building will be developed in the next stage of the project. The goal is to use existing access ways as much as possible in order to simplify installation and minimize the cost.

The ConEd utility electrical system infrastructure is an underground networked cable system. The system contains a mix of above ground and underground vault located transformers that are network protected. The building electrical systems are typical radial distribution systems.

Costs vs. Community Benefits and Renewable Energy

A comprehensive cost/benefit analysis that includes the community, utility and developer's perspective was conducted; the mix of equipment and electrical and thermal profiles will provide a strong indication of the optimum mix of technologies and economic benefits for participants. For backup power or optional standby as defined by the National Electric Code, reciprocating synchronous engine generators will be considered. The value for reliable power must be determined in the analysis. To allow for planned maintenance, a temporary generator connection circuit breaker will be included in the electrical design. Electrical equipment and infrastructure upgrades will be included on a case by case basis, where necessary to achieve a minimum level of microgrid reliability and robustness. In some cases, existing equipment may be adequate and be left intact to save cost.

Since most of the seven facilities included in the microgrid are Government or Non-Profit owned, it is likely that some of the grid-parallel generation will be owned by a third party, with power delivered to the off-takers under power purchase and/or energy services agreements. This is typically done where large tax credits are available (such as the Federal Investment Tax Credit for Solar PV at 30%). For base load generation, there may be a trade-off between the relatively low cost of capital for municipalities/non-profits (under a tax-exempt lease or bond, for example) compared to the tax benefits of third-party ownership. Most likely, both ownership scenarios will be presented so that participants may assess the costs and benefits of each before making a decision in the future. Furthermore, unless otherwise exempted, solicitation of future services provided for the City of Yonkers will be subject to procurement or other applicable requirements under general municipal law in NY State.

The current concept includes renewable energy generated from Solar PV mounted on carports at the City parking garage. There is some potential for smaller (<100kW) solar arrays at the Justice Center parking lot (100 South Broadway lot), City-owned property surrounding the Justice Center parking lot (including the 76 South Broadway lot at the corner of South Broadway and Nepperhan Avenue), and the SJMC parking garage across Vark Street. These sites will be investigated further during the detailed design phase.

For base load generation, natural gas fuel offers the cleanest fuel source. Base load generators will include traditional CHP, which will offset higher grid emissions. For each technology, NYSERDA grants or other incentives will be leveraged in order to meet the financial goals of the project. The optimal mix of generation sources will meet the technical needs of the microgrid as well as the financial needs of the project participants.

The Yonkers microgrid project will be expected to result in valuable experience and tangible benefits related to the effective integration of clean and efficient DER and development of new business models with customer, local utility, community, and competitive solutions provider engagement. In addition, the microgrid project will be expected to relieve stress on the local grid transmission and distribution infrastructure, as well as remote generation infrastructure, by the kW developed and supplied on-site. This will also provide optional standby power for the facilities. The system will be expandable and modularized to the extent feasible to account for future growth and ensuing power needs of the buildings, further relieving the surrounding power grid of future stress and contributing to overall reliability of the area electric grid.

CUSTOMER/STAKEHOLDER	BENEFITS INCLUDE:
CON ED	Relieve Stress on the System, Microgrid Experience
MEDICAL CENTER	Additional Standby Power & Heat Source
GRIFFIN HOUSE	Additional Standby Power & Heat Source
JUSTICE CENTER	Additional Standby Power & Heat Source
CITY HALL, 87 NEPPERHAN AVE	Additional Standby Power

Section 2 – Preliminary Technical Design Costs and Configuration

Task 2.1 – Proposed Microgrid Infrastructure and Operations

The ConEd electrical secondary networked power grid supplies the electricity to the subject buildings. The buildings electrical services are normally connected in parallel with this highly reliable underground network. The DER will operate in parallel with this system as one. If utility service is not available for any reason, the proposed microgrid will operate in two separate islanded parts. The separation is along South Broadway. There will be no electrical power connections across this street because of the large presence of electrical, natural gas, water and sewer lines under the roadway.

St. Joseph's Hospital and Nursing Home make one islanded microgrid, west of South Broadway. The Justice Center, Griffin House and the City of Yonkers Buildings make the second islanded microgrid, east of South Broadway. The simplified single-line diagram contained in the report illustrates all the electrical connections related to the existing services, the DER, and the utility connections.

The electrical infrastructure will include new service entrance switchgear that will allow for the new DER to be interconnected. The switchgear will also include the required metering, protection and control devices to allow for simple operation based on the power needs of the facilities. A human machine interface personal computer will provide the supervisory controls for the microgrid system's operation.

The electrical generation in normal operating mode will be in parallel with the utility. The supervisory controller will regulate the electrical power output to meet the available microgrid kW power. Each unit's thermal waste heat will be captured and utilized for maximizing the buildings thermal efficiencies. Any excess building kW demand load beyond the available generation kW will be supplied by the utility, as it is today.

The controls will continuously monitor the normal operation and if there is a loss of utility power and natural gas is available, the DER will automatically switch over to island operation. The equipment and controls will allow the facilities to keep operating. The islanded DER system is not considered emergency power. The existing emergency equipment can be started and switched into operation for critical loads with the loss of utility service. If the kW of DER generation is not sufficient and the demand load is above the generation, a priority-based load shedding scheme will be implemented.

The proposed microgrid improves the resiliency of the electrical system when natural gas service is available. The DER generation can be black started using existing facility emergency generation or DER starting batteries. The proposed arrangement allows for scheduled maintenance of single units by supplying a cross connection for unexpected island operation. The design supplies multiple units to allow for staged maintenance and thus minimize risk of a required island operation during a maintenance interval.

Task 2.2 – Load Characterization

The electrical loads for each facility are listed below, along with facility peak demand and estimated peak demand in Island Mode. Peak demand in Island Mode is assumed to be equal to 75% of the sum of facility demands. Monthly demand data and load duration curves for the City administration buildings, Justice Center, and SJMC Hospital are provided in Appendix A.

	Facility	Annual Electric Usage (MWh)	Average Load (MW)	Peak Demand (MW)	Source
Islanded Section #1, East of Broadway	City Hall	581	0.066	0.236	Billing Summary
	City Offices (Health Dept.)	801	0.091	0.213	Interval Data
	City Parking Garage	637	0.073	0.088	Billing Summary
	Robert W. Cacace Justice Center and Police HQ	1,925	0.220	0.420	Interval Data
	Griffin House	876	0.100	0.267	Estimated
	Estimated Total:	4,820	0.550	0.918	Est. to be 75% of total facility peak demands
Islanded Section #2, West of Broadway	St. Joseph's Hospital	7,400	0.845	1.522	Interval Data
	St. Joseph's Nursing Home	1,811	0.207	0.272	Billing Summary
	Estimated Total:	9,211	1.051	1.346	Est. to be 75% of total facility peak demands

Electrical Loads for Yonkers Microgrid Facilities
Table 3

The design intent is to maximize the installed distributed generation resources while limiting the amount of excess electrical or thermal energy. For resiliency purposes, additional generation is provided for island operation and to allow for planned maintenance outages.

The site's thermal load characterization is matched with the type of proposed equipment selection. Microturbines produce high quality waste heat in the form of steam for offsetting the existing boiler loads for the SJMC Hospital and Nursing Home. Reciprocating engine driven generators for the Justice Center and Griffin House will produce hot water. The specific load analysis is provided in the energy savings calculations. Historical monthly thermal load data for all the buildings with ConEd accounts for gas service is provided in Appendix B.

Task 2.3 – Distributed Energy Resources Characterization

Standard commercially available CHP equipment will be used for the DER equipment. The proposed microturbines will be provided with heat recovery steam generators. The proposed reciprocating engines will include hot water heat exchangers. The new equipment locations are planned to be close to existing mechanical equipment rooms at each facility. This thermally generated energy from the DER will offset the need to burn fuel for heating, hence improving the facilities' overall efficiency. This recovered heat can help the facilities supply thermal energy in the event of a power outage.

DER will include black start from batteries for the reciprocating engine generation equipment. Black starting for microturbine units will need a power fed from batteries and power from existing site standby generators.

The DER units and their base governor and controls will receive signals from secondary supervisory controllers. The supervisory controls will allow for multiple or single unit operation in load following or import/export modes. The controllers will monitor the system for parallel operation and will detect when the generator separates from the grid. When separation is triggered, an automatic transition from voltage to frequency control will be completed without a DER shutdown. The voltage and frequency setpoints will be maintained. The supervisory secondary controllers to be used for this project can be manufactured by Woodward Controls (or equal).

The source of the DER fuel is delivered via ConEd natural gas distribution system. The gas fuel will be used directly for reciprocating engines, and a gas booster and regulator will be required for microturbines, as ConEd cannot guarantee a delivery pressure of 75 psig. The fuel delivery systems design is dependent on the ConEd delivery pressures; the tapped gas main has an operating range of 19-99 psig with a normal pressure of 60 psig. Yonkers does have natural gas capacity, and it is a very reliable system. Natural gas has advantages over liquid fuel in cleaner emissions and gas does not require on-site storage and deliveries. Furthermore, since the proposed buildings are less than 600 feet from a gas main, ConEd has stated that there should be no cost to get gas service to these buildings.

Task 2.4 – Electrical and Thermal Infrastructure Characterization

Electrically, the interconnection strategy is to provide new service entrance electrical switchgear. The new switchgear will allow for the connection of the existing utility service and interconnection of the new DER. This equipment will be located in weather proof enclosures near the utility services. The switchgear will include control sensing and protection devices to operate the system.

All the existing electrical rooms are space limited, and installing the new equipment will allow for the phased construction of the project. The existing equipment, which is all functional, is not set up for DER interconnection. Many of the existing protection devices are fuses and would require replacement for automating. The simplified single-line diagram shows the microgrid scheme and how the new and existing equipment will be interconnected. The points of common coupling will be the bus in the new switchgear, which is shown in the single-line diagram surrounded by dashed lines. The design will be further developed in the next stages of this project.

The new equipment will be designed and supplied on raised pitched concrete slabs to protect the equipment from weather conditions, such as flooding and snow drifts. The locations and arrangements will be developed to allow for equipment maintenance and safe operation.

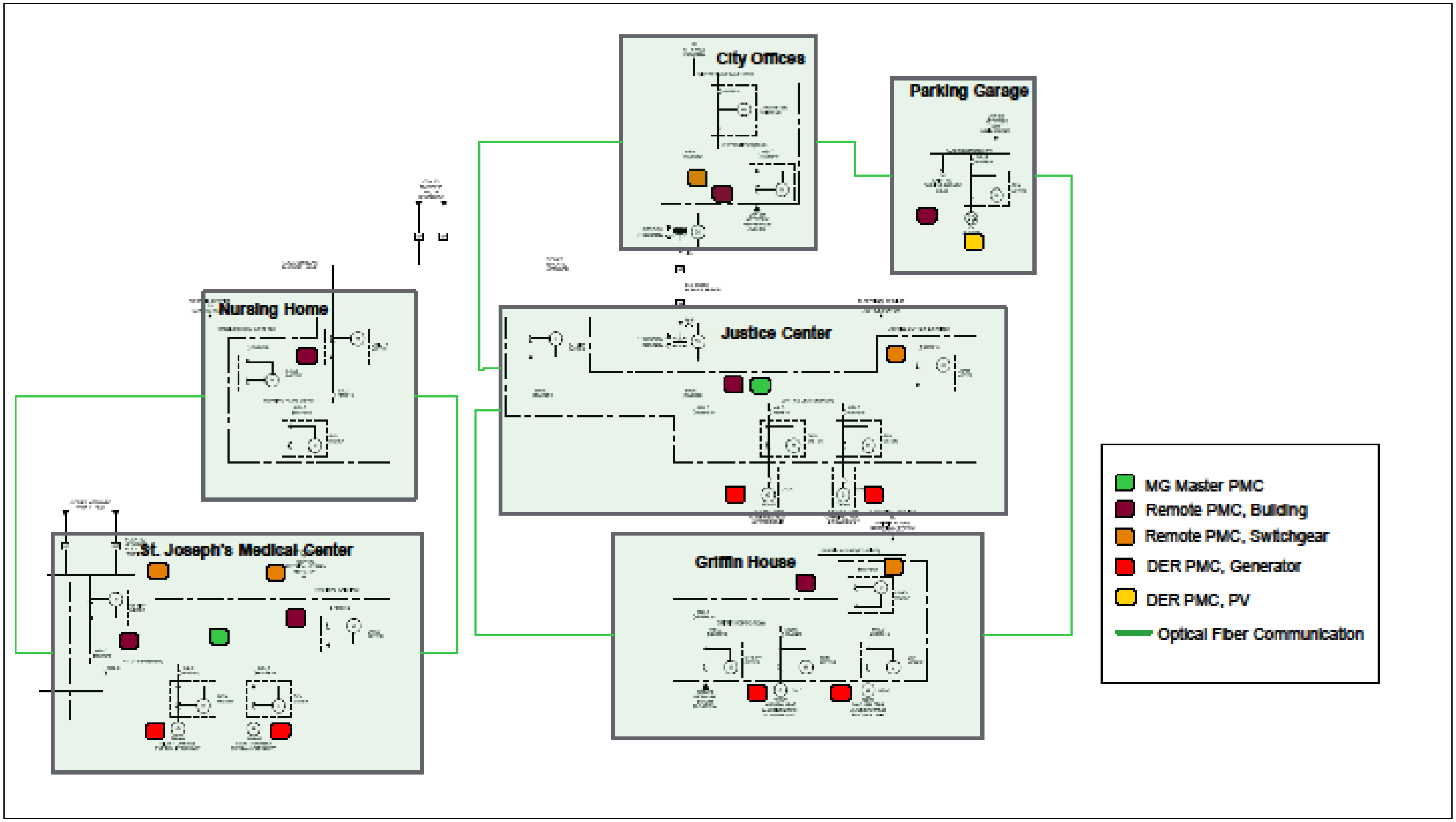
The new electrical equipment and infrastructure will be commercial or industrial grade suitable for the operation. Current and Voltage transformers will be included to monitor and control the electrical power. Utility approved protective relays will supervise the interties and the generating package operations per the utility company's standard (ConEd). The cables will be installed in the conduit or EMT suitable for the installation to connect the new and existing equipment. Where possible, bus duct may be used. Please refer to Project Background in Section 1 for a brief description of the existing electrical systems and equipment for each of the facilities.

Each interconnection device will be provided with a commercially available master load synchronizer and load controller. The exact device selection and manufacturer are to be determined. The devices will all communicate circuit breaker position status, load, and phase angle measurements and contain protection functions.

Task 2.5 – Microgrid and Building Controls Characterization

A distributed microgrid controller system will govern system operations in parallel with the utility and coordinate the DER equipment operation in two separate islanded sections. The microgrid control solution is comprised of two complementary levels of control that both (1) coordinate the microgrid assets in real-time for maintaining and monitoring power quality and reliability and (2) optimize the scheduled functioning of the microgrid with historical and predictive algorithms and cloud-based information. This control solution consists of the **PowerLogic™ Microgrid Controller** ("PMC"), a real-time controller that is operating on the millisecond and second time scale, and **StruxureWare™ Demand Side Operation** ("SWDSO") software, a predictive controller that provides optimized DER schedules in 15-minute windows for the day ahead. While the PMC maintains responsibility for balancing of generation with loads and islanding/reconnection events, SWDSO utilizes outside information in the form of weather and load forecasts, energy tariff data (such as Time-of-Use rates), Demand Response commands, and user-imposed system constraints to optimize system performance. SWDSO will log trend data for viewing by the customer(s) and can accept utility signals and control instructions for the distributed energy resources to participate in ancillary services markets (such as frequency regulation, demand response, etc.).

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



Proposed Control System Layout
Figure 8

A free standing master PMC enclosure will be provided at the microgrid distribution switchboard. Wall-mounted distributed remote PMC enclosures will be located at each DER to enable secure and dedicated control of each resource. Remote PMC enclosures located in each microgrid participant building will concentrate and communicate information back to the main controls. The existing buildings controls capabilities in some of the participant buildings will connect to the remote PMC enclosures. Depending on feasibility, the microgrid building remote PMC may be integrated with any existing building management controllers.

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

Description of Operation and Functions

Each islanded microgrid section will be powered by multiple DER sources. The west of South Broadway portion, comprised of the St Joseph's Medical Center Hospital and Nursing Home, will be anchored by two groupings of natural gas fired microturbine generators. The east of South Broadway portion (comprised of the Justice Center, Griffin House, the City Offices, the Parking Garage, and City Hall) will be powered by four natural gas CHP reciprocating machine generators and a 300 kW solar photovoltaic (PV) system. The two largest natural gas generators located at the Justice Center will serve as the anchor resources for this islanded portion. The generating equipment has not been selected yet. The equipment will most likely be selected from those listed in NYSERDA's CHP Catalog[4], which includes detailed specifications for the equipment. For the purposes of this analysis, Capstone C800 was assumed for the microturbine (page 227 of the catalog). Reciprocating engine CHP characteristics used for analysis at the Justice Center and Griffin House are based off of typical system performance specifications, such as 2g-Energy Patruus 160 (page 3 of the catalog) and 2g-Energy Agenitor306 (page 9 of the catalog).

When operating in normal grid-connected (parallel mode), all online DER sources will obtain voltage and frequency reference from the area electrical power system ("EPS"). If there is an outage, all DER sources will detect the loss of voltage and frequency and isolate from the grid at their connection points in accordance to the governing grid tie connection standards. The PMC will also detect the loss of the utility voltage and frequency reference. In accordance with utility directives, the PMC will assess the grid status over a short period to determine the duration of the service interruption.

Upon time out of any predetermined grid restoration delays, the PMC will commence the sequence for Island Mode operation by first opening all grid connection switches, and then any

[4] NYSERDA CHP Catalog: http://www.nyserda.ny.gov/-/media/Files/FO/Current%20Funding%20Opportunities/PON%202568/2568attc.pdf

controllable electrical mains disconnection switches at each building. The PMC will then initiate black start of the anchor generators, bringing them on line and creating a microgrid voltage and frequency reference for the other DER sources.

Through a predetermined sequence, the DER sources will be made available to the microgrid, and the buildings will be brought back on line. During the transition to microgrid islanded operation following an outage, critical facilities with existing backup generators will exercise their normal backup generator transfer sequence. Once the microgrid is established, the automatic transfer switches at these locations will perceive the microgrid voltage and frequency reference as a return of electrical service and transfer the facility to the microgrid. Load meters, which will be located in each building, will allow the PMC to manage the building loads in conjunction with the available DER sources.

Should any DER source drop off line, the PMC will work via the remote PMC controllers located at the buildings to shed appropriate loads or facilities in order to maintain a stable microgrid.

The PMC will constantly monitor for utility availability. Once the utility service is restored, it will initiate a reverse sequence by shedding all loads and interrupting islanded operation. The utility intertie switches will be closed and the buildings brought back on line. DER sources will be restarted in grid-tied operation compliance mode and synchronize to the utility voltage and frequency.

Controls Resilience

The PMC system is built from the same standard, rugged, and reliable hardware platform used in thousands of critical applications in the industrial automation and process industries. To ensure resilience against severe weather conditions, control system components will be housed in protective indoor or outdoor-rated enclosures, and control points will be linked via a buried self-healing optical fiber ring. All control panels will be equipped with a battery-based, uninterruptible power supply.

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

IT/Telecommunications Infrastructure and Protocols/ Communications within the Microgrid and between Microgrid and Utility

A closed self-healing underground optical fiber ring will form the physical communication medium between control components within the microgrid. The master PMC will communicate with local controllers and utility interfaces using modbus TCP, DNP3, and proprietary remote I/O protocols. The PMC will interface with the DSO hardware via modbus TCP. External communications between the microgrid and the utility will be in accordance to the specifications of the utility to be further determined during the interconnection approval process.

If communications with the utility is lost during normal grid-tied operation, the PMC will be able to assess whether there is also a loss of the utility voltage and frequency reference. If the determination is that the utility EPS is electrically present but communication to the utility has been lost, the microgrid will continue to operate and be seen as a load center on the utility EPS. If the utility stipulates that a loss of communication under any circumstance should direct islanded operation of the microgrid, then the PMC will act accordingly. If the loss of communications with the utility can also be associated with a loss of utility voltage and frequency reference, the microgrid will disconnect from the utility and commence the Islanded operation sequence. Once the microgrid is islanded from the utility, it can operate in the absence of communications with the utility.

Section 3 – Assessment of Commercial and Financial Feasibility

Task 3.1 – Commercial Viability – Customers

The idea behind the microgrid is to provide reliable and robust power to the various critical loads that have been identified in the City of Yonkers. These buildings include three city buildings (City Hall, City Offices along with a multi-level parking garage, and the Robert W. Cacace Justice Center including Yonkers Police Department Headquarters), Griffin House, and St. Joseph's Medical Center (Hospital and Nursing Home). In the recent past, New York has faced natural calamities such as Superstorm Sandy, which highlighted the need for a more resilient power grid. In line with the objectives of improving reliability and resiliency of the grid, promoting clean energy, and reducing energy costs for communities, NYSERDA has launched the NY Prize Community Grid Competition to incentivize the development of local multi-customer microgrids in various locations across New York State and kickstart the microgrid market by testing competitive market-driven solutions and new business models.

In the event of a grid failure, all of the individuals working or inside the seven facilities will be directly affected. During business hours, the number of people is estimated to be between [1,000 and 1,250] in these buildings [during business hours or at all times]. The Robert W. Cacace Justice Center, including Yonkers Police Department Headquarters, serves the approximately 200,000 residents of the City of Yonkers directly or indirectly on a daily basis and plays an important role in law enforcement and safety for all Yonkers residents. St. Joseph's Medical Center, primarily consisting of a 194-bed inpatient acute care hospital and a 200-bed nursing home, has provided critical healthcare services to the community since 1888.

Hurricane Irene and Superstorm Sandy hit Yonkers with full force, causing widespread and long-lasting damage to public and private property as well as serious physical, economic, and safety hardships to Yonkers residents and businesses. ConEd reported that more than 24,000 Yonkers residents were left without power in the aftermath of Superstorm Sandy. These power outages were caused by destruction of generation equipment and uprooted trees that took out distribution wires, and other weather-related issues, such as flooding, caused more damage. This highlighted the vulnerability of the power grid and the need to strengthen the resiliency of energy infrastructure and the people it supports. The microgrid proposes to improve reliability and resiliency by procuring enough generation assets to meet the peak load demand of the seven facilities listed earlier. It will also employ measures like underground cabling and flood protection schemes.[5]

[5] Mayor Mike Spano, "Updates for Yonkers sites on Hurricane Sandy Restoration and Recovery Efforts," 3 November 2012, Yonkers Tribune. <http://www.yonkerstribune.com/2012/11/updates-for-yonkersites-on-hurricane-sandy-restoration-and-recovery-efforts-by-mayor-mike-spano>.

These seven facilities were chosen strategically and have been identified to be critical to the health and safety of the community. The City of Yonkers facilities continue to play the role of the nerve center for support services to the community during weather and other emergencies. The importance of the Justice Center, including Police Dept. Headquarters, and the Medical Center cannot be overstated, and uninterrupted power even during the worst of circumstances is paramount to Yonkers residents. Despite a renaissance for more than a decade, especially near the waterfront, Southwest Yonkers and its downtown neighborhoods remain severely distressed areas. There are 12 contiguous census tracts in downtown Yonkers and the surrounding areas to the north, east and south where 25% or more of the population is below the poverty level.

Financing of the microgrid assets will generally be accomplished by either: (1) Purchase of the assets by the owners of the buildings (City of Yonkers, St. Joseph's Medical Center, and Griffin House), or (2) By third-party ownership of the assets. If the assets are owned by a third party, such as NRG, the power, heat, and other services will be sold to the owners of each building under Power Purchase Agreements ("PPA") and/or Energy Services Agreements ("ESA"). Reliability, resiliency, and efficiency offered to customers will be paid directly by those customers via a pricing structure to be agreed upon in the future and may include a combination of fixed and/or variable components, including a resiliency and/or subscription fee. Addition of new customers in the future is not contemplated at this time, but could be accomplished by adding infrastructure and then charging that customer a fee for the resiliency during island mode. It is not likely that other facilities would be served during grid-connected operation.

Due to the presence of distributed generation on site, the microgrid will also relieve stress on the utility infrastructure. As a result, the facilities in the vicinity of the microgrid are expected to benefit from the increased reliability.

The microgrid operation may directly or indirectly benefit the local utility and the New York Independent System Operator ("NYISO") in three ways:

1. Ancillary services, such as frequency control and voltage support.

Traditionally the utility has had to install devices like capacitors and reactors to maintain stability of the grid. After the advent of microgrids, utilities are starting to see the ancillary services potential these microgrids offer and are beginning to incentivize it. Although the scale of the generation and loads of this particular microgrid might not make it financially feasible for participation in NYISO's ancillary services program (i.e. providing real-time operating reserves and/or regulation services through NYISO's Demand Side Ancillary Service Program, which involves a 1 MW minimum reduction in aggregate and mandatory participation when scheduled), it can potentially support ConEd in its local grid support. The project team will further investigate this during the detailed design phase.

2. Demand response program participation.

NYISO and ConEd both have demand response programs, in which the load drop at individual customer locations within a non-utility microgrid can participate. ConEd can benefit from the microgrid operation by the enrollment of the resources in its Distribution Load Relief Program (Tariff Rider U), and the project team believes there is also potential to leverage microgrid DER for participation in NYISO demand response, which is further discussed in Task 3.5.

Current rules for NYISO demand response limit the capacity value of resources to the demand located at the same retail electric meter where the generation is connected. The aggregation and combined treatment of microgrid DER and loads will require a change in NYISO rules. NRG believes such a rule change is warranted and achievable, to support the implementation of microgrids and other distributed energy resources, consistent with NY State policies, and to support the use of the full capability of these resources in NYISO planning and operations.

3. Deferring infrastructure upgrade costs.

ConEd stands to benefit from reduced stress on its distribution system due to the local DER present in the microgrid. Also, the microgrid will provide other energy commodities, such as heat, to its customer participants. The heat from the base load generators, natural gas reciprocating engines and microturbines will be configured to be recovered in CHP operation. Constraints, such as distance from the sources, will define which customers will have access to this thermal energy, and this will be evaluated in more detail at a later stage. CHP is sized to provide each building with heat, where it is practical, and then these facilities will be electrically paralleled during island mode. It does not appear practical or cost-effective to run piping between the buildings.

Task 3.2 – Commercial Viability – Value Proposition

The Yonkers community relies directly on the critical services provided by the facilities supported by the microgrid. This importance only increases exponentially during natural calamities, such as weather-related or other emergency events. The microgrid's resilient design, using underground cables, robust outdoor equipment containment and flooding measures (where necessary), will protect the infrastructure and equipment from the elements. The on-site generation being considered is a mixture of solar PV and generators that use cleaner burning fuels (i.e. natural gas) than diesel. This will result in lower air emissions compared to the existing electric "macrogrid" power plants for the 20+ year lifespan of the microgrid. Project benefits to the local economy will include nominally higher employment due to construction and maintenance of the microgrid assets.

If the microgrid owner decides to enroll in demand response programs sponsored by ConEd or NYISO, this will directly improve the stability of the macrogrid. During emergencies or in the case of an overloaded grid, the generation assets on site can offset peak load by participating in demand response. To the extent eligible, the microgrid owner may also choose to provide ancillary services, such as frequency and voltage support, to the utility or NYISO, which will add to the reliability of the grid.

The primary business model involves PPA and/or ESA contracts signed between the microgrid owner and customer participants. Planned contracts may also include Engineering, Procurement and Construction Agreements, Site Lease/Ownership Agreements, and Site Improvement Agreements. There are secondary revenue streams that may be utilized by the microgrid owner, such as ancillary services, demand response, and/or utility infrastructure investment deferrals. These are discussed in greater detail later in the report.

Microgrid business models are constantly changing and a source of innovation. The project team will propose a more detailed business model at a later phase, based on customer preferences and all available value streams and cost saving measures. Upon establishing the technical and economic feasibility of the Yonkers microgrid project, the parties expect to commence discussion of commercial terms for further phases of work on the project.

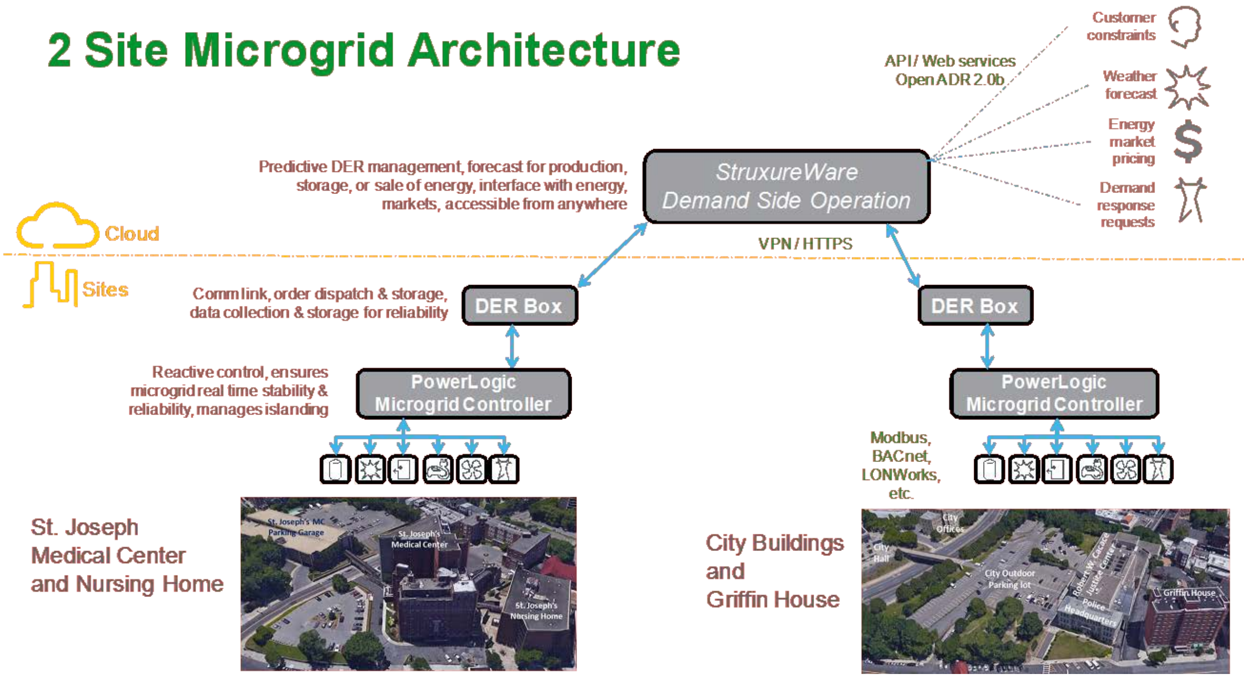
Task 3.2.1 – SWOT Analysis

Strengths

1. Design and new technologies.

The proposed microgrid involves two segmentable areas, which can be interconnected and islanded together or islanded as individual segments by the PowerLogic™ Microgrid Controller. This level of added redundancy and resiliency makes the microgrid design unique.

StruxureWare™ Demand Side Operation software is part of the Schneider Electric controls suite. It is an innovative tool that provides economic optimization and dispatch of DER, allowing the system to integrate renewables and storage while minimizing energy costs. These intelligent decisions are made after analyzing data on market pricing signals, weather and forecasting information, historical energy usage and real-time building information. This tool can add value to the segmentable architecture of the Yonkers microgrid and provide reliable and robust operation.



Microgrid Architecture for Two Islandable Areas
Figure 9

Furthermore, the City of Yonkers has expressed interest in exploring innovative technologies, including geothermal, micro-wind, and hydropower (from a water main that will be extended along Nepperhan Avenue to South Broadway within the next 2-3 years). Potential projects involving less established technologies will be evaluated in the future for technical and economic viability. The City of Yonkers has demonstrated its ability to deploy innovative and sustainable technologies, such as its first solar+wind-powered streetlight (OmniLED smart lighting system) in March 2016.[6]

2. Support from stakeholders.

The project has received strong support from ConEd and leadership at the City of Yonkers and St. Joseph's Medical Center. The objectives of the proposed microgrid, including building a stronger, more resilient Yonkers and expanding the use of clean and efficient distributed energy solutions, align with the Yonkers Five Cities Energy Plan, supported by the New York Power Authority and guided by Governor Cuomo's landmark BuildSmart NY program, and the Yonkers NY Rising Community Reconstruction Plan, supported by the Governor's Office of Storm Recovery and funded with grants from U.S. HUD's CDBG-DR program. Continued support from the project partners and community will be critical to the success of the project. Furthermore,

[6] Ernie Garcia, "Yonkers installs first solar+wind streetlight," 5 March 2016, The Journal News. <http://www.lohud.com/story/news/local/westchester/yonkers/2016/03/04/solarwind-streetlight/81274502/>.

the considerable depth of technical, regulatory and project management expertise present in the project team will prove to be an invaluable asset for the ultimate success of the project.

Opportunities

Customer participants may be added to the project down the line after demonstrating successful construction, commissioning, and operation. The microgrid is designed to be scalable, where additional DER can be added or removed depending on the energy demands of new and existing customer facilities. Schneider Electric's StruxureWare™ Demand Side Operation software can support expansion of the microgrid to individual facilities or areas, with the addition of minimal control hardware (DER boxes). Site-level microgrid controllers will be added only if the expansion area is segmented from the existing two planned microgrid "islands." This will leverage economies of scale to deliver acceptable financial performance to microgrid customers.

This project can serve as a framework that enables future development and construction of local microgrids to power critical infrastructure and serve customers in Westchester County and across NY State. Although the design and specifications of microgrids vary from place to place, the experience gained from addressing technical, regulatory, and contractual challenges will be invaluable for all parties involved in the Yonkers project and promote ease of replication by others.

Weaknesses & Threats

The primary weakness of the proposed microgrid is the potential need for grant or other incentive funds to support detailed design and installation of microgrid infrastructure. While the proposed distributed generation will likely make financial sense on its own (for example, with the use of NYSERDA CHP financial incentives), there will likely not be enough savings from the distributed generation to cover installation of underground power and controls wiring necessary to tie the multiple facilities together. The team proposes to overcome this weakness by applying for advanced stage NY Prize program funds.

A threat to the long-term viability of the project may arise from potential variation in fuel availability. The proposed microgrid DER will rely heavily on natural gas, with no significant on-site storage of fuel. Historically (such as during Superstorm Sandy), the natural gas infrastructure in Yonkers has remained largely unaffected by heavy storms and can serve as a reliable source of energy compared to the electric macrogrid.[7] In the low likelihood event that the natural gas delivery infrastructure is affected, then this could reduce the availability of DER power during operation of the microgrid.

[7] "Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure," U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability, April 2013.

Task 3.2.2 – Value Proposition

Electricity Purchaser/Host Sites

The seven facilities listed earlier are the host sites, and the facility owners are purchasers of electricity, heat, and other energy-related services, such as reliability/resiliency (i.e. via power purchase and/or energy services agreements). These buildings stand to benefit from the increased reliability and resiliency and potentially from energy cost savings provided by the proposed microgrid.

Community

The Yonkers community benefits from the microgrid in various ways, including but not limited to, reliability benefits, environmental benefits, and public safety, health and security benefits.

As discussed earlier, the microgrid provides quality power during extreme weather events, such as Superstorm Sandy, which might result in major power outages and grid failure. The use of natural gas CHP and solar PV technologies will reduce the air emissions and carbon footprint of New York compared to traditional power plants. Cleaner air will be one of many benefits the community will enjoy because of the microgrid.

As envisioned, the microgrid plans to service critical loads, such as the Justice Center (and Police HQ) and St Joseph's Medical Center. Keeping these facilities operational during storms will allow the City administration to stay functional and critical Police and Hospital facilities to continue to provide services uninterrupted and potentially provide warming shelters for area residents. Operation of the Griffin House and SJMC Nursing Home will allow less mobile, elderly residents to shelter in place.

Local Utility

The proposed microgrid can provide impacts on utility capacity requirements and relieve stress on the local utility network by providing on-site local generation. The microgrid project is anticipated to alleviate capacity loading on existing transmission and distribution infrastructure. It may result in reduced losses on the system and marginally less fatigue and aging of distribution equipment.

NY State

NY State stands to benefit from the proposed microgrid in many ways. Directly, the environment benefits from reduced emissions from CHP base load generators and zero emissions from using solar PV panels to generate electricity. With the operability of City of Yonkers, Griffin House, and St. Joseph's Medical Center services intact, state resources can be allocated to other affected areas during future disaster events. Based on 2010 eGrid and using the U.S. EPA's CHP emissions calculator, the CHP and solar PV installations are estimated to save more than 8,000 tons per year in greenhouse gas emissions, the equivalent of taking more than 300 cars off the road and over a 30% reduction in emissions when compared to NYUP subregion electric grid emissions.

Task 3.2.3 – Additional Revenue Streams

As part of the microgrid detailed design, different Energy Conservation Measures (ECM) will be evaluated for the individual buildings served. A formal energy audit may be conducted in order to identify the best ECM to address. These measures will likely result in energy cost savings for the seven facilities supported by the proposed microgrid and further expand the capability of the installed DER generation. Typical measures may include lighting retrofits, HVAC controls and equipment upgrades.

Yonkers has already implemented a number of sustainability programs and efficiency measures. Projects include high-efficiency LED lighting (building's clock tower, City Council Chamber, and Ceremonial Court Room), smart plugs and temperature control, and window replacement (500 premium efficiency windows) at City Hall; LED lighting at the New Main Street parking garage (in design stage); an Alerton building management system and LED lighting installed at the Cacace Justice Center; and a planned City Hall oil-to-gas conversion within 1-2 years and City Hall LED lighting project (in partnership with NYPA and on the City's list of energy conservation projects).

Customer participants may also benefit from participating in demand response programs, which require customers to reduce their loads and/or use their generation sources to support the stability of the utility system when requested. The utility and/or ISO will typically provide bill credits and/or payments for the services rendered.

Task 3.2.4 – Promoting NY REV Objectives

The individual electrical generation plants will allow for future integration of generation technologies as these become more cost-effective and available from competitive solutions providers, as envisioned under NY State's Reforming the Energy Vision ("REV") policy initiative. The project team members believe that the proposed microgrid will advance innovative energy solutions, including market-based technologies, products, services, and business models, in NY State.

The project will explore the market opportunity and a technical, regulatory, and contractual framework for ConEd, its customers, and competitive solutions providers to establish public-private partnerships and develop efficient and resilient microgrids. The project will test the demand for enhanced reliability/resiliency services, promote clean and distributed generation, and determine value steams that can be quantified and captured by the parties as well as commercial structures that may be replicated and used to engage additional customers.

The project will also contribute to NY State's pending Clean Energy Standard by generating Renewable Energy Credits ("RECs").

Task 3.3 – Commercial Viability – Project Team

The project team is primarily comprised of NRG, Schneider Electric, ConEd, the City of Yonkers, St. Joseph's Medical Center, and Griffin House. Along with being key partners and stakeholders, the City of Yonkers, St. Joseph's, and Griffin House will also be microgrid customer participants. Their facilities will house the generation equipment, and their electrical infrastructure will have to accommodate some modifications.

NRG, a competitive energy solutions provider, is the applicant and a third party that can serve as the long-term owner and operator of the Yonkers microgrid. NRG is a Fortune 200 company, the largest competitive power producer in the U.S., and owns and operates nearly 50,000 MW of net generation capacity nationwide, representing a diversified mix of fuel sources, generation technologies, output configurations, and geographical locations. NRG is also one of the nation's largest renewable generation owners and developers, both at the utility and distribution scale, with 3,000+ MW of wind generation assets and 2,000+ MW of solar in operation, construction, and development.

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

As an owner and operator of power generation assets and on-site energy systems nationwide, NRG is familiar with navigating the regulatory landscape, including working to identify and overcome regulatory barriers at the municipal, state, and federal levels. NRG has an experienced team in Market & Regulatory Affairs, as well as Government Affairs and Legal professionals dedicated to these issues. NRG actively comments on regulatory proceedings and has effectively helped to shape the legal and regulatory landscape within which third-party generators compete at the utility and distribution scale, both behind and in front of the meter. NRG is participating in NY State's REV proceeding and voicing strong support for competitive markets, customer choice and participation, renewables deployment and integration, and enhanced system efficiency, reliability, and resiliency. The NY Prize microgrid projects will present new challenges for regulators as well as for the parties implementing the projects, and NRG is well-positioned to work cooperatively and constructively with state regulators, utilities, customers, and other stakeholders to craft workable business models and market rules within which microgrids and distributed energy resources can operate efficiently and profitably.

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

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

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

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

Behind the operational excellence of NRG is a solid balance sheet. With $693 million of unrestricted cash and $2.1 billion in liquidity at the NRG Corporate level as of December 31, 2015, as well as $14.7 billion in annual operating revenues in 2015, NRG has sufficient liquidity to fund and deliver the proposed microgrid development and construction project on balance sheet. If financing is deemed appropriate as project execution nears, NRG would strive to finance the energy system in the most optimal, cost-effective manner, which could involve a combination of NRG and third-party funds. NRG would also take steps to increase the attractiveness of the project to sources of potential financing, as well as other project participants, such as EPC contractors. This would include efforts to structure financeable, long-term power purchase and/or energy services agreement(s) with microgrid customer participants. NRG has ample balance sheet liquidity, NRG Yield (NYSE: NYLD) as a potential financing vehicle and long-term owner upon commercial operation, deep relationships with third-party capital providers, including lenders, tax equity investors and institutional investors, and experience with government grants and incentive funds, including for innovative renewable energy projects.

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

Schneider Electric (Design/Engineering Services and Supplier) is the global specialist in energy management and manufactures and supplies products ranging from electrical infrastructure to controls and software. Schneider Electric has experience designing and deploying microgrids globally, with a team of technical experts as well as staff experienced in some regulatory and legal issues. The organization is backed by a strong team of experienced engineers and industry leading expertise. Schneider Electric is a global company ranking 206 on the Forbes global 2000 list with a market capitalization of $47.5 billion.

Today, 170,000 Schneider Electric employees apply their expertise in energy management and automation, delivering innovative solutions for customers in more than 100 countries. This rich and integrated portfolio of products & services combines with a strong and broad global footprint, ensuring a best-in-class customer experience. Schneider Electric is committed to transformative solutions that provide connectivity, sustainability, efficiency, reliability, and safety while dramatically reducing power consumption.

ConEd is the local distribution company serving 349,000 residential and commercial electric customers and 232,000 residential and commercial gas customers in Westchester County. ConEd will maintain the interconnection of the Yonkers microgrid system with the regulated transmission and distribution systems. In addition, ConEd will continue to own and operate the distribution system components incorporated in the microgrid and certain additional switchgear components on the distribution network required for islanding capability.

The City of Yonkers is New York State's fourth largest city, with 195,976 residents as of 2010 and behind only NYC, Buffalo, and Rochester. It is the largest city in Westchester County and the Hudson Valley.

SJMC has served the city and community of Yonkers since 1888. SJMC's healthcare facilities in Yonkers primarily consist of a 194-bed inpatient acute care hospital and a 200-bed nursing home. SJMC also sponsors two affordable senior housing facilities, including Griffin House.

Griffin House is a 10-story, 81-unit residence for very low income senior citizens. It is sponsored by SJMC Senior Development Fund Corp., managed by H.H. Management Corp., and federally subsidized by the U.S. HUD.

Task 3.4 – Commercial Viability – Creating and Delivering Value

Task 3.4.1 – The Design

The microgrid architecture by itself is innovative as it divides the seven facilities into islandable segments that will be interconnected to each other through ConEd combiner switchgear. Each building will have its own control system, which will optimize the power output based on generation availability and the demand load. These individual control systems will then be interfaced to a main microgrid controller.

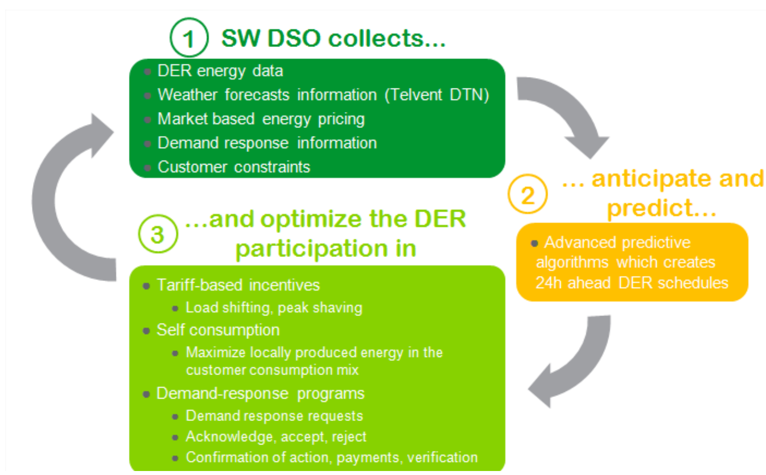
The system design is an interplay of various technologies in the electrical, mechanical and control domains. Solar PV and CHP equipment were chosen as the sources of variable generation and primary generation, respectively. CHP will be designed to meet the electrical base load and operate at high overall efficiency, delivering heat to the buildings to offset boiler usage. This optimized mix of generation sources will be decided after reviewing detailed individual building load data at a later stage.

Total energy required by the buildings was estimated from monthly billing demand, since billed energy usage was not available. It was estimated that total energy required from all facilities will be 14,031 MWh/year, and the total energy potential from on-site generation was estimated to be 24,134 MWh/year, comprised of an optimized mix of CHP and solar PV. Therefore, 172% of the annual electricity usage can be met through the proposed grid-parallel generation. The load can also be met by connection to the grid during normal operation. During islanded operation, the microgrid master controller will manage generation and loading dynamically to maintain system stability. It can also load shed non-critical loads based on available generation and other system parameters, such as voltage, frequency, etc., if the need arises.

Task 3.4.2 – The Technology

The design proposes using StruxureWare™ Demand Side Operation software, a cloud-based predictive DER management tool to optimize the generation, loading and/or storage of energy. Relatively new to the market, it has been successfully deployed in over a dozen sites globally, including two demonstration sites in the US, where it has performed well in controlling multiple DER. SWDSO was awarded a Sustainable Development Award at the European Utility Industry Awards ceremony on November 4, 2015.[8] It will interface with the microgrid master controller to perform predictive modeling, and historical reference data can be used to further enhance the optimization of the microgrid assets.

Using real-time pricing data feeds and weather conditions in conjunction with predicted load profiles, the SWDSO software uses advanced algorithms to coordinate communications with the smart grid and optimize microgrid operation. By tracking, forecasting, and visualizing all microgrid parameters, it controls energy assets to maximize financial benefits while maintaining optimal operation.



Task 3.4.3 – Existing Assets Being Utilized

The Cacace Justice Center and St. Joseph's Medical Center have diesel generators on site. These units will be leveraged to assist and complement the new generation sources wherever

8 "Schneider Electric wins the Sustainable Development award at European Utility Week," 6 November 2015. <http://www2.schneider-electric.com/corporate/en/products-services/energy-distribution/news/viewer-news.page?c_filepath=/templatedata/Content/News/data/en/shared/mv-distribution-and-energy-automation/general_information/2015/11/20151106_schneider_electric_wins_the_sustainable_development_award_at_european_.xml>.

possible. This will depend on factors such as compatibility with the microgrid master controller, cost of operation, etc. and will be analyzed in the detailed design phase of the project.

EXISTING GENERATORS		
SJMC Hospital (new)	750 kW	Emergency Diesel Generator
SJMC Hospital (old 1934 wing)	250 kW	Emergency Diesel Generator
SJMC Nursing Home	250 kW	Emergency Diesel Generator
Cacace Justice Center / Police HQ	500 kW	Emergency Diesel Generator

The microgrid design also proposes to use the existing switchgear and electrical infrastructure in the buildings wherever possible. The switchgear will be modified to accommodate a connection to a new intertie circuit breaker.

Task 3.4.4 – Business Models and Barriers for Future Microgrids

According to a report from Navigant Research, the microgrid market is expected to exceed $40 billion annually by 2020.[9] Demand for new microgrids comes primarily from the following:

1. Utility-integrated campus microgrids
2. Community microgrids
3. Off-grid or remote area microgrids
4. Nanogrids – typically serving a single building or single load, defined by Navigant Research as being 100 kW for grid-tied systems and 5 kW for remote systems not interconnected with a utility grid

Microgrid business models are a source of change and innovation. If a third-party financier purchases the generation equipment, the ownership structure can be called a 'Hybrid Model' where the utility owns the distribution infrastructure and a non-utility owns the generation equipment. This model has been implemented in many sites across the country and can be replicated. Once the ownership model is finalized during the next phase of the project, a more detailed and thorough business model can be developed utilizing project-specific considerations and best practices from existing operational microgrids.

The details of this commercial structure will need to be worked out within the legal and regulatory environment. Responsibility for operations and maintenance of the microgrid system and its components up to the point of common coupling could reside with the system/equipment owner, a third party operator, or the customers depending upon the ultimate ownership

[9] "Worldwide Microgrid Market Will Surpass $40 Billion in Annual Revenue by 2020," Navigant Research, 1 April 2013. <https://www.navigantresearch.com/newsroom/worldwide-microgrid-market-will-surpass-40-billion-in-annual-revenue-by-2020>.

structure as well as technical expertise. NRG is one such party that can successfully fulfill a design-build-own-operate-maintain role on a "turn-key" basis. ConEd shall continue to own and operate the distribution system components incorporated in the microgrid and certain additional switchgear components on the distribution network required for islanding capability. New generation will be installed behind the customer's meter, so that DER can be used to offset retail electric rates and ConEd's existing interconnection processes can be used. The project team does not expect that special permits will be required.

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

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

The local utility (ConEd) will need to work commercially and technically with the microgrid design team to develop the project. The tasks will include review and approval of design documents, relay settings, and coordinating the integration of the intertie switchgear for each generating package and switchgear. Establishing communication with each distributed generator and resolving the metering issues will also be required.

The benefits of the microgrid will flow to the community in a number of direct and indirect ways, some of which are listed in the table at the end of Task 1.2. The microgrid will help to ensure the operational continuity of FEMA critical facilities, which provide health and social services to the Yonkers community or housing services to senior citizens, in the face of a severe, protracted grid failure. The microgrid will provide significant benefits to the approximately 200,000 people relying on these facilities and services daily, as well as the 81 senior residents at Griffin House and up to 200 residents at SJMC's Nursing Home. In addition to no upfront capital requirements expected from customer participants (or minimal if a desire to invest and take minority interest in the project company) under the proposed third-party ownership structure, potential revenues and savings from the microgrid operation may also provide budgetary relief for the City of Yonkers, SJMC, and Griffin House.

Related to charges and metering, the project owner would enter into long-term power purchase and/or energy services agreements with the various customer participants wherein the price per kWh, price for thermal energy, and other pricing components would be established and agreed upon by all parties during the detailed design and structuring phase. The microgrid owner would provide electrical and thermal energy, as well as reliability/resiliency services, to customers via a pricing structure that may include a combination of fixed and variable pricing components as well as a resiliency and/or subscription fee. Costs would be charged to the customer associated with the meter where the DER asset is tied, and energy usage at individual sites would all be recorded by revenue grade meters.

Task 3.5 – Financial Viability

Summary of Preliminary Economic Modeling

Preliminary economic modeling for the Yonkers Microgrid System, i.e. the proposed DER in aggregate, indicates a payback period of approximately fourteen years excluding additional NY Prize funding. Assuming the $5.6 million in additional incentives for the Justice Center CHP, which is burdened by (1) equipment costs for the 750 kW in additional capacity for Island Mode operation and (2) electrical interconnection costs of $2.8 million to cross Nepperhan Avenue, the payback period on the proposed microgrid DER in aggregate would improve to approximately nine years under current assumptions described in this section.

Projected savings and net cash flow estimates are shown in the table at the end of Task 3.5 for the individual resources and for the Yonkers microgrid DER in aggregate. In terms of the estimated Annual Utility Savings in aggregate over the life of the microgrid system's useful life, the relative contributions by individual DER are estimated to be the following: City Parking Garage Solar PV (6%); Griffin House CHP (26%); Justice Center CHP (10%); and SJMC Microturbine System (58%). The relative contributions of estimated total Net Cash Flows by individual DER are the following: City Parking Garage Solar PV (8%); Griffin House CHP (43%); Justice Center CHP (1% -- includes $5.6 million in additional incentives to ensure a payback within 20 years for this particular resource); and SJMC Microturbine System (49%).

Microgrid Revenue Streams, Incentives, and Costs

A microgrid can generally recover costs and earn a reasonable return on investment via the following revenue streams. Below is a table that presents the relative magnitude of each revenue stream in an estimated range for the Yonkers microgrid project.

Revenue Stream	Estimated % of Total Revenue
Sale of energy to off-takers	70 - 90%
Sale of energy to utility	0 - 20%
Ancillary services	0 - 5%
Demand response programs	0 - 5%
Investment deferral incentives	0%

1. Sale of energy commodities and services to off-takers.

This is the primary source of revenue for most microgrids. The owner installs the equipment behind the off-takers' electric meters and sells power to these customers, typically at a rate lower than their all-in, blended retail electric rate. Heat can be separately metered and sold to the off-takers, or the off-takers may simply pay a higher rate for electricity in order to have access to the available heat and/or premium energy services, such as improved reliability and resiliency. Under power purchase and/or energy services agreements, the third-party microgrid owner can provide electrical and thermal energy, as well as reliability/resiliency services, via an agreed-upon and transparent pricing structure with a combination of fixed and variable components.

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

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

2. Sale of energy to the utility and/or NYISO.

The microgrid owner can choose to sell excess power generated to the utility if the off-takers cannot take all of the electricity. Excess power that cannot be purchased directly by the off-takers to offset their retail electric usage and charges (i.e. by reducing their load or by net metering against their billed electric usage) is typically sold to the utility or the regional power grid at the wholesale electric rate.

Allocation of added market-based revenues would be subject to the commercial structure, to be negotiated and agreed upon by the engaged parties in a future phase of the project. In general, with the potential enactment of new policies and market rule changes to allow "behind-the-meter net generation" or "BTM-NG" to participate in the NYISO wholesale markets by the end of 2016, it is hoped that the microgrid will sell power, capacity, and/or ancillary services to the grid and receive new on-going revenues as a result. NYISO's current proposal for BTM-NG would apply to a generator (or interconnected group of generators) that serves load behind the meter and has excess generation capability (at least 1 MW of energy to export) after serving its retail load. The intent is to allow for routine "exports" into the NYISO markets for over-sized BTM capacity, while smaller DER will be considered in the future, perhaps under a different set of rules. The magnitude of these potential revenues is difficult to predict at this stage given the emerging nature of these grid services and markets. Many of the market rules would have to be changed in order to fully support selling into *both* the DSP (or Distribution System Platform envisioned under REV) and the NYISO.

3. Provision of ancillary services.

A microgrid can provide reactive power support at the transmission level and distribution level. The transmission level is administered by NYISO, which incentivizes customers to provide frequency and voltage regulation and black-start service, and the distribution level is managed by the local utility, ConEd. The feasibility of utilizing this revenue stream will be investigated during the detailed design and structuring phase.

4. Demand response program participation.

The microgrid owner may choose to participate in demand response programs initiated by the utility and/or NYISO. This may involve pledging generation resources and/or load shedding non-critical loads when the utility and/or NYISO requests it.

NYISO has four demand response programs. The first two listed below are reliability-based programs where NYISO determines activation, while the last two are economic-based programs where the resource determines when to participate via supply offers.

1. Emergency Demand Response Program (EDRP)
2. ICAP-Special Case Resources Program (SCR)
3. Day-Ahead Demand Response Program (DADRP)
4. Demand-Side Ancillary Service Program (DSASP)

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

NYISO DSASP resources can offer real-time operating reserves and/or regulation services, and participation is mandatory when scheduled. This program involves a 1 MW minimum reduction in aggregate, which is not quite feasible for the proposed microgrid in Yonkers. Curtailable Load and/or Local Generators may participate as non-synchronized reserve suppliers.

In addition to NYISO's ICAP-SCR program, the microgrid owner may choose to participate in ConEd's Distribution Load Relief Program (Tariff Rider U), which offers incentives for load reduction. This will be further evaluated in the detailed design and structuring phase.

5. Investment deferral incentives.

If applicable, the microgrid owner can request the utility to provide compensation for deferring distribution infrastructure upgrades. In the case of Yonkers, however, ConEd has a robust underground distribution system in downtown Yonkers and does not anticipate that the proposed microgrid will result in T&D investment avoidance or deferral at this time.

The primary upfront costs for the microgrid owner are the purchases of generation equipment and microgrid infrastructure. A third-party financier can typically monetize the tax benefits, such as the Federal Investment Tax Credit, in order to offset capital costs for eligible technologies. In addition, costs may be offset by other incentives at the federal, state, or local levels, such as NYSERDA's CHP incentives program. If a municipality decides to purchase the assets, it can typically use tax-exempt bonds to raise capital at low interest rates.

The microgrid owner may choose to sign maintenance contracts with the equipment manufacturers or select a third party O&M services provider. The operating costs for natural gas-driven CHP can be variable due to fuel prices. The microgrid owner may also seek to negotiate a fixed price over a period of time with the natural gas supplier in order to mitigate the risk of fuel price changes.

Incentives to deploy solar PV and CHP would buy down the initial cost of these technologies. Other incentives required or preferred will depend in part on the magnitude of the NY Prize funding received in future stages. The project team believes that the NY Prize Stage 2 funding will be particularly important for communities and their partners to move forward with the microgrid development process. Absent this funding from NYSERDA, communities will most likely be challenged to secure additional funds and proceed to a final, buildable project design.

A number of federal and state-level incentives, subject to funding availability and eligibility and changes in incentive levels and structures, will contribute to the overall financial viability of the project. To the extent available and eligible, the project team expects to leverage incentive programs or other financial assistance offered by NYSERDA, NYPA, and ConEd. The incentives listed below are currently reflected in the preliminary economic modeling of the Yonkers generation resources, in addition to subsequent funding from the NY Prize program described in the preliminary economic modeling section for the Justice Center CHP. Also, note that the preliminary modeling does *not* include potential revenues from future participation in NYISO or local utility markets/programs for energy, capacity, demand response, and/or ancillary services.

- Federal Investment Tax Credit
  - 30% - Solar PV (extended at 30% through 12/31/2019 and gradually stepping down each year thereafter)
  - 10% - CHP (currently set to expire on 12/31/2016)
- NY-SUN Commercial / Industrial Performance-Based Incentive – NY PON 3082
  - $0.114/kWh-AC for 4 years (not to exceed - $400K)
- NYSERDA CHP Program – NY PON 2568

It is important to highlight that the previous NYSERDA CHP offerings were merged as of March 1, 2016 under the Clean Energy Fund structure. The maximum incentive available is $2,500,000 per eligible project, and incentives for systems 50 kW - 3 MW will periodically be reduced along a declining glide path with applications for projects up to 3 MW accepted until December 31, 2018.[10]

Through NY State's Net Metering Law and the ConEd Tariff for Electric Service, customers with eligible renewable systems, such as solar PV, are entitled to net metering. When the customer's solar system generates more electricity than consumed, excess electricity is returned to the system, and the customer will be billed only for the net consumption at the end of each month. The 300 kW solar PV system at the City Parking Garage will be behind its own meter and take advantage of net metering and potentially remote net metering to maximize savings from the PV array.

The fully installed capital cost of the proposed microgrid is estimated to be $15-16 million before rebates and incentives, plus a $1.6 million cost estimate for initial planning and design. Fixed O&M costs are currently estimated at $400,000 per year. The fully installed cost estimates (+/-30%) and engineering life span for all the capital equipment is shown in the below table:

[10] NYSERDA PON 2568 CHP Program (Updated March 2016) - http://www.nyserda.ny.gov/PON2568.
Clean Energy Fund Investment Plant: Resource Acquisition Transition Chapter (Revised 2/22/16) - http://www.nyserda.ny.gov/About/Clean-Energy-Fund

Capital Component	Installed Cost ($ in millions)	Component Lifespan (round to nearest year)	Description of Component
Justice Center CHP Recip. Generator 1	$0.88	20	CHP Generator Complete
Justice Center CHP Recip. Generator 2	$2.60	20	CHP Generator Complete
Griffin House CHP Recip. Generator 1	$0.53	20	CHP Generator Complete
Griffin House CHP Recip. Generator 2	$0.53	20	CHP Generator Complete
St. Joseph's Medical Center Microturbine System	$5.60	20	Elec & Mech equipment & installation
New Main St City Parking Garage Solar PV Array	$1.10	25	Elec & Mech equipment & installation
Utility Modifications	$1.00	20	ConEd Scope of Work
Microgrid Controls	$0.60	20	Control panels, Software, Comms
Electrical Interconnection City Bldg to Justice Center	$3.00	20	Electrical Equipment & Install
Subtotal - Capital Costs	**$15.84**		
Initial Planning & Design	$1.58		Design, Construction Documents
Total	**$17.42**		

The financing structure is expected to be similar to other power generation projects wherein a construction loan and/or equity is used to fund construction costs that are then recovered along with a reasonable return on investment under long-term energy off-take/services agreements. A third party is expected to serve as long-term owner and operator of the proposed microgrid, subject to competitive procurement requirements of customer participants. NRG is one such company that can provide a design-build-own-operate-maintain solution with project financing. NRG has sufficient liquidity on balance sheet to deliver the proposed microgrid development and construction project, assuming that it meets corporate investment criteria and receives required approvals for the allocation of funds. Alternatively, customer participants may elect to take a sole or majority ownership interest in the microgrid project company or specific generation resources and then, as may be needed, solicit additional investors as well as a third party to operate the system and provide on-going O&M services.

Preliminary Economic Modeling – City Parking Garage Solar PV

The following image illustrates key elements, as summarized below, from the financial model for 300 kW of solar PV at the City Parking Garage:

- $2.70/Watt base installed cost for solar PV system, plus additional cost estimates for parking structure, microgrid controls, and utility upgrades and infrastructure and a 40% adjustment factor
- $6,000/year for operations and maintenance; escalation 3% annually

- Base energy costs of $0.13/kWh; escalation 4% annually[11]
- 30% Federal Investment Tax Credit; and approximately $47k/year for 4 years as part of NYSERDA PON 3082 (NY-SUN Commercial / Industrial Performance-Based Incentive)
- No value for RECs, as NY State is only now moving to an RPS that would have a tradable value for RECs in the future

Energy Model Details

Solar Resource

Parameter	Value	Units
Location	NY, Newburgh	
Longitude	73.86	degrees
Latitude	40.94	degrees
Daily Average Irradiance	1,596	Btu/ft2/day
Daily Total Generation	50	Wh/ft2/day
Annual Power Density	1,389	kWh/kW
Estimated Production	416,763	kWh

Electricity

Parameter	Value	Units
Fuel Units	kWh	
Energy Content	3,413	Btu per kWh
Baseline Energy Cost	0.129	$/kWh
Post Retrofit Energy Cost	0.144	$/kWh
What type of net metering?	12 Month	
Credits for Net Export	$ 0.0500	$/kWh
Energy Escalation Rates	4.00%	

Net Metering Math

Parameter	Value	Units
Total Facility Usage	422,139	kWh
Total PV Generation	416,763	kWh
Avoided Grid Usage	416,763	kWh
Net Excess	0	kWh
Grid Buy-Back	0	kWh

Technology Estimate Assumptions

Installed Cost Estimate

Parameter	Value	Units	Year 1	Include?	
Solar PV System, Installed	2.70	$/Watt	$ 810,000	Y	1
Parking Structure	101,250	$	$ 101,250	Y	1
Batteries	$0	$	$ -	Y	1
Microgrrid Controls	$60,000	$	$ 60,000	Y	1
Utility Upgrades+Infra cost	100,000.00	$	$ 100,000	Y	1
Labor	0.00	$/Watt	$ -	Y	1

On-Going Costs

Parameter	Value	Units	Year 1	Frequency	Escalation
Operation and Maintenance	$6,000	$	$ 6,000	1	3.0%
Repair and Replacement	0.00	$/Watt	$ -	10	3.0%
M+V	0.00	$/Watt	$ -	1	3.0%
Other	0.00	$/Watt	$ -	1	
Other	0.00	$	$ -	1	
Other	0.00	$	$ -	1	

Based on these assumptions, the initial cash flow modeling illustrates a breakeven point in approximately thirteen years for solar PV at the City Parking Garage.

	Energy			Technology Cost					Total	
Year	Baseline Utility Cost $	Future Utility Cost $	Utility Savings $	Technology Cost $	Financing $	O+M $	Incentive $	Scheduled Principal Payment $	Net Cashflow	Cummulative Cashflow
0	$ 54,456	$ 54,456	$ -	$ (1,002,549)		$ -	$ 47,276	$ -	$ (955,273)	$ (955,273)
1	$ 56,634	$ (288)	$ 56,922		$ -	$ (6,000)	$ 47,276	$ -	$ 98,198	$ (857,075)
2	$ 58,900	$ (3)	$ 58,903		$ -	$ (6,180)	$ 47,276	$ -	$ 99,999	$ (757,076)
3	$ 61,255	$ 303	$ 60,953		$ -	$ (6,365)	$ 47,276	$ -	$ 101,863	$ (655,213)
4	$ 63,706	$ 632	$ 63,074		$ -	$ (6,556)	$ -	$ -	$ 56,517	$ (598,696)
5	$ 66,254	$ 985	$ 65,269		$ -	$ (6,753)	$ -	$ -	$ 58,516	$ (540,180)
6	$ 68,904	$ 1,364	$ 67,540		$ -	$ (6,956)	$ -	$ -	$ 60,584	$ (479,595)
7	$ 71,660	$ 1,770	$ 69,891		$ -	$ (7,164)	$ -	$ -	$ 62,726	$ (416,869)
8	$ 74,527	$ 2,204	$ 72,323		$ -	$ (7,379)	$ -	$ -	$ 64,943	$ (351,926)
9	$ 77,508	$ 2,668	$ 74,840		$ -	$ (7,601)	$ -	$ -	$ 67,239	$ (284,687)
10	$ 80,608	$ 3,164	$ 77,444		$ -	$ (7,829)	$ -	$ -	$ 69,615	$ (215,072)
11	$ 83,832	$ 3,693	$ 80,139		$ -	$ (8,063)	$ -	$ -	$ 72,075	$ (142,996)
12	$ 87,186	$ 4,258	$ 82,928		$ -	$ (8,305)	$ -	$ -	$ 74,622	$ (68,374)
13	$ 90,673	$ 4,859	$ 85,814		$ -	$ (8,555)	$ -	$ -	$ 77,259	$ 8,886
14	$ 94,300	$ 5,500	$ 88,800		$ -	$ (8,811)	$ -	$ -	$ 79,989	$ 88,874
15	$ 98,072	$ 6,182	$ 91,890		$ -	$ (9,076)	$ -	$ -	$ 82,815	$ 171,689
16	$ 101,995	$ 6,907	$ 95,088		$ -	$ (9,348)	$ -	$ -	$ 85,740	$ 257,429
17	$ 106,075	$ 7,678	$ 98,397		$ -	$ (9,628)	$ -	$ -	$ 88,769	$ 346,198
18	$ 110,318	$ 8,496	$ 101,821		$ -	$ (9,917)	$ -	$ -	$ 91,904	$ 438,103
19	$ 114,730	$ 9,366	$ 105,365		$ -	$ (10,215)	$ -	$ -	$ 95,150	$ 533,253
20	$ 119,320	$ 10,288	$ 109,031		$ -	$ (10,521)	$ -	$ -	$ 98,510	$ 631,763
21	$ 124,092	$ 11,267	$ 112,826		$ -	$ (10,837)	$ -	$ -	$ 101,989	$ 733,752
22	$ 129,056	$ 12,304	$ 116,752		$ -	$ (11,162)	$ -	$ -	$ 105,590	$ 839,342
23	$ 134,218	$ 13,403	$ 120,815		$ -	$ (11,497)	$ -	$ -	$ 109,318	$ 948,661
24	$ 139,587	$ 14,568	$ 125,019		$ -	$ (11,842)	$ -	$ -	$ 113,178	$ 1,061,839
25	$ 145,171	$ 15,800	$ 129,370		$ -	$ (12,197)	$ -	$ -	$ 117,173	$ 1,179,012

[11] 1999-2003 CAGR for Industrial customers – http://www.nyserda.ny.gov/Cleantech-and-Innovation/Energy-Prices/Electricity

Preliminary Economic Modeling – Griffin House CHP

The financial model for 300 kW of CHP at Griffin House assumes base energy costs of $0.15/kWh (4% annual escalation) and the following related to plant availability and costs:

- Plant availability: 90%
- Heating fuel cost: $10/MMBtu; CHP fuel cost: $7/MMBtu
- Heating fuel system efficiency: 85%
- CHP gross installed cost: $4.29/Watt
    - Includes $200k of utility upgrades and infrastructure cost

CHP System Assumptions

General Cogen Performance Data

Parameter	Value	Units
Nameplate Electrical Power Output	292	kW
Electrical Efficiency (HHV)	33%	%
Fuel Input Capacity (HHV)	3,019.99	kBtu/hr
Fuel Input Capacity (HHV)	3.02	Therm/hr
Overall Efficiency (HHV)	85%	%
Recoverable Heat	1,570.39	kBtu/hr
Unrecoverable Heat	453.00	kBtu/hr

Plant Operation Inputs

Parameter	Value	Units
Total Number of Generators	1	Qty
Plant Nameplate Electrical Capacity	292	kW
Plant Electrical Output Capacity	292	kW
Plant Availability	90%	%
Load Matching	Electric Follow	
Plant Useful Life	20	Years

Energy Model Details

Electricity

Parameter	Value	Units
Fuel Units	kWh	
Energy Content	3,413	Btu per kWh
Baseline Energy Cost	$ 0.150	$/kWh
Post Retrofit Energy Cost	$ 0.165	$/kWh
What type of net metering?	None	
Credits for Net Export	$ -	$/kWh
Escalation Rates	4.00%	

Firing Fuel

Parameter	Value	Units
Fuel Units	MMBtu	
Energy Content, HHV	1,000,000	Btu per MMBtu
Baseline Energy Cost	$ 10.00	per MMBtu
Post Retrofit Energy Cost	$ 7.00	per MMBtu
Heating Fuel System Efficiency	85.0%	
Escalation Rates	3.0%	

In terms of fuel savings, the CHP reciprocating generator at Griffin House is estimated to offset the need for 7,510 MMBtu/year of heating, as shown below by month. These are rough estimates based on fuel usage. Actual heat recovery will depend on site-specific factors, such as existing equipment configuration and operating temperatures.

Existing Utility Usage		Existing Loads		Operation	Electric			Heat Recovery			Fuel	
Electricity kWh	Total Heating Fuel MMBtu	Addressable Heating Load kBtu	Addressable Cooling Load Ton-Hrs	Run Hours Hours	Electric Generation kWh	Avoided Electric Usage kWh	Excess Electric Generation kWh	Adjusted Max Heat Recovery kBtu	Avoided Addressable Heat kBtu	Excess Addressable Heat kBtu	Fuel Usage MMBtu	Avoided Fuel MMBtu
119,189	4,890	3,667,500		408	119,189	119,189	0	641,005	641,005	0	1,233	754
115,344	4,038	3,028,500		395	115,344	115,344	0	620,327	620,327	0	1,193	730
119,189	2,122	1,591,500		408	119,189	119,189	0	641,005	641,005	0	1,233	754
115,344	1,207	905,250		395	115,344	115,344	0	620,327	620,327	0	1,193	730
119,189	865	648,750		408	119,189	119,189	0	641,005	641,005	0	1,233	754
119,189	805	603,750		408	119,189	119,189	0	641,005	603,750	37,255	1,233	710
115,344	1,251	938,250		395	115,344	115,344	0	620,327	620,327	0	1,193	730
119,189	2,928	2,196,000		408	119,189	119,189	0	641,005	641,005	0	1,233	754
115,344	4,421	3,315,750		395	115,344	115,344	0	620,327	620,327	0	1,193	730
119,189	6,438	4,828,500		408	119,189	119,189	0	641,005	641,005	0	1,233	754
119,189	7,736	5,802,000		408	119,189	119,189	0	641,005	641,005	0	1,233	754
107,654	4,703	3,527,250		369	107,654	107,654	0	578,972	578,972	0	1,113	681
1,403,352	**41,404**	**31,053,000**	**0**	**4,806**	**1,403,352**	**1,403,352**	**0**	**7,547,312**	**7,510,058**	**37,255**	**14,514**	**8,835**

For the Griffin House CHP reciprocating generators, the projected cash flow estimates below show that the CHP units (300 kW in aggregate) are expected to have a payback of approximately four years.

	Energy			Technology Cost					Total	
Year	Baseline Utility Cost $	Future Utility Cost $	Utility Savings $	Technology Cost $	Financing $	O+M $	Incentive $	Scheduled Principal Payment $	Net Cashflow	Cummulative Cashflow
0	$ 624,543	$ 329,579	$ -	$ (1,252,000)		$ -	$ 408,400	$ -	$ (843,600)	$ (843,600)
1	$ 645,384	$ 339,466	$ 305,918		$ -	$ (56,134)	$ -	$ -	$ 249,784	$ (593,816)
2	$ 666,935	$ 349,650	$ 317,285		$ -	$ (57,818)	$ -	$ -	$ 259,467	$ (334,350)
3	$ 689,220	$ 360,140	$ 329,080		$ -	$ (59,553)	$ -	$ -	$ 269,527	$ (64,822)
4	$ 712,264	$ 370,944	$ 341,320		$ -	$ (61,339)	$ -	$ -	$ 279,981	$ 215,159
5	$ 736,095	$ 382,072	$ 354,022		$ -	$ (63,179)	$ -	$ -	$ 290,843	$ 506,002
6	$ 760,739	$ 393,534	$ 367,204		$ -	$ (65,075)	$ -	$ -	$ 302,129	$ 808,131
7	$ 786,224	$ 405,340	$ 380,884		$ -	$ (67,027)	$ -	$ -	$ 313,857	$ 1,121,988
8	$ 812,581	$ 417,501	$ 395,080		$ -	$ (69,038)	$ -	$ -	$ 326,043	$ 1,448,030
9	$ 839,839	$ 430,026	$ 409,814		$ -	$ (71,109)	$ -	$ -	$ 338,705	$ 1,786,735
10	$ 868,031	$ 442,926	$ 425,104		$ -	$ (73,242)	$ -	$ -	$ 351,862	$ 2,138,597
11	$ 897,188	$ 456,214	$ 440,973		$ -	$ (75,440)	$ -	$ -	$ 365,534	$ 2,504,131
12	$ 927,344	$ 469,901	$ 457,443		$ -	$ (77,703)	$ -	$ -	$ 379,740	$ 2,883,871
13	$ 958,534	$ 483,998	$ 474,537		$ -	$ (80,034)	$ -	$ -	$ 394,503	$ 3,278,374
14	$ 990,795	$ 498,518	$ 492,278		$ -	$ (82,435)	$ -	$ -	$ 409,843	$ 3,688,217
15	$ 1,024,164	$ 513,473	$ 510,691		$ -	$ (84,908)	$ -	$ -	$ 425,783	$ 4,114,000
16	$ 1,058,680	$ 528,877	$ 529,803		$ -	$ (87,455)	$ -	$ -	$ 442,348	$ 4,556,348
17	$ 1,094,384	$ 544,744	$ 549,640		$ -	$ (90,079)	$ -	$ -	$ 459,561	$ 5,015,910
18	$ 1,131,315	$ 561,086	$ 570,229		$ -	$ (92,781)	$ -	$ -	$ 477,448	$ 5,493,358
19	$ 1,169,519	$ 577,919	$ 591,601		$ -	$ (95,565)	$ -	$ -	$ 496,036	$ 5,989,394
20	$ 1,209,040	$ 595,256	$ 613,784		$ -	$ (98,431)	$ -	$ -	$ 515,352	$ 6,504,746

Preliminary Economic Modeling – Justice Center CHP

The financial model for 1,000 kW of CHP reciprocating generation at the Justice Center assumes base energy costs of $0.13/kWh (4% annual escalation) and the following related to plant availability and costs.

- Plant availability: 81%
- Heating fuel cost: $10/MMBtu; CHP fuel cost: $7/MMBtu
- Heating fuel system efficiency: 85%
- CHP gross installed cost: $6.55/Watt (total cost for 1,000 kW)

- Includes $2.8 million of utility upgrades and infrastructure cost, primarily due to the electrical connection across Nepperhan Avenue

Note that the modeling assumes that only Justice Center Generator 1 (250 kW) is used in grid-parallel mode. Justice Center Generator 2 (750 kW) is primarily intended to be used in Island Mode; it will also be used for peak shaving, if possible. Costs for the total 1,000 kW are included in the economic model.

CHP System Assumptions

General Cogen Performance Data

Parameter	Value	Units
Nameplate Electrical Power Output	250	kW
Electrical Efficiency (HHV)	33%	%
Fuel Input Capacity (HHV)	2,585.61	kBtu/hr
Fuel Input Capacity (HHV)	2.59	Therm/hr
Overall Efficiency (HHV)	85%	%
Recoverable Heat	1,344.52	kBtu/hr
Unrecoverable Heat	387.84	kBtu/hr

Plant Operation Inputs

Parameter	Value	Units
Total Number of Generators	1	Qty
Plant Nameplate Electrical Capacity	250	kW
Plant Electrical Output Capacity	250	kW
Plant Availability	81%	%
Load Matching	Electric Follow	
Plant Useful Life	20	Years

Energy Model Details

Electricity

Parameter	Value	Units
Fuel Units	kWh	
Energy Content	3,413	Btu per kWh
Baseline Energy Cost	$ 0.129	$/kWh
Post Retrofit Energy Cost	$ 0.144	$/kWh
What type of net metering?	None	
Credits for Net Export	$ -	$/kWh
Escalation Rates	4.00%	

Firing Fuel

Parameter	Value	Units
Fuel Units	MMBtu	
Energy Content, HHV	1,000,000	Btu per MMBtu
Baseline Energy Cost	$ 10.0000	per MMBtu
Post Retrofit Energy Cost	$ 7.0000	per MMBtu
Heating Fuel System Efficiency	85.0%	
Escalation Rates	3.0%	

In terms of fuel savings, the base load CHP reciprocating generation at the Justice Center is estimated to offset the need for 2,073 MMBtu/year of heating, as shown below by month. Again, these are rough estimates based on fuel usage. Actual heat recovery will depend on site-specific factors, such as existing equipment configuration and operating temperatures.

Existing Utility Usage		Existing Loads		Operation	Electric			Heat Recovery			Fuel	
Electricity kWh	Total Heating Fuel MMBtu	Addressable Heating Load kBtu	Addressable Cooling Load Ton-Hrs	Run Hours Hours	Electric Generation kWh	Avoided Electric Usage kWh	Excess Electric Generation kWh	Adjusted Max Heat Recovery kBtu	Avoided Addressable Heat kBtu	Excess Addressable Heat kBtu	Fuel Usage MMBtu	Avoided Fuel MMBtu
285,089	575	287,250		603	150,660	150,660	0	810,259	287,250	523,009	1,558	338
247,657	364	181,850		583	145,800	145,800	0	784,121	181,850	602,271	1,508	214
331,193	85	42,500		603	150,660	150,660	0	810,259	42,500	767,759	1,558	50
368,410	26	13,100		603	150,660	150,660	0	810,259	13,100	797,159	1,558	15
396,903	24	11,850		544	136,080	136,080	0	731,846	11,850	719,996	1,407	14
367,512	22	11,000		603	150,660	150,660	0	810,259	11,000	799,259	1,558	13
374,388	32	16,000		583	145,800	145,800	0	784,121	16,000	768,121	1,508	19
296,445	341	170,400		603	150,660	150,660	0	810,259	170,400	639,859	1,558	200
255,779	471	235,500		583	145,800	145,800	0	784,121	235,500	548,621	1,508	277
238,114	576	288,150		603	150,660	150,660	0	810,259	288,150	522,109	1,558	339
239,485	862	430,850		603	150,660	150,660	0	810,259	430,850	379,409	1,558	507
219,696	769	384,350		583	145,800	145,800	0	784,121	384,350	399,771	1,508	452
3,620,671	4,146	2,072,800	0	7,096	1,773,900	1,773,900	0	9,540,142	2,072,800	7,467,342	18,346	2,439

The projected cash flow estimates below show that the Justice Center CHP reciprocating generation (1,000 kW in aggregate) is expected to have a payback of approximately eighteen years, based on 250 kW of base load CHP and an additional 750 kW primarily for Island Mode operation. Economic payback on only 250 kW of base load CHP at the Justice Center would be more attractive than what is shown below.

It is important to note that there is currently an assumption of $5.6 million in additional funding from NY Prize or other incentive programs in the Justice Center CHP preliminary results shown below. This is an estimate of additional incentives that would be required to enhance the financial viability and ensure a payback within the 20-year useful life of this particular resource, since this resource is burdened by (1) equipment costs for the 750 kW in additional capacity for Island Mode operation and (2) interconnection costs of $2.8 million to connect the Justice Center plant to City Hall and the City Offices across Nepperhan Avenue. During detailed design, the financial feasibility of making this electrical connection across Nepperhan Avenue will be further evaluated. The project team notes that excluding this electrical inter-tie and/or scaling back the generation resource sizes (e.g. base load generation at the Justice Center, Griffin House, and SJMC with less additional capacity for islanded/emergency operation) would enhance the financial viability of a microgrid project in Yonkers.

	Energy			Technology Cost					Total	
Year	Baseline Utility Cost $	Future Utility Cost $	Utility Savings $	Technology Cost $	Financing $	O+M $	Incentive $	Scheduled Principal Payment $	Net Cashflow	Cummulative Cashflow
0	$ 508,523	$ 406,309	$ -	$ (6,550,000)		$ -	$ 6,403,138	$ -	$ (146,862)	$ (146,862)
1	$ 528,449	$ 421,158	$ 107,291		$ -	$ (120,956)	$ -	$ -	$ (13,665)	$ (160,527)
2	$ 549,160	$ 436,558	$ 112,602		$ -	$ (124,585)	$ -	$ -	$ (11,983)	$ (172,510)
3	$ 570,686	$ 452,531	$ 118,155		$ -	$ (128,322)	$ -	$ -	$ (10,167)	$ (182,677)
4	$ 593,061	$ 469,099	$ 123,962		$ -	$ (132,172)	$ -	$ -	$ (8,210)	$ (190,886)
5	$ 616,317	$ 486,283	$ 130,034		$ -	$ (136,137)	$ -	$ -	$ (6,103)	$ (196,989)
6	$ 640,489	$ 504,107	$ 136,382		$ -	$ (140,221)	$ -	$ -	$ (3,839)	$ (200,828)
7	$ 665,613	$ 522,595	$ 143,019		$ -	$ (144,428)	$ -	$ -	$ (1,409)	$ (202,237)
8	$ 691,728	$ 541,772	$ 149,956		$ -	$ (148,761)	$ -	$ -	$ 1,195	$ (201,042)
9	$ 718,872	$ 561,665	$ 157,207		$ -	$ (153,223)	$ -	$ -	$ 3,984	$ (197,058)
10	$ 747,086	$ 582,300	$ 164,786		$ -	$ (157,820)	$ -	$ -	$ 6,966	$ (190,092)
11	$ 776,412	$ 603,705	$ 172,707		$ -	$ (162,555)	$ -	$ -	$ 10,152	$ (179,940)
12	$ 806,895	$ 625,910	$ 180,985		$ -	$ (167,431)	$ -	$ -	$ 13,553	$ (166,387)
13	$ 838,580	$ 648,945	$ 189,634		$ -	$ (172,454)	$ -	$ -	$ 17,180	$ (149,207)
14	$ 871,514	$ 672,842	$ 198,672		$ -	$ (177,628)	$ -	$ -	$ 21,044	$ (128,163)
15	$ 905,748	$ 697,632	$ 208,115		$ -	$ (182,957)	$ -	$ -	$ 25,159	$ (103,004)
16	$ 941,332	$ 723,350	$ 217,981		$ -	$ (188,446)	$ -	$ -	$ 29,536	$ (73,468)
17	$ 978,320	$ 750,032	$ 228,288		$ -	$ (194,099)	$ -	$ -	$ 34,189	$ (39,279)
18	$ 1,016,767	$ 777,713	$ 239,054		$ -	$ (199,922)	$ -	$ -	$ 39,132	$ (147)
19	$ 1,056,732	$ 806,432	$ 250,300		$ -	$ (205,919)	$ -	$ -	$ 44,381	$ 44,234
20	$ 1,098,274	$ 836,227	$ 262,047		$ -	$ (212,097)	$ -	$ -	$ 49,950	$ 94,184

Preliminary Economic Modeling – SJMC Microturbine System

The financial model for the 1,600 kW SJMC Microturbine System assumes base energy costs of $0.13/kWh (4% annual escalation) and the following related to plant availability and costs. Only

1,000 kW or so is expected to be used in grid-parallel mode, but costs for the total 1,600 kW are included in the financial model.

- Plant availability: 90%
- Heating fuel cost: $12.2/MMBtu; CHP fuel cost: $7/MMBtu
- Heating fuel system efficiency: 85%
- Gross installed cost: $4.21/Watt (total cost for 1,600 kW)
  - Includes $900k of utility upgrades and infrastructure cost

CHP System Assumptions

General Cogen Performance Data

Parameter	Value	Units
Nameplate Electrical Power Output	1000	kW
Electrical Efficiency (HHV)	27%	%
Fuel Input Capacity (HHV)	12,640.74	kBtu/hr
Fuel Input Capacity (HHV)	12.64	Therm/hr
Overall Efficiency (HHV)	85%	%
Recoverable Heat	7,331.63	kBtu/hr
Unrecoverable Heat	1,896.11	kBtu/hr

Plant Operation Inputs

Parameter	Value	Units
Total Number of Generators	1	Qty
Plant Nameplate Electrical Capacity	1000	kW
Plant Electrical Output Capacity	1000	kW
Plant Availability	90%	%
Load Matching	Electric Follow	
Plant Useful Life	20	Years

Energy Model Details

Electricity

Parameter	Value	Units
Fuel Units	kWh	
Energy Content	3,413	Btu per kWh
Baseline Energy Cost	$ 0.129	$/kWh
Post Retrofit Energy Cost	$ 0.144	$/kWh
What type of net metering?	None	
Credits for Net Export	$ -	$/kWh
Escalation Rates	4.00%	

Firing Fuel

Parameter	Value	Units
Fuel Units	MMBtu	
Energy Content, HHV	1,000,000	Btu per MMBtu
Baseline Energy Cost	$ 12.2000	per MMBtu
Post Retrofit Energy Cost	$ 7.0000	per MMBtu
Heating Fuel System Efficiency	85.0%	
Escalation Rates	3.0%	

In terms of fuel savings, the base load microturbine generation at SJMC is estimated to offset the need for 18,104 MMBtu/year of heating, as shown below by month.

Existing Utility Usage		Existing Loads		Operation	Electric			Heat Recovery			Fuel	
Electricity kWh	Total Heating Fuel MMBtu	Addressable Heating Load kBtu	Addressable Cooling Load Ton-Hrs	Run Hours Hours	Electric Generation kWh	Avoided Electric Usage kWh	Excess Electric Generation kWh	Adjusted Max Heat Recovery kBtu	Avoided Addressable Heat kBtu	Excess Addressable Heat kBtu	Fuel Usage MMBtu	Avoided Fuel MMBtu
491,040	5,433	2,716,300		491	491,040	491,040	0	3,600,123	2,716,300	883,823	6,207	3,196
458,352	3,022	1,511,000		458	458,352	458,352	0	3,360,467	1,511,000	1,849,467	5,794	1,778
653,976	4,895	2,447,711		654	653,976	653,976	0	4,794,710	2,447,711	2,346,999	8,267	2,880
702,000	3,734	1,867,019		670	669,600	669,600	0	4,909,259	1,867,019	3,042,241	8,464	2,196
769,594	3,252	1,625,800		605	604,800	604,800	0	4,434,170	1,625,800	2,808,370	7,645	1,913
739,238	2,223	1,111,400		670	669,600	669,600	0	4,909,259	1,111,400	3,797,859	8,464	1,308
713,664	1,500	750,200		648	648,000	648,000	0	4,750,896	750,200	4,000,696	8,191	883
691,474	1,961	980,300		670	669,600	669,600	0	4,909,259	980,300	3,928,959	8,464	1,153
637,200	1,319	659,650		637	637,200	637,200	0	4,671,714	659,650	4,012,064	8,055	776
474,077	2,997	1,498,550		474	474,077	474,077	0	3,475,756	1,498,550	1,977,206	5,993	1,763
474,077	1,522	760,800		474	474,077	474,077	0	3,475,756	760,800	2,714,956	5,993	895
435,053	4,351	2,175,400		435	435,053	435,053	0	3,189,646	2,175,400	1,014,246	5,499	2,559
7,239,744	36,208	18,104,129	0	6,885	6,885,374	6,885,374	0	50,481,015	18,104,129	32,376,886	87,036	21,299

The projected cash flow estimates below show that the SJMC Microturbine System is expected to pay for itself in approximately eleven years, based on 1,000 kW used in grid-parallel mode and an additional 600 kW primarily for Island Mode operation. Economic payback on only 1,000 kW of base load generation would be more attractive than what is shown below.

	Energy			Technology Cost					Total	
Year	Baseline Utility Cost $	Future Utility Cost $	Utility Savings $	Technology Cost $	Financing $	O+M $	Incentive $	Scheduled Principal Payment $	Net Cashflow	Cummulative Cashflow
0	$ 1,375,668	$ 764,648	$ -	$ (6,740,000)		$ -	$ 1,910,000	$ -	$ (4,830,000)	$ (4,830,000)
1	$ 1,426,277	$ 788,098	$ 638,179		$ -	$ (275,415)	$ -	$ -	$ 362,764	$ (4,467,236)
2	$ 1,478,778	$ 812,271	$ 666,507		$ -	$ (283,677)	$ -	$ -	$ 382,830	$ (4,084,406)
3	$ 1,533,243	$ 837,191	$ 696,052		$ -	$ (292,188)	$ -	$ -	$ 403,864	$ (3,680,542)
4	$ 1,589,746	$ 862,881	$ 726,865		$ -	$ (300,953)	$ -	$ -	$ 425,911	$ (3,254,631)
5	$ 1,648,364	$ 889,364	$ 758,999		$ -	$ (309,982)	$ -	$ -	$ 449,017	$ (2,805,614)
6	$ 1,709,177	$ 916,666	$ 792,511		$ -	$ (319,281)	$ -	$ -	$ 473,229	$ (2,332,384)
7	$ 1,772,270	$ 944,812	$ 827,458		$ -	$ (328,860)	$ -	$ -	$ 498,598	$ (1,833,786)
8	$ 1,837,728	$ 973,828	$ 863,900		$ -	$ (400,219)	$ -	$ -	$ 463,680	$ (1,370,106)
9	$ 1,905,641	$ 1,003,741	$ 901,900		$ -	$ (348,887)	$ -	$ -	$ 553,012	$ (817,094)
10	$ 1,976,103	$ 1,034,579	$ 941,523		$ -	$ (359,354)	$ -	$ -	$ 582,169	$ (234,924)
11	$ 2,049,210	$ 1,066,372	$ 982,838		$ -	$ (370,135)	$ -	$ -	$ 612,703	$ 377,779
12	$ 2,125,064	$ 1,099,149	$ 1,025,915		$ -	$ (381,239)	$ -	$ -	$ 644,676	$ 1,022,455
13	$ 2,203,768	$ 1,132,940	$ 1,070,828		$ -	$ (392,676)	$ -	$ -	$ 678,152	$ 1,700,607
14	$ 2,285,432	$ 1,167,778	$ 1,117,654		$ -	$ (404,456)	$ -	$ -	$ 713,197	$ 2,413,804
15	$ 2,370,167	$ 1,203,695	$ 1,166,472		$ -	$ (416,590)	$ -	$ -	$ 749,882	$ 3,163,687
16	$ 2,458,092	$ 1,240,725	$ 1,217,367		$ -	$ (506,986)	$ -	$ -	$ 710,381	$ 3,874,068
17	$ 2,549,327	$ 1,278,903	$ 1,270,424		$ -	$ (441,960)	$ -	$ -	$ 828,464	$ 4,702,532
18	$ 2,643,999	$ 1,318,264	$ 1,325,735		$ -	$ (455,219)	$ -	$ -	$ 870,516	$ 5,573,048
19	$ 2,742,238	$ 1,358,845	$ 1,383,393		$ -	$ (468,876)	$ -	$ -	$ 914,517	$ 6,487,565
20	$ 2,844,182	$ 1,400,686	$ 1,443,496		$ -	$ (482,942)	$ -	$ -	$ 960,554	$ 7,448,119

Preliminary Economic Modeling – Yonkers Microgrid System

Projected annual utility savings and net cash flow estimates are shown below for the individual resources and for the Yonkers microgrid DER in aggregate.[12] Based on the preliminary modeling, the proposed microgrid has a payback period of approximately fourteen years. This excludes the additional $5.6 million from NY Prize described above in the Justice Center CHP preliminary economic modeling. However, note that this implies that, as currently shown, the added generator equipment and electrical interconnection costs in the Justice Center CHP financial model are recovered through net cash flows from the other proposed resources.

If $3.0 and $5.0 million in additional funding from NY Prize or other incentive programs is included, the estimated payback period would decline to approximately twelve and ten years, respectively. Assuming the $5.6 million in additional incentives used in the Justice Center CHP financial model, the payback period on the proposed microgrid would improve to approximately nine years under current assumptions.

[12] Based on individual DER costs in aggregate, plus Electrical Interconnection (City Buildings to Justice Center), and thus does not include full microgrid implementation costs related to Initial Planning & Design, Utility Modifications, and Microgrid Controls (as shown in Task 4.4).

Year	City Parking Garage Solar PV			Griffin House CHP			Justice Center CHP			SJMC Microturbine System			Yonkers Microgrid System		
	Annual Utility Savings	Annual Net Cashflow	Cumulative Net Cashflow	Annual Utility Savings	Annual Net Cashflow	Cumulative Net Cashflow	Annual Utility Savings	Annual Net Cashflow	Cumulative Net Cashflow	Annual Utility Savings	Annual Net Cashflow	Cumulative Net Cashflow	Annual Utility Savings	Annual Net Cashflow	Cumulative Net Cashflow
0	$ -	$ (955,273)	$ (955,273)	$ -	$ (843,600)	$ (843,600)	$ -	$ (5,746,862)	$ (5,746,862)	$ -	$ (4,830,000)	$ (4,830,000)	$ -	$ (12,375,735)	$ (12,375,735)
1	$ 56,922	$ 98,198	$ (857,075)	$ 305,918	$ 249,784	$ (593,816)	$ 107,291	$ (13,665)	$ (5,760,527)	$ 638,179	$ 362,764	$ (4,467,236)	$ 1,108,310	$ 697,081	$ (11,678,654)
2	$ 58,903	$ 99,999	$ (757,076)	$ 317,285	$ 259,467	$ (334,350)	$ 112,602	$ (11,983)	$ (5,772,510)	$ 666,507	$ 382,830	$ (4,084,406)	$ 1,155,296	$ 730,312	$ (10,948,342)
3	$ 60,953	$ 101,863	$ (655,213)	$ 329,080	$ 269,527	$ (64,822)	$ 118,155	$ (10,167)	$ (5,782,677)	$ 696,052	$ 403,864	$ (3,680,542)	$ 1,204,239	$ 765,087	$ (10,183,254)
4	$ 63,074	$ 56,517	$ (598,696)	$ 341,320	$ 279,981	$ 215,159	$ 123,962	$ (8,210)	$ (5,790,886)	$ 726,865	$ 425,911	$ (3,254,631)	$ 1,255,221	$ 754,200	$ (9,429,054)
5	$ 65,269	$ 58,516	$ (540,180)	$ 354,022	$ 290,843	$ 506,002	$ 130,034	$ (6,103)	$ (5,796,989)	$ 758,999	$ 449,017	$ (2,805,614)	$ 1,308,324	$ 792,273	$ (8,636,781)
6	$ 67,540	$ 60,584	$ (479,595)	$ 367,204	$ 302,129	$ 808,131	$ 136,382	$ (3,839)	$ (5,800,828)	$ 792,511	$ 473,229	$ (2,332,384)	$ 1,363,637	$ 832,104	$ (7,804,677)
7	$ 69,891	$ 62,726	$ (416,869)	$ 380,884	$ 313,857	$ 1,121,988	$ 143,019	$ (1,409)	$ (5,802,237)	$ 827,458	$ 498,598	$ (1,833,786)	$ 1,421,251	$ 873,772	$ (6,930,905)
8	$ 72,323	$ 64,943	$ (351,926)	$ 395,080	$ 326,043	$ 1,448,030	$ 149,956	$ 1,195	$ (5,801,042)	$ 863,900	$ 463,680	$ (1,370,106)	$ 1,481,259	$ 855,862	$ (6,075,043)
9	$ 74,840	$ 67,239	$ (284,687)	$ 409,814	$ 338,705	$ 1,786,735	$ 157,207	$ 3,984	$ (5,797,058)	$ 901,900	$ 553,012	$ (817,094)	$ 1,543,760	$ 962,940	$ (5,112,104)
10	$ 77,444	$ 69,615	$ (215,072)	$ 425,104	$ 351,862	$ 2,138,597	$ 164,786	$ 6,966	$ (5,790,092)	$ 941,523	$ 582,169	$ (234,924)	$ 1,608,858	$ 1,010,613	$ (4,101,491)
11	$ 80,139	$ 72,075	$ (142,996)	$ 440,973	$ 365,534	$ 2,504,131	$ 172,707	$ 10,152	$ (5,779,940)	$ 982,838	$ 612,703	$ 377,779	$ 1,676,657	$ 1,060,465	$ (3,041,026)
12	$ 82,928	$ 74,622	$ (68,374)	$ 457,443	$ 379,740	$ 2,883,871	$ 180,985	$ 13,553	$ (5,766,387)	$ 1,025,915	$ 644,676	$ 1,022,455	$ 1,747,270	$ 1,112,592	$ (1,928,434)
13	$ 85,814	$ 77,259	$ 8,886	$ 474,537	$ 394,503	$ 3,278,374	$ 189,634	$ 17,180	$ (5,749,207)	$ 1,070,828	$ 678,152	$ 1,700,607	$ 1,820,812	$ 1,167,094	$ (761,340)
14	$ 88,800	$ 79,989	$ 88,874	$ 492,278	$ 409,843	$ 3,688,217	$ 198,672	$ 21,044	$ (5,728,163)	$ 1,117,654	$ 713,197	$ 2,413,804	$ 1,897,404	$ 1,224,074	$ 462,733
15	$ 91,890	$ 82,815	$ 171,689	$ 510,691	$ 425,783	$ 4,114,000	$ 208,115	$ 25,159	$ (5,703,004)	$ 1,166,472	$ 749,882	$ 3,163,687	$ 1,977,169	$ 1,283,639	$ 1,746,372
16	$ 95,088	$ 85,740	$ 257,429	$ 529,803	$ 442,348	$ 4,556,348	$ 217,981	$ 29,536	$ (5,673,468)	$ 1,217,367	$ 710,381	$ 3,874,068	$ 2,060,239	$ 1,268,005	$ 3,014,377
17	$ 98,397	$ 88,769	$ 346,198	$ 549,640	$ 459,561	$ 5,015,910	$ 228,288	$ 34,189	$ (5,639,279)	$ 1,270,424	$ 828,464	$ 4,702,532	$ 2,146,749	$ 1,410,983	$ 4,425,360
18	$ 101,821	$ 91,904	$ 438,103	$ 570,229	$ 477,448	$ 5,493,358	$ 239,054	$ 39,132	$ (5,600,147)	$ 1,325,735	$ 870,516	$ 5,573,048	$ 2,236,840	$ 1,479,001	$ 5,904,361
19	$ 105,365	$ 95,150	$ 533,253	$ 591,601	$ 496,036	$ 5,989,394	$ 250,300	$ 44,381	$ (5,555,766)	$ 1,383,393	$ 914,517	$ 6,487,565	$ 2,330,659	$ 1,550,085	$ 7,454,446
20	$ 109,031	$ 98,510	$ 631,763	$ 613,784	$ 515,352	$ 6,504,746	$ 262,047	$ 49,950	$ (5,505,816)	$ 1,443,496	$ 960,554	$ 7,448,119	$ 2,428,358	$ 1,624,367	$ 9,078,812
21	$ 112,826	$ 101,989	$ 733,752	$ -	$ -	$ 6,504,746	$ -	$ -	$ (5,505,816)	$ -	$ -	$ 7,448,119	$ 112,826	$ 101,989	$ 9,180,802
22	$ 116,752	$ 105,590	$ 839,342	$ -	$ -	$ 6,504,746	$ -	$ -	$ (5,505,816)	$ -	$ -	$ 7,448,119	$ 116,752	$ 105,590	$ 9,286,392
23	$ 120,815	$ 109,318	$ 948,661	$ -	$ -	$ 6,504,746	$ -	$ -	$ (5,505,816)	$ -	$ -	$ 7,448,119	$ 120,815	$ 109,318	$ 9,395,710
24	$ 125,019	$ 113,178	$ 1,061,839	$ -	$ -	$ 6,504,746	$ -	$ -	$ (5,505,816)	$ -	$ -	$ 7,448,119	$ 125,019	$ 113,178	$ 9,508,888
25	$ 129,370	$ 117,173	$ 1,179,012	$ -	$ -	$ 6,504,746	$ -	$ -	$ (5,505,816)	$ -	$ -	$ 7,448,119	$ 129,370	$ 117,173	$ 9,626,061
Total	**$ 2,211,213**	**$ 1,179,012**		**$ 8,856,690**	**$ 6,504,746**		**$ 3,491,179**	**$ (5,505,816)**		**$19,818,015**	**$ 7,448,119**		**$ 34,377,096**	**$ 9,626,061**	

Task 3.6 – Legal Viability

A third party is expected to serve as long-term owner and operator of the Yonkers microgrid, subject to an organization's procurement policy requirements and future competitive solicitations for services as may be required under law. NRG is capable of and interested in serving in such as role for the Yonkers microgrid customer participants. NRG would establish a single purpose, project-specific limited liability company that would hold and own project contracts, assets, and property. This special purpose entity would most likely be a wholly-owned project subsidiary of NRG, or it could be majority-owned by NRG with minority ownership encouraged from microgrid customer participants or other strategic partners or investors.

The sites where the microgrid equipment and systems are to be installed are owned by the customer participants (the City of Yonkers, SJMC, and SJMC Fund Development Corp. in the case of Griffin House). A third-party owner would have to enter into site access and lease agreements with these owners. Upon establishing the technical and economic feasibility, the parties expect to commence discussion of commercial terms for future phases of work on the project, including a conversation on the potential for future site control through lease, purchase, and/or option agreements.

The project team believes robust deployment of microgrids in New York State can be best accomplished through competitive development driven by customer engagement and value, and that microgrids can and should be financed by customers or by third parties. Based on "NRG's Response to Notice Soliciting Comments on Microgrids" (filed with the PSC on May 1, 2015), NRG offers the following three recommendations to help enable microgrid development:

1) Just as the PSC has directed that utility ownership of DER should be very limited, the PSC should restrict utilities (and DSPs) in their ownership of microgrids in order to ensure that market-based solutions drive microgrid adoption. Keeping the burgeoning microgrid industry competitive will enable the robust deployment of microgrids and create a business environment in which competitive providers of microgrids can bring their innovation and private capital to bear on meeting customer and community objectives. Regulated utility ownership and control of microgrids would delay and constrain deployment, add to utility costs, and thus expose ratepayers and utility investors to excessive risk.
2) Properly valuing and accounting for the multiple benefits a microgrid offers – to its individual customers, the community, the wholesale market, as well as to the distribution system – is a crucial element in ensuring their widespread adoption. Microgrids become more cost-effective if they are operated more frequently than just as a back-up solution, but this requires the development of markets and revenue generation opportunities that appropriately compensate microgrids for the services they provide. As envisioned under REV, an important role of the DSP will be to pay DER for the "value they provide to the grid… in fair and open markets." The DSP will serve as a means of providing a price signal for enhanced

resiliency, delayed distribution upgrades, and other values that currently are not expressly valued in our energy infrastructure. Likewise, NYISO rules must enable participation by microgrids in the wholesale markets.

3) PSC precedent allowing microgrid developers to connect adjoining or related facilities is well-established, but it would be helpful for developers if the PSC clarifies that related facilities are those that may cross a right of way as of right, without seeking an additional PSC ruling and running afoul of utility franchise laws. The ability to connect two or more related sites is extremely important in reducing customer costs, because spreading the fixed costs of a microgrid development across a wider array of customers and/or facilities can allow additional economies of scale and reduce costs for each participating customer.

NRG's ability to successfully finance, build, own, operate, and maintain DER and microgrids for host customers is demonstrated by the following operational systems:

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

The development and implementation of "first-of-a-kind" community-based microgrids that are both reliable and economic will involve complexity and challenges. For example, state legislatures and public utility commissions may need to act to resolve legal issues related to local distribution utility exclusive franchise rights and whether microgrids serving multiple, unaffiliated end users fall under public utility regulations.

NRG and its partners are well-positioned to work cooperatively and constructively with state regulators, utilities, communities, customers, and other stakeholders to lead and support the project team through the NY Prize Competition process, craft workable business models and structures within which DER and microgrids can operate, and increase the likelihood of successful development and implementation of a Yonkers microgrid project, thus advancing the objectives of NY Prize and NY State's REV policy initiative.

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

Given the complexities involved in the design, engineering, development, and implementation of reliable and economical microgrid systems, communities and other customer participants are encouraged to partner with energy service companies, such as NRG, that have a proven track record and the necessary financial, technical, and regulatory expertise. In addition, private firms that use the proposed third-party business model and implement these distributed projects are accustomed to ensuring the privacy of their public and private host customers. As a competitive services provider and third-party owner/operator of distributed generation, NRG is leading the transition to a clean renewables-driven, increasingly distributed, and grid-resilient future.

This microgrid project proposed by NRG and Schneider Electric in Yonkers seeks to serve essential customer needs with reliable and cost-effective power from clean and efficient on-site resources, minimize the economic impact of power outages to participants and the community, ensure the continuity of critical public healthcare and city services, protect vulnerable populations and infrastructure during and after crises, and facilitate community revitalization and sustainable development in a severely distressed area of Yonkers.

Section 4 – Microgrid Benefit-Cost Analysis

Task 4.0 – Benefit-Cost Analysis Summary Report

PROJECT OVERVIEW

As part of NYSERDA's NY Prize Community Grid Competition, NRG on behalf of its project partners in the City of Yonkers has proposed development of a microgrid project that would enhance the resiliency of electric service for the following facilities:

- City Hall, which includes the offices of the Mayor, City Clerk, and Department of Public Works, as well as the City's Voice over IP (VoIP) servers;
- City Hall Annex, an office building at 87 Nepperhan Avenue that houses the Department of Planning and Development and the Department of Housing and Buildings, as well as the City's administrative data servers;
- New Main St. City Parking Garage, a multi-level parking garage adjacent to the two facilities listed above;
- Robert W. Cacace Justice Center, which includes a criminal court (and jail), a small claims court, and the police headquarters for the Yonkers Police Department;
- St. Joseph's Medical Center Hospital, a 194-bed inpatient acute care hospital;
- St. Joseph's Medical Center Nursing Home, a 200-bed facility; and
- Griffin House, a residential apartment complex with 81 units for low-income senior citizens.

The microgrid would be powered by four natural gas-fired combined heat and power (CHP) turbines with a combined nameplate capacity of 1.3 MW, one natural gas-fired microturbine system with a nameplate capacity of 1.6 MW, and one photovoltaic (PV) array with a nameplate capacity of 0.3 MW. The project team anticipates that the microgrid's distributed energy resources (DER) would meet nearly all of the served facilities' electricity demand during normal operations and that the system would have sufficient generating capacity to fully support all facilities during a major power outage. The project team also indicates that the system would have the capability of providing ancillary services to the grid.

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

METHODOLOGY AND ASSUMPTIONS

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

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

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

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

[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 CO2 emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO2, NOx, and PM2.5, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the present value of the project's costs and 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]

[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.

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the present value of the project's costs would exceed its benefits. In order for the present value of the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 2.6 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	**SCENARIO 2: 2.6 DAYS/YEAR**
Net Benefits - Present Value	-$11,200,000	$297,000
Benefit-Cost Ratio	0.7	1.0
Internal Rate of Return	N/A	6.7%

Scenario 1

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

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

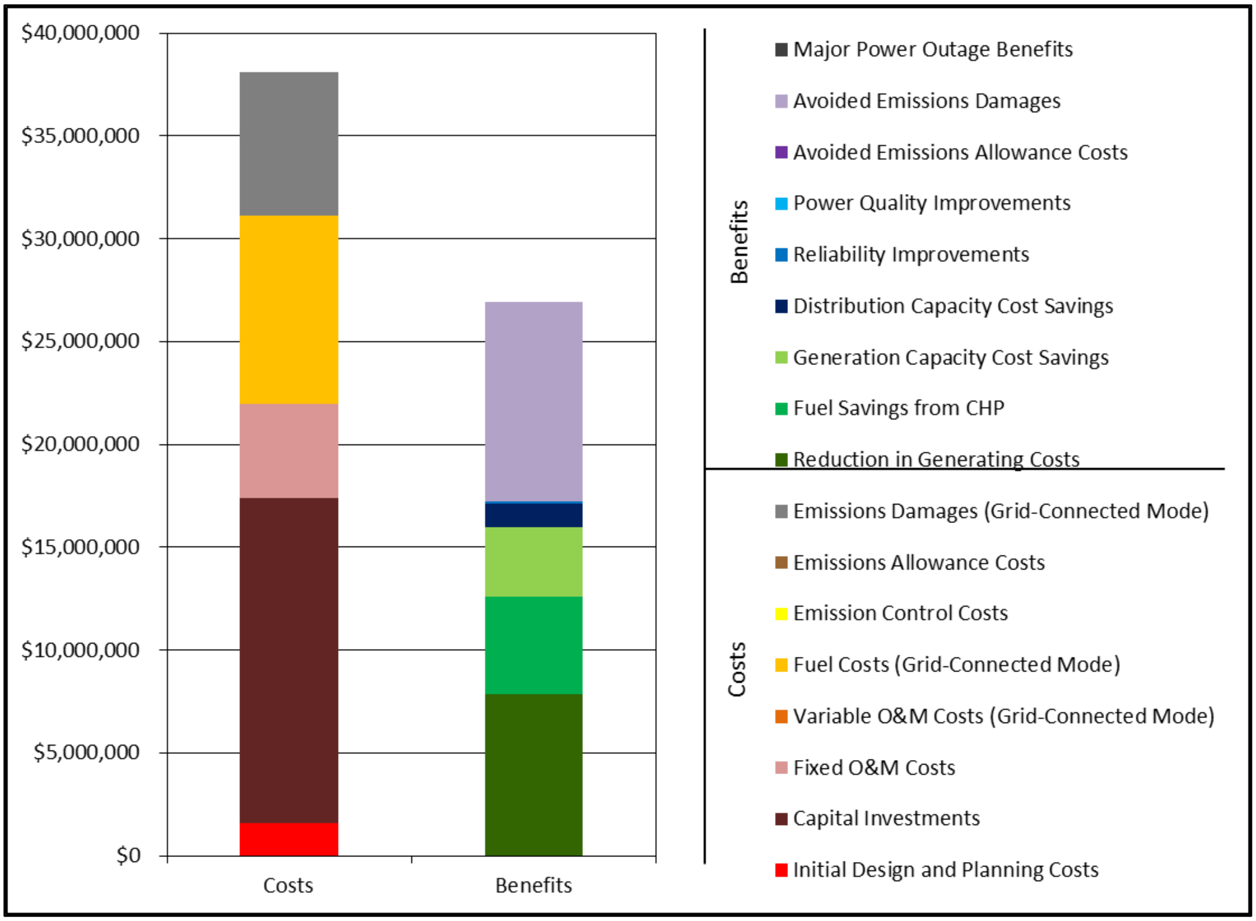


Table 2 – Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,580,000	$139,000
Capital Investments	$15,800,000	$1,390,000
Fixed O&M	$4,530,000	$400,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$9,180,000	$810,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$6,960,000	$454,000
Total Costs	**$38,100,000**	
Benefits		
Reduction in Generating Costs	$7,870,000	$694,000
Fuel Savings from CHP	$4,730,000	$417,000
Generation Capacity Cost Savings	$3,380,000	$298,000
Distribution Capacity Cost Savings	$1,140,000	$100,000
Reliability Improvements	$97,500	$8,610
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$3,870	$341
Avoided Emissions Damages	$9,710,000	$634,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$26,900,000**	
Net Benefits	**-$11,200,000**	
Benefit/Cost Ratio	**0.7**	
Internal Rate of Return	**N/A**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the proposed microgrid. The project team's best estimate of initial design and planning costs is approximately $1.58 million. The present value of the project's capital costs is estimated at approximately $15.8 million, including costs associated with acquiring and installing the new natural gas-fired generators and the PV array; utility modifications; microgrid controls; and creating new electrical interconnections between the served facilities. The present value of fixed operation and maintenance (O&M) costs over a 20-year operating period, including comprehensive maintenance of equipment and controls, is estimated to be approximately $4.53 million.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of fuel for the system's five natural gas 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 $9.18 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the DER that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that the five natural gas generators would not be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the new natural gas generators are estimated at approximately $454,000 annually. The majority of these damages are attributable to the emission of CO2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $6.96 million.

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 microgrid proposed by NRG in the City of Yonkers, the primary source of cost savings would be a reduction in demand for electricity from bulk energy suppliers, with a resulting reduction in generating costs. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $7.87 million; this estimate uses average electricity prices to value the reduced demand for electricity from bulk energy suppliers, consistent with the operating profile upon which the analysis is based. In addition, the four CHP generators are expected to reduce demand for natural gas for heating,

[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.

resulting in savings of approximately 61,000 MMBtu per year. The present value of this reduction in fuel demand is estimated to be approximately $4.73 million over a 20-year period. The reduction in demand for electricity from bulk energy suppliers and the reduction in natural gas consumption for heat would also reduce emissions of CO2 and particulate matter, and produce a shift in demand for SO2 and NOx emissions allowances. The present value of these benefits is approximately $9.71 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] Based on the project team's application of standard capacity factors for PV systems and natural gas generators, the analysis estimates the present value of the project's generating capacity benefits to be approximately $3.38 million over a 20-year operating period. Similarly, the project team estimates that the microgrid project would reduce the need for local distribution capacity by approximately 2.75 MW. Over a 20-year period, the present value of this benefit is estimated to be approximately $1.14 million.

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

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $8,610 per year, with a present value of $97,500 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate

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

[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.

(ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[18]

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.[19]

The estimate takes into account the number of large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[20] 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 0.7; i.e., the estimate of project benefits is approximately 70 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

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation –

[18] www.icecalculator.com.

[19] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Consolidated Edison.

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

on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[21,22]

As noted above, the City of Yonkers microgrid project would serve seven facilities, including municipal offices, the city's police headquarters, a hospital and nursing home, and an apartment complex for low-income senior citizens. The project's consultants indicate that at present, the Robert W. Cacace Justice Center, the St. Joseph's Medical Center Hospital, and the St. Joseph's Medical Center Nursing Home are equipped with backup generators. If an extended outage occurred, City Hall, City Hall Annex, and Griffin House would rent backup diesel generators (assuming rental units were available). If these generators failed or if rental units were unavailable, all supported facilities would experience a complete loss in operating capabilities.

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

- During an extended outage, the Robert W. Cacace Justice Center would experience a 50 percent loss in service capability, the St. Joseph's Medical Center Hospital would experience a 40 percent loss in service capability, and the St. Joseph's Medical Center nursing home would experience a 60 percent loss in service capability while using their backup generators.

- During a major outage, City Hall would experience a 40 percent loss in service capability, City Hall Annex would experience an 80 percent loss in service capability, and Griffin House would experience a 10 percent loss in service capability while operating with rental generators.

- During a major outage, if the existing backup generator at the St. Joseph's Medical Center Hospital were to fail, the hospital's patients would be evacuated, and the additional staffing required for the evacuation would result in one-time costs of $15,000 to the hospital. In addition, if the hospital were evacuated, it would experience a business impact of about $280,000 per day in lost revenue, which the analysis uses as a proxy for the non-emergency services that the hospital would be unable to provide.

[21] 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.

[22] 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.

- During a major power outage, if the existing backup generator at the St. Joseph's Medical Center nursing home were to fail, the nursing home's residents would be evacuated, and the additional staffing required for the evacuation would result in one-time costs of $7,000 to the nursing home.[23]

- During a major power outage, if the rented backup generator at Griffin House were to fail, residents would be transported to an alternate housing facility, at a one-time cost of $600 for transportation.[24]

- For all facilities, the supply of fuel necessary to operate the backup generator would be maintained indefinitely.

- In all cases, there is a 15 percent chance that the backup generator would fail.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities of interest. IEc's approach to estimating the value that would be lost for each facility during a major power outage (with no backup power available) is described below.

- For the police headquarters housed in the Robert W. Cacace Justice Center, the analysis estimates the social cost of any loss in police effectiveness that would result from a loss of power, based on an assumption that all 115 officers operating out of this facility would be unable to work if backup power were not available.[25] This assumption yields an estimate of lost value of approximately $84,000 per day.

- For the St. Joseph's Medical Center Hospital, the analysis estimates the social cost of the hospital's emergency room being unable to function, based on an estimate of approximately 33,800 emergency room visits per year at this facility.[26] This assumption yields an estimate of lost value of approximately $81,600 per day.

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[23] The project team estimates that the nursing home would experience a business impact of about $80,000 per day in lost revenue. In order to avoid double counting the lost value of service provided by the nursing home (estimated at $74,800 per day), the analysis excludes these costs.

[24] The project team estimates that costs to house residents in an alternate facility would be $2,500 per day. In order to avoid double counting the lost value of service provided by the Griffin House residences, the analysis excludes these costs.

[25] The analysis also assumes that the Yonkers Police Department employs about 600 officers (based on this source: http://www.johnmeyerconsulting.com/crosscounty/text/Section%2004-K-Environmental%20Analyses-Community%20Facilities%20and%20Services.pdf); thus, a loss of 115 officers would reduce the department's effectiveness by about 19 percent.

[26] http://health.usnews.com/best-hospitals/area/ny/st-josephs-medical-center-6215460.

- For the St. Joseph's Medical Center Nursing Home, the analysis estimates a value based on a standard cost of $374 per bed per day for nursing home care, yielding a total value of $74,800 per day.[27]

- For Griffin House, the analysis estimates the value associated with providing electrical power to 81 residents at approximately $2,120 per day.

- For City Hall, City Hall Annex, and the courthouse in the Robert W. Cacace Justice Center, the analysis employs the ICE calculator to estimate the economic costs of a sustained interruption of service, based on each facility's location, economic sector, and average electricity use. The calculator estimates that the services provided by these three facilities would have a value of approximately $283,000 per day.[28]

- For the New Main St. City Parking Garage, the project team believes no loss of service would occur during a major power outage, even without the microgrid in place; therefore, the analysis does not evaluate the impact of an outage on this facility.

Summary

Figure 2 and Table 3 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 2.6 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.

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

[28] The value estimated by the ICE Calculator for the Robert W. Cacace Justice Center courthouse is based on the electricity usage of the entire Robert W. Cacace Justice Center facility. Because this facility also houses the Yonkers Police Department Headquarters, it is likely that the value estimated by the ICE Calculator overestimates the value provided by the courthouse.

Figure 2 – Present Value Results, Scenario 2 (Major Power Outages Averaging 2.6 Days/Year; 7 Percent Discount Rate)

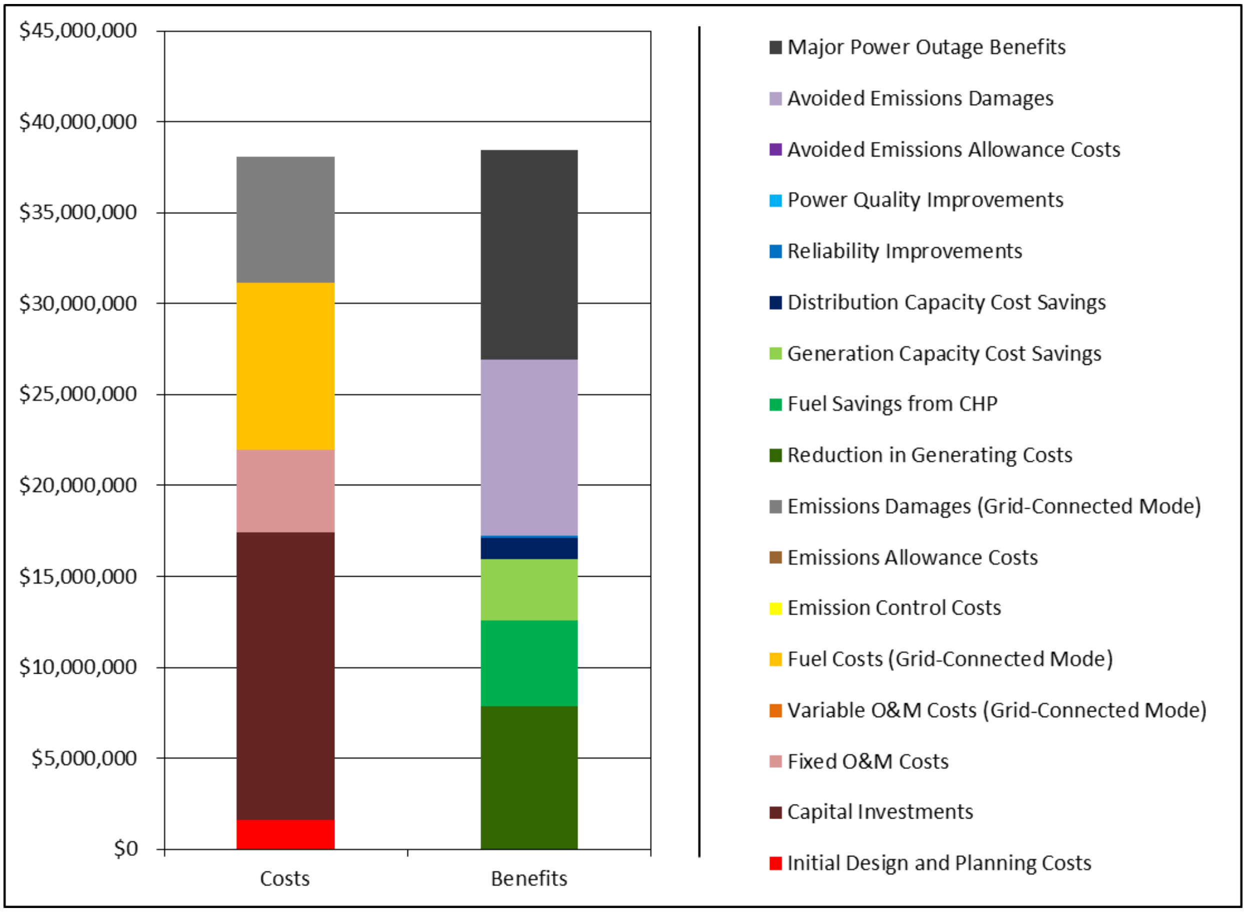


Table 3 – Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 2.6 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,580,000	$139,000
Capital Investments	$15,800,000	$1,390,000
Fixed O&M	$4,530,000	$400,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$9,180,000	$810,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$6,960,000	$454,000
Total Costs	**$38,100,000**	
Benefits		
Reduction in Generating Costs	$7,870,000	$694,000
Fuel Savings from CHP	$4,730,000	$417,000
Generation Capacity Cost Savings	$3,380,000	$298,000
Distribution Capacity Cost Savings	$1,140,000	$100,000
Reliability Improvements	$97,500	$8,610
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$3,870	$341
Avoided Emissions Damages	$9,710,000	$634,000
Major Power Outage Benefits	$11,500,000	$1,010,000
Total Benefits	**$38,400,000**	
Net Benefits	**$297,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.7%**	

Task 4.1 – Facility List and Customer Description

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
City Hall	Large Commercial/Industrial (>50 annual MWh)	Office of the Mayor, City Clerk, Dept. of Public Works, and City's VOIP servers	All other industries	581	0.21	100%	24
87 Nepperhan Ave City Offices	Large Commercial/Industrial (>50 annual MWh)	City's admin data servers (Management Information System), Dept. of Housing and Buildings, and Dept. of Planning and Development	All other industries	801	0.21	100%	24
New Main St City Parking Garage	Large Commercial/Industrial (>50 annual MWh)	Multi-level parking garage adjacent to City Hall and 87 Nepperhan Ave	All other industries	637	0.09	100%	24
Robert W. Cacace Justice Center, incl. YPD HQ	Large Commercial/Industrial (>50 annual MWh)	Criminal court (and jail), small claims court, and police HQ (incl. detectives division and police radio system)	All other industries	1,925	0.42	100%	24
St. Joseph's Medical Center - Hospital	Large Commercial/Industrial (>50 annual MWh)	194-bed inpatient acute care hospital	All other industries	6,295	1.46	100%	24
St. Joseph's Medical Center - Nursing Home	Large Commercial/Industrial (>50 annual MWh)	200-bed nursing home	All other industries	1,489	272	100%	24
Griffin House	Residential *Note: microgrid assumes conversion to master meter with sub-metering*	Apartments for very low income senior citizens (10 stories, 81 1BR units)	Residential	876	0.27	100%	24

Task 4.2 – Characterization of Proposed Distributed Energy Resources

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
Justice Center CHP Recip. Generator 1	Robert W. Cacace Justice Center, incl. YPD HQ	Natural Gas	0.25	1,770	4.8	9.5	MMBtu/MWh
Justice Center CHP Recip. Generator 2	Robert W. Cacace Justice Center, incl. YPD HQ	Natural Gas	0.75	114	4.9	10.5	MMBtu/MWh
Griffin House CHP Recip. Generator 1	Griffin House	Natural Gas	0.15	750	1.8	9.5	MMBtu/MWh
Griffin House CHP Recip. Generator 2	Griffin House	Natural Gas	0.15	750	1.8	9.5	MMBtu/MWh
St. Joseph's Medical Center Microturbine System	St. Joseph's Medical Center - Hospital and Nursing Home	Natural Gas	1.6	7,500	20	11.5	MMBtu/MWh
New Main St City Parking Garage Solar PV Array*	New Main St City Parking Garage	Solar	0.3	525	1.4	0	N/A

**Production estimates for Solar PV assume a 20% capacity factor*

Task 4.3 – Capacity Impact and Ancillary Services

The following resources would be available for peak load support.

Distributed Energy Resource Name	Facility Name	Available Capacity (MW / year)	Does distributed energy resource currently provide peak load support?
Justice Center CHP Recip. Generator 1	Robert W. Cacace Justice Center, incl. YPD HQ	0.25	☐ Yes
Justice Center CHP Recip. Generator 2	Robert W. Cacace Justice Center, incl. YPD HQ	0.75	☐ Yes
Griffin House CHP Recip. Generator 1	Griffin House	0.15	☐ Yes
Griffin House CHP Recip. Generator 2	Griffin House	0.15	☐ Yes
St. Joseph's Medical Center Microturbine System	St. Joseph's Medical Center - Hospital and Nursing Home	1.60	☐ Yes
New Main St City Parking Garage Solar PV Array*	New Main St City Parking Garage	0.06	☐ Yes

**Based on guidance from IEc, project team used 20% of nameplate capacity as availability factor for solar PV*

Facility Name	Capacity Participating in Demand Response Program (MW / year)	
	Following Development of Microgrid	Currently
Robert W. Cacace Justice Center, incl. YPD HQ	0.750	0
St. Joseph's Medical Center – Hospital and Nursing Home combined (summer participation only)	0	1.393

The microgrid operation will relieve the local distribution network by the kW generated capacity of the microgrid. The kW power offset will allow the utility and the system to provide more power to other energy consumers. If applicable, ConEd's regional engineering team will provide a value of what this capacity is worth in system avoided costs for the increased power availability. If there was a need in the area, potential utility T&D capacity relief from the proposed project would be 3.2 MW/year (transmission) and 2.75 MW/year (distribution).

The microgrid DER would be available for real (power) and reactive (voltage) local utility support. Base load generators will be configured for black-start capability.

CHP resources are planned for the Justice Center, Griffin House, and SJMC facilities. The combined annual energy savings are projected to be 61,000 MMBtu.

No emission allowances will be purchased for the operation of the DER. For regulated NOx and Particulate Matter emissions, the generator engines meet the required limit. Estimated emission rates for the equipment are in the following table. These rates are weighted averages for only the natural gas-based generators (reciprocating engines and microturbines), rather than for all DER in the microgrid.

Emissions Type	Emissions per MWh	Unit
CO_2	1413	Lbs./MWh
SO_2	0.00002	Lbs./MWh
NO_x	0.414	Lbs./MWh
PM	0.000004	Lbs./MWh

Task 4.4 – Project Costs

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

Capital Component	Installed Cost ($ in millions)	Component Lifespan (round to nearest year)	Description of Component
Justice Center CHP Recip. Generator 1	$0.88	20	CHP Generator Complete
Justice Center CHP Recip. Generator 2	$2.60	20	CHP Generator Complete
Griffin House CHP Recip. Generator 1	$0.53	20	CHP Generator Complete
Griffin House CHP Recip. Generator 2	$0.53	20	CHP Generator Complete
St. Joseph's Medical Center Microturbine System	$5.60	20	Elec & Mech equipment & installation
New Main St City Parking Garage Solar PV Array	$1.10	25	Elec & Mech equipment & installation
Utility Modifications	$1.00	20	ConEd Scope of Work
Microgrid Controls	$0.60	20	Control panels, Software, Comms
Electrical Interconnection City Bldg to Justice Center	$3.00	20	Electrical Equipment & Install
Subtotal - Capital Costs	**$15.84**		
Initial Planning & Design	$1.58		Design, Construction Documents
Total	**$17.42**		

Initial planning and design costs are estimated at $1.58 million. Fixed O&M costs are projected to be $400,000 per year. There are no anticipated non-fuel variable O&M costs.

All of the proposed fuel-based DER will use natural gas. According to ConEd, the local gas distribution company, the supply should be considered unlimited for the expected design basis events. Fuel consumption is listed in the below table.

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
Justice Center CHP Recip. Generator 1	Robert W. Cacace Justice Center, incl. YPD HQ	Indefinitely	9.5	MMBtu/MWh
Justice Center CHP Recip. Generator 2	Robert W. Cacace Justice Center, incl. YPD HQ	Indefinitely	10.5	MMBtu/MWh
Griffin House CHP Recip. Generator 1	Griffin House	Indefinitely	9.5	MMBtu/MWh
Griffin House CHP Recip. Generator 2	Griffin House	Indefinitely	9.5	MMBtu/MWh
St. Joseph's Medical Center Microturbine System	St. Joseph's Medical Center - Hospital and Nursing Home	Indefinitely	11.5	MMBtu/MWh
New Main St City Parking Garage Solar PV Array	New Main St City Parking Garage	Indefinitely	None	None

Task 4.5 – Costs to Maintain Service during a Power Outage

Existing Backup Generation Capabilities:

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Robert W. Cacace Justice Center, incl. YPD HQ	JC 1	Diesel	0.500	80	9.6	800	gal	0	1,542
St. Joseph's Medical Center - Hospital (new)	SJMC 1	Diesel	0.750	90	16.2	1,165	gal	0	3,500

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
St. Joseph's Medical Center - Hospital (old 1934 building)	SJMC 2	Diesel	0.250	90	5.4	388	gal	0	1,200
St. Joseph's Medical Center - Nursing Home	SJMC 3	Diesel	0.250	90	5.4	388	gal	0	1,200

Cost of Maintaining Service while Operating on Backup Power:

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Cacace Justice Center, incl. YPD HQ	One-Time Measures	Setting up a Mobile Command Center	No estimate	$	24/7 operations

Cost of Maintaining Service while Backup Power is Not Available:

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
City Hall	One-Time Measures	Hooking up portable generator	1,600	$	24/7 operations
City Hall	Ongoing Measures	Renting of portable generator	1,500	$/day	24/7 operations
87 Nepperhan Ave City Offices	One-Time Measures	Hooking up portable generator	1,600	$	24/7 operations
87 Nepperhan Ave City Offices	Ongoing Measures	Renting of portable generator	1,500	$/day	24/7 operations
Cacace Justice Center, incl. YPD HQ	One-Time Measures	Hooking up portable generator	1,600	$	24/7 operations
Cacace Justice Center, incl. YPD HQ	Ongoing Measures	Renting of portable generator	1,500	$/day	24/7 operations
Cacace Justice Center, incl. YPD HQ	One-Time Measures	Setting up a Mobile Command Center	No estimate	$	24/7 operations
St. Joseph's Medical Center - Hospital	One-Time Measures	Hooking up additional portable generator	30,000	$	24/7 operations
St. Joseph's Medical Center - Hospital	Ongoing Measures	Renting additional portable generator	9,000	$/week	24/7 operations
St. Joseph's Medical Center - Hospital	One-Time Measures	Additional staffing (evacuation)	15,000	$	During an evacuation
St. Joseph's Medical Center - Hospital	Ongoing Measures	Business impact	280,000	$/day	During an evacuation (revenue loss / staffing impact)

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
St. Joseph's Medical Center - Nursing Home	One-Time Measures	Hooking up additional portable generator	22,000	$	24/7 operations
St. Joseph's Medical Center - Nursing Home	Ongoing Measures	Renting additional portable generator	3,333	$/week	24/7 operations
St. Joseph's Medical Center - Nursing Home	One-Time Measures	Additional staffing (evacuation)	7,000	$	During an evacuation
St. Joseph's Medical Center - Nursing Home	Ongoing Measures	Business impact	80,000	$/day	During an evacuation (revenue loss / staffing impact)
Griffin House	One-Time Measures	Hooking up additional portable generator	20,000	$	24/7
Griffin House	Ongoing Measures	Renting additional portable generator	3,333	$/week	24/7
Griffin House	One-Time Measures	Transport, food/water	600	$	Major outage
Griffin House	Ongoing Measures	Temporary housing	2,500	$/day	Major outage

Task 4.6 – Services Supported by the Microgrid

The total population served by St. Joseph's Medical Center is approximately 200,000, and the nearest alternative (St. John's Riverside Hospital) is ~1 mile away. With respect to residential facilities, the SJMC Nursing Home has 200 beds and is typically >90% occupied (~190 beds filled), and Griffin House consists of 81 one-bedroom apartments for very low income senior citizens (U.S. HUD subsidized residence).

The Yonkers Police Department Headquarters at the Justice Center serves a total population of approximately 200,000 and is located in a Metropolitan Statistical Area. Under normal operations, 115 police officers work at the station. During a power outage, staffing would be expected to decline by 50% if backup power is available and 100% (to 0 officers) if backup is not available. Service effectiveness would decline by 50% (backup power is available) and 100% (backup is not available) during a major power outage. If backup power is not available, the services normally provided at the Cacace Justice Center would be transferred elsewhere to other facilities.

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

Facility Name	Percent Loss in Services When Using Backup Gen.
City Hall (40 South Broadway)	40%
City Offices (87 Nepperhan Ave)	80%
City Parking Garage (118 New Main St)	0%
Cacace Justice Center, incl. YPD HQ (104 South Broadway)	50%

Facility Name	Percent Loss in Services When Using Backup Gen.
St. Joseph's Medical Center - Hospital (127 South Broadway)	40%
St. Joseph's Medical Center - Nursing Home (115 South Broadway)	60%
Griffin House (122 South Broadway)	10%

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
City Hall (40 South Broadway)	100%
City Offices (87 Nepperhan Ave)	100%
City Parking Garage (118 New Main St)	0%
Cacace Justice Center, incl. YPD HQ (104 South Broadway)	100%
St. Joseph's Medical Center - Hospital (127 South Broadway)	100%
St. Joseph's Medical Center - Nursing Home (115 South Broadway)	100%
Griffin House (122 South Broadway)	100%

Section 5 – Feasibility Study Results

The City of Yonkers microgrid integrates critical government and healthcare facilities into the ConEd networked system and is designed to provide increased reliability and resiliency, as well as to deploy a mix of clean and efficient local generation sources and allow customer participants to better manage energy usage and costs. The seven facilities in the proposed microgrid include a Hospital, Nursing Home, Senior Residence (U.S. HUD-subsidized for very low income senior citizens), Justice Center (criminal and small claims courts, a jail, and Police Headquarters with police communications radio system), City Hall, City Offices (houses the datacenter servers that support the City's IT infrastructure), and City Parking Garage.

The St. Joseph's Medical Center facilities primarily consist of a Hospital and Nursing Home, which each have a dedicated electrical power service. The services will be combined with the proposed on-site generation, and new electrical interconnection controls and switchgear will regulate this operation. The SJMC site is physically separated from the other subject facilities by South Broadway, which contains many city services underground and will be difficult to cross. A cross connection will be further explored during the detailed design phase.

The rest of the facilities in the proposed Yonkers microgrid are located on the opposite side of South Broadway from SJMC. Griffin House is a relatively new residential facility with basement heating systems for space heating and hot water generation. The proposed natural gas CHP reciprocating engine generator will produce electrical and thermal energy tying into the basement mechanical and electrical equipment rooms and thus offsetting the need for the conventional heating equipment. The ConEd individual metering will have to be combined to a master meter with sub-metering. An electrical connection to the Justice Center, which is adjacent to Griffin House, is considered in the initial feasibility study to improve reliability for Island Mode operation.

The Justice Center will include a base load natural gas CHP reciprocating engine generator, and the thermal energy will be captured for space heating and hot water generation. An electrical connection across Nepperhan Avenue to City Hall and the City Offices will be provided. There isn't a consistent thermal load in the City buildings across Nepperhan Avenue, so there would not be enough utilization for CHP to be viable. For standby power in islanded/emergency operation (without the utility), an additional natural gas generator is proposed to provide power to the City of Yonkers facilities during an outage.

All CHP generators were sized to optimize the thermal usage and the estimated base electrical building loads. The intent is to meet eligibility requirements for the NYSERDA CHP incentive offering. For reliability of island operation, additional generation is included in the initial proposal for both sections (separated by South Broadway) of the microgrid.

A CHP generator is a relatively straightforward mechanical addition. The engine has a heat exchanger in parallel with the engine radiator. Coolant is diverted from the radiator to the heat exchanger depending on the building heating requirements. The heat exchanger is piped in series with the boiler inlet heating the incoming feed water. This reduces the heating burden of the boiler without having to make complex modifications to the existing boiler controls.

The Yonkers community microgrid is technically feasible but will most likely require additional incentives to attract private funding for full build-out in its proposed form. Incentives could include NYSERDA grants, favorable gas tariffs, and/or credits for DER generation or capacity. Preliminary economic modeling for the Yonkers Microgrid System, i.e. the proposed DER in aggregate, indicates a payback period of approximately fourteen years excluding additional NY Prize funding. Assuming $5.6 million in additional NY Prize or other incentives for the Justice Center CHP, the payback on the proposed microgrid would improve to approximately nine years under current assumptions. Financial feasibility is presented in detail in Task 3.5.

The $5.6 million for the Justice Center CHP is an estimate of the additional incentives required to enhance the financial viability and ensure a payback within the 20-year useful life of this particular resource, since this resource is burdened by (1) equipment costs for the 750 kW in additional capacity for Island Mode operation and (2) electrical interconnection costs of $2.8 million to connect the Justice Center plant to City Hall and the City Offices across Nepperhan Avenue. During detailed design, the financial feasibility of making this electrical connection across Nepperhan Avenue will be further evaluated. The project team notes that excluding this electrical inter-tie and/or scaling back the generation resource sizes (e.g. base load generation at the Justice Center, Griffin House, and SJMC with less additional capacity for islanded/emergency operation) would enhance the financial viability of a microgrid project in Yonkers, but likely with some tradeoff in system reliability and resiliency.

Given the technical feasibility, the expected benefits for participants and the Yonkers community, the need to build a stronger, greener city and promote revitalization, and the alignment with the NY REV policy initiative, Five Cities Energy Plan, and NY Rising Community Reconstruction Plan, as described in detail in this study, the project team recommends that the Yonkers community microgrid be considered for NY Prize funding in future stages. An additional level of incentive funding would serve to reduce the payback period in preliminary modeling to less than fourteen years and attract private or other sources of capital, thus improving the financial and commercial feasibility of the microgrid. Absent full microgrid implementation in its proposed form, a path forward could also involve some combination of conducting energy audits and ECM at the facilities, implementing economically favorable and efficient DER (e.g. base load CHP at SJMC and Griffin House), pursuing clean and renewable generation resources, and excluding the electrical inter-tie across Nepperhan Ave to City Hall and City Offices and thus avoiding the significant costs of this interconnection. These considerations will be fully evaluated during the detailed design phase of the project, but components can also be pursued on a more accelerated timeline with or without additional funding from the NY Prize program, if financially attractive and agreed upon by the project participants.

Listed below are some of the lessons learned during the Stage 1 feasibility assessment from the perspective of the microgrid's design engineers. In addition, legal/regulatory recommendations are presented in Task 3.6.

- Working with a mix of government, not-for-profit, and private energy customers required significant communication to validate customer needs and preferences pertaining to a microgrid and the proposed configuration.
- As customer needs and preferences were learned over time, proposed configuration changes had to be communicated to the design team for validation, such that any of the individual entity's requirements or objectives would not be compromised.
- Energy providers and customers were hesitant to divulge energy consumption/demand data and security sensitive infrastructure documents; multiple protective documents were required to obtain useful and necessary information for the development of an applicable conceptual microgrid design.
- Many skills and subject matter experts were required for a complete conceptual microgrid design, i.e. power systems design engineers, energy management process control design engineers, financial/commercial consultants, distributed energy resource consultants, energy efficiency consultants, etc.
- There is a need on smaller meters for more accurate energy time of day interval and consumption metering to better optimize energy equipment operation.

The proposed microgrid design addresses the objectives of the Yonkers customer participants, including a mix of clean and efficient localized generation to provide economic, environmental, and public safety, health, and security benefits. It is an actionable and feasible design that meets the technical needs of the microgrid and maximizes the economic performance for project participants with an optimal mix of DER, while still allowing for adequate generation during Island Mode operation. The Yonkers microgrid will improve reliability and enhance resiliency for multiple FEMA critical facilities, thus ensuring the continuity of government and administrative services, emergency operations/response, senior housing services, and healthcare services in the event of a power outage.

Asset Name	Critical Facility	Community Value
Yonkers City Hall	Yes, FEMA	High
Yonkers Police Dept. Headquarters	Yes, FEMA	High
St. Joseph's Medical Center	Yes, FEMA	High
St. Joseph's Nursing Home/Aging	Yes, FEMA	High

The Yonkers microgrid project will be expected to result in valuable experience and tangible benefits related to the effective integration of clean and efficient DER and development of new business models with customer, local utility, community, and competitive solutions provider engagement. For the Electricity Purchasers/Host Sites, customer participants and their facilities stand to benefit from increased reliability and resiliency and potentially from energy cost savings provided by the proposed microgrid. The Yonkers microgrid will provide additional standby power and a source of heat for critical facilities in the project footprint.

The Yonkers community will benefit from the proposed microgrid in various ways, including but not limited to, reliability benefits, environmental benefits, and public safety, health and security benefits. The microgrid will help to ensure the operational continuity of FEMA critical facilities, listed in the table above, in the face of a severe, protracted grid failure. The microgrid will provide significant benefits to the approximately 200,000 people relying on these facilities and services daily, as well as the 81 very low income senior residents at Griffin House and up to 200 residents at SJMC's Nursing Home.

In addition to providing quality power during extreme weather events, which might result in major power outages and grid failure, the microgrid will produce environment benefits in the form of reduced emissions from the CHP base load generators and zero emissions from using solar PV panels to generate electricity. Based on 2010 eGrid and using the U.S. EPA's CHP emissions calculator, the CHP and solar PV installations are estimated to save more than 8,000 tons per year in greenhouse gas emissions, the equivalent of taking more than 300 cars off the road and over a 30% reduction in emissions compared to NYUP subregion electric grid emissions.

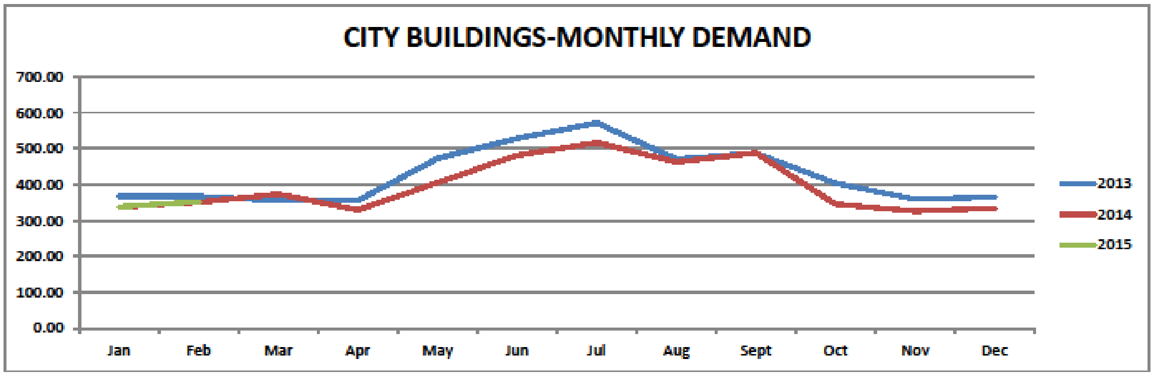
The proposed microgrid can provide impacts on utility capacity requirements and relieve stress on ConEd's network by providing on-site local generation. The system is also scalable and flexible, with a control solution that serves as a platform for future development and a design that can accommodate and adapt to a phased build-out, additional DER, and/or ECM that lower demand and produce energy cost savings for the facilities. The system will be expandable and modularized to the extent feasible to account for future growth and ensuing power needs of the buildings, further relieving the surrounding grid of future stress.

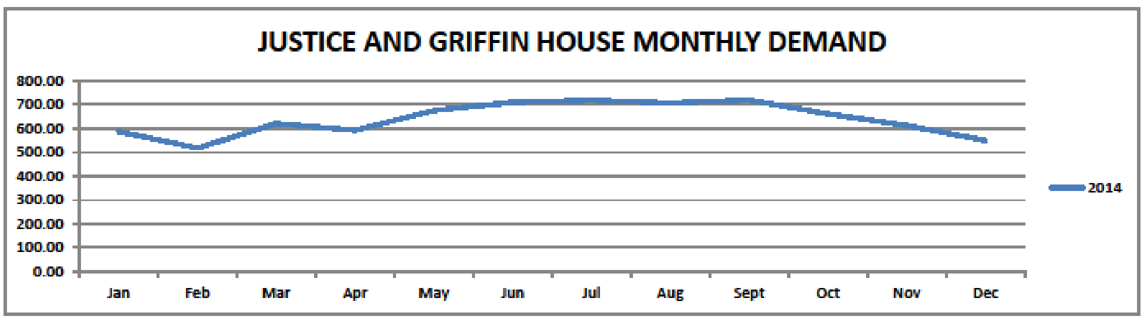
The real-time microgrid controller will balance generation with loads, maintain and monitor power quality and reliability, and take on responsibility for islanding/reconnection events. The advanced software technology will utilize historical/predictive algorithms and cloud-based information to optimize system dispatch and performance. As a result, the microgrid will reduce susceptibility to power outages by enabling a seamless transition from grid-connected to islanded mode, and while in normal grid-connected operation, the management technology platform will coordinate and optimize the microgrid assets.

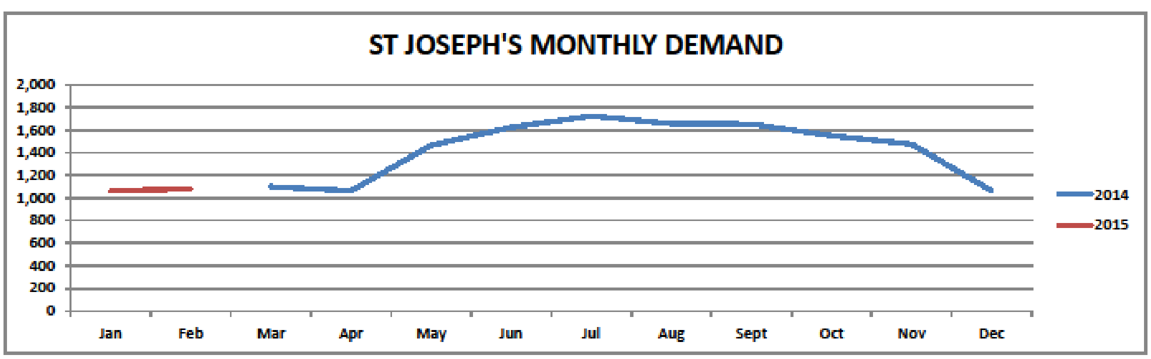
The proposed microgrid will advance objectives under NY Prize and the NY REV policy initiative, the Yonkers Five Cities Energy Plan, and the Yonkers NY Rising Community Reconstruction Plan. The reliable, resilient, and efficient microgrid proposed by the NY Prize project team will help the City of Yonkers move into the next phase of sustainable development, and it represents an opportunity for Yonkers to address its energy challenges, promote revitalization downtown, and build a stronger, greener city.

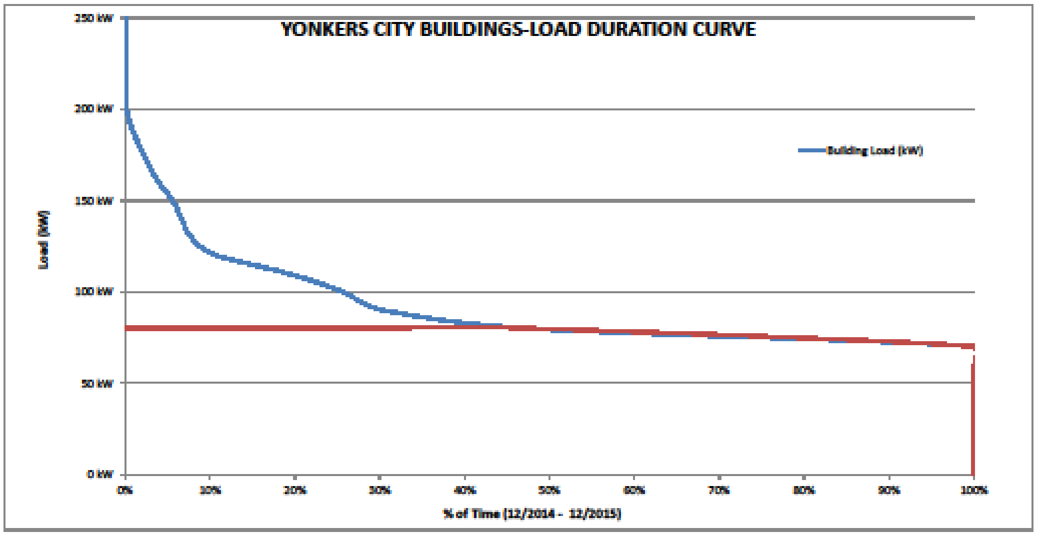
Section 6 – Appendices

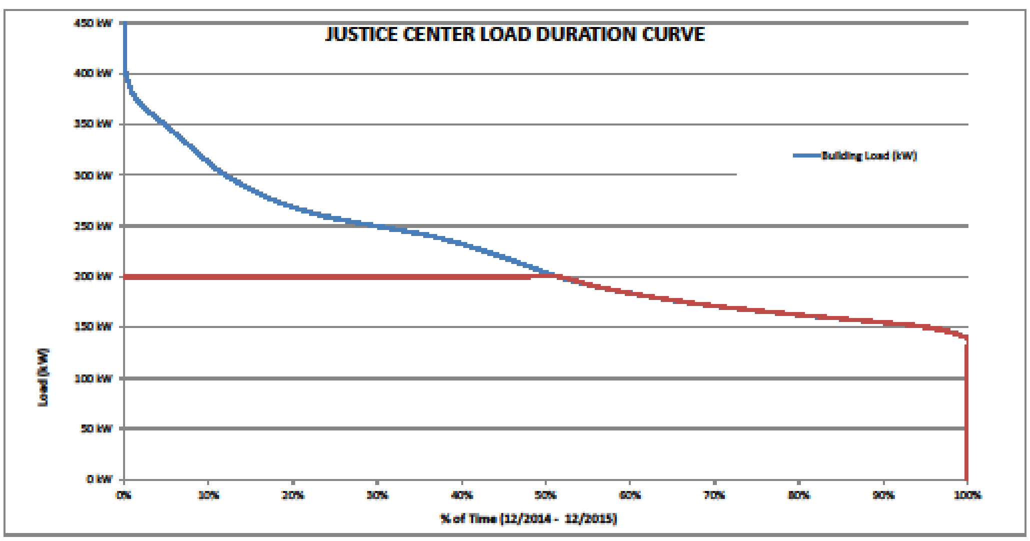
Appendix A – Monthly Demand and Load Duration Curves

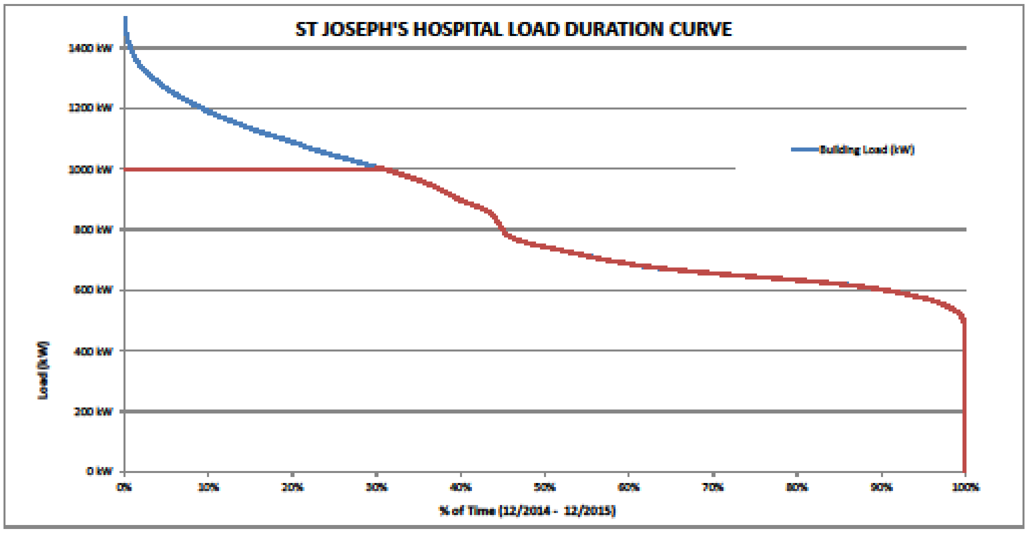







YONKERS CITY BUILDINGS-LOAD DURATION CURVE
Building Load (kW)
Load (kW)
% of Time (12/2014 - 12/2015)


JUSTICE CENTER LOAD DURATION CURVE
Building Load (kW)
Load (kW)
% of Time (12/2014 - 12/2015)


ST JOSEPH'S HOSPITAL LOAD DURATION CURVE
Building Load (kW)
1400 kW
1200 kW
1000 kW
800 kW
600 kW
400 kW
200 kW
0 kW
Load (kW)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% of Time (12/2014 - 12/2015)

Appendix B – Thermal Load Data

Projected Gas Profile Report 104 South Broadway

Customer: CITY OF YONKERS POLICE COURT BLDG
Service Class: 12
Account Number: 590921421364004

CALENDAR MONTH	(*) GAS USE THERMS (A)	MONTHLY DELIVERY	DAILY DELIVERY
1/1/2016	8617	8786.76	283.44
2/1/2016	7687	7838.43	279.94
3/1/2016	5745	5858.18	188.97
4/1/2016	3637	3708.65	123.62
5/1/2016	850	866.75	27.96
6/1/2016	262	267.16	8.91
7/1/2016	237	241.67	7.8
8/1/2016	220	224.33	7.24
9/1/2016	320	326.3	10.88
10/1/2016	3408	3475.14	112.1
11/1/2016	4710	4802.79	160.09
12/1/2016	5763	5876.53	189.57
Totals	41456	42272.69	

(*) - For Heating Customers, calendar usage is normalized for weather.

(A) - Calendar usage based on actual values

(E) - Calendar usage based on estimated values

(L) - Calendar usage based on load shape values

See TCIS User Guide for more information on (A), (E), and (L).

Projected Gas Profile Report **87 Nepperhan Ave**

Customer: CITY OF YONKERS
87 NEPPERHAN HEALTH DEPT
Service Class: 12
Account Number: 590921421712004

CALENDAR MONTH	(*) GAS USE THERMS (A)	MONTHLY DELIVERY	DAILY DELIVERY
1/1/2016	16115	16432.47	530.08
2/1/2016	12778	13029.73	465.35
3/1/2016	3262	3326.26	107.3
4/1/2016	78	79.54	2.65
5/1/2016	N/A		
6/1/2016	N/A		
7/1/2016	N/A		
8/1/2016	N/A		
9/1/2016	N/A		
10/1/2016	N/A		
11/1/2016	6164	6285.43	209.51
12/1/2016	15003	15298.56	493.5
Totals	53400	54451.99	

(*) - For Heating Customers, calendar usage is normalized for weather.

(A) - Calendar usage based on actual values

(E) - Calendar usage based on estimated values

(L) - Calendar usage based on load shape values

See TCIS User Guide for more information on (A), (E), and (L).

Projected Gas Profile Report **122 South Broadway**

Customer:	SJMC SENIOR HSG DEVEL CORP. GRIFFIN HOUSE
Service Class:	12
Account Number:	511138171610017

CALENDAR MONTH	(*) GAS USE THERMS (A)	MONTHLY DELIVERY	DAILY DELIVERY
1/1/2016	7537	7685.48	247.92
2/1/2016	4561	4650.85	166.1
3/1/2016	4715	4807.89	155.09
4/1/2016	3879	3955.42	131.85
5/1/2016	1966	2004.73	64.67
6/1/2016	1061	1081.9	36.06
7/1/2016	722	736.22	23.75
8/1/2016	666	679.12	21.91
9/1/2016	1102	1123.71	37.46
10/1/2016	2749	2803.16	90.42
11/1/2016	4258	4341.88	144.73
12/1/2016	6245	6368.03	205.42
Totals	**39461**	**40238.39**	

(*) - For Heating Customers, calendar usage is normalized for weather.

(A) - Calendar usage based on actual values

(E) - Calendar usage based on estimated values

(L) - Calendar usage based on load shape values

See TCIS User Guide for more information on (A), (E), and (L).

Projected Gas Profile Report 122 South Broadway

Customer: SJMC SENIOR HSG DEVEL CORP.
GRIFFIN HOUSE
Service Class: 2
Account Number: 511138171615016

CALENDAR MONTH	(*) GAS USE THERMS (A)	MONTHLY DELIVERY	DAILY DELIVERY
1/1/2016	32	32.63	1.05
2/1/2016	35	35.69	1.27
3/1/2016	32	32.63	1.05
4/1/2016	30	30.59	1.02
5/1/2016	30	30.59	0.99
6/1/2016	27	27.53	0.92
7/1/2016	29	29.57	0.95
8/1/2016	27	27.53	0.89
9/1/2016	28	28.55	0.95
10/1/2016	33	33.65	1.09
11/1/2016	29	29.57	0.99
12/1/2016	32	32.63	1.05
Totals	364	371.16	

(*) - For Heating Customers, calendar usage is normalized for weather.

(A) - Calendar usage based on actual values

(E) - Calendar usage based on estimated values

(L) - Calendar usage based on load shape values

See TCIS User Guide for more information on (A), (E), and (L).

Projected Gas Profile Report 122 South Broadway

Customer: SJMC SENIOR HSG DEVEL CORP. GRIFFIN HOUSE
Service Class: 2
Account Number: 511138171625015

CALENDAR MONTH	(*) GAS USE THERMS (A)	MONTHLY DELIVERY	DAILY DELIVERY
1/1/2016	199	202.92	6.55
2/1/2016	142	144.8	5.17
3/1/2016	175	178.45	5.76
4/1/2016	159	162.13	5.4
5/1/2016	156	159.07	5.13
6/1/2016	146	148.88	4.96
7/1/2016	143	145.82	4.7
8/1/2016	139	141.74	4.57
9/1/2016	149	151.94	5.06
10/1/2016	179	182.53	5.89
11/1/2016	163	166.21	5.54
12/1/2016	193	196.8	6.35
Totals	1943	1981.29	

(*) - For Heating Customers, calendar usage is normalized for weather.

(A) - Calendar usage based on actual values

(E) - Calendar usage based on estimated values

(L) - Calendar usage based on load shape values

See TCIS User Guide for more information on (A), (E), and (L).

Projected Gas Profile Report **113 South Broadway**

Customer: ST JOSEPH NURSING HOME
Service Class: 2
Account Number: 590017142710003

CALENDAR MONTH	(*) GAS USE THERMS (A)	MONTHLY DELIVERY	DAILY DELIVERY
1/1/2016	2226	2269.85	73.22
2/1/2016	2712	2765.43	98.77
3/1/2016	2150	2192.36	70.72
4/1/2016	1230	1254.23	41.81
5/1/2016	662	675.04	21.78
6/1/2016	600	611.82	20.39
7/1/2016	618	630.17	20.33
8/1/2016	616	628.14	20.26
9/1/2016	724	738.26	24.61
10/1/2016	1214	1237.92	39.93
11/1/2016	1704	1737.57	57.92
12/1/2016	2274	2318.8	74.8
Totals	**16730**	**17059.59**	

(*) - For Heating Customers, calendar usage is normalized for weather.

(A) - Calendar usage based on actual values

(E) - Calendar usage based on estimated values

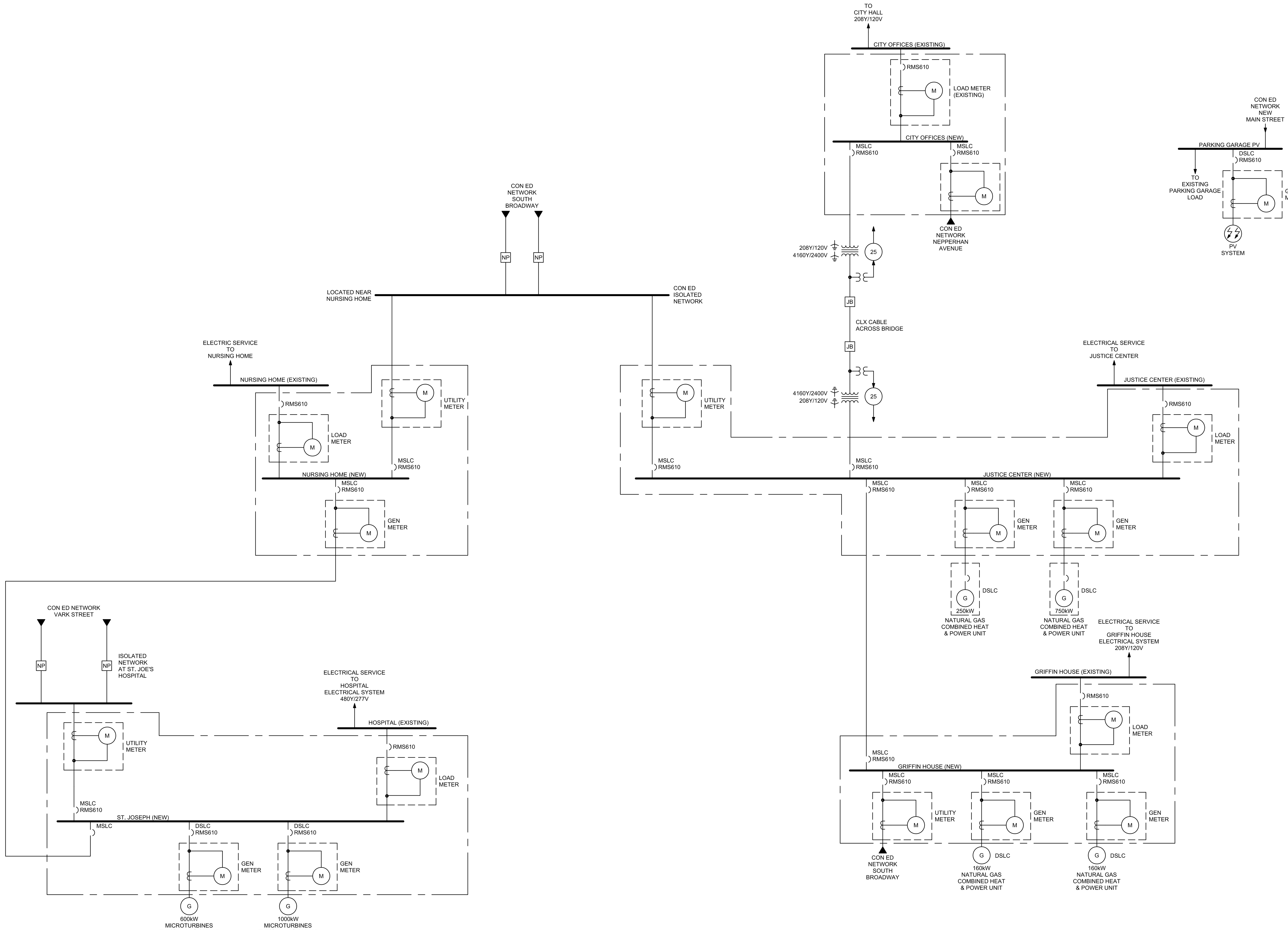
(L) - Calendar usage based on load shape values

See TCIS User Guide for more information on (A), (E), and (L).

Appendix C – Preliminary 1-Line Diagram

[document enclosed on next page]

NOTES:
1. PRELIMINARY DESIGN THE TYPE OF EQUIPMENT, SIZES AND RATINGS WILL CHANGE AS PROJECT IS DEVELOPED FUTHER.
2. CONTROLLERS REFERENCED WILL CHANGE AS THE DESIGN IS FUTURED. SHOWN ARE MSLC-MASTER SYNRONIZIER & LOAD CONTROLLER BY WOODWARD, RMS610 OVERCURRENT PROTECTION BY SQUARE D.



PRELIMINARY

Schneider Electric

SCHNEIDER ELECTRIC ENGINEERING SERVICES, LLC
1090 ELM ST
SUITE 101
ROCKY HILL, CT 06067

NOTES:
1) NP = NETWORK PROTECTOR
2)—·—=NEW EQUIPMENT BOUNDRY

REVISIONS				
8				
7				
6				
5				
4				
3				
2				
1				
REV	DATE	DESCRIPTION	DRAWN	CHKD

YONKERS MICROGRID

YONKERS, NY

NOT FOR CONSTRUCTION

DRAWN BY:	E. MILLER
CHECKED BY:	A. LYNCH
DATE:	1/27/16
SCALE:	NTS

PROJECT NO.
37467332

SIMPLIFIED ONE-LINE DIAGRAM

SHEET NO.
1 OF 1