1 - Village of Babylon

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Notice

Program: NY Prize Community Grid Competition

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NY Prize Community Grid Competition
Stage 1 Feasibility Assessment

Final Report

Prepared For

Village of Babylon
Long Island, NY

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1. Executive Summary

The goal of the NY Prize Competition is to improve the performance and resiliency of electrical distribution systems under both normal operational conditions and during emergency electrical grid outages. Stage 1 of the competition consists of the Feasibility Assessment. This study evaluates the minimum technical, financial, commercial, and regulatory feasibility specifications in the design of a community microgrid. It comprises a high level analysis of the specification, design, and operations necessary to implement a successful microgrid. For the Village of Babylon, this feasibility assessment furthers a conceptual plan that was developed by the Village of Babylon/West Babylon Planning Committee as part of the NY Rising Community Reconstruction Program (NYRCR) within the Governor's Office of Storm Recovery.

The Village of Babylon seeks to develop a microgrid to interconnect and provide uninterruptible electric power to critical response organization facilities that are within the Village. This proposal includes buildings that service the Village and which proved invaluable during restoration after Superstorm Sandy. These facilities were identified as the Village Hall, which includes the Village Administrative Offices, Fire and EMS Departments; the Department of Public Works, which includes the Highway and Sanitation Departments; the Babylon Union Free Junior-Senior High School, the American Legion Hall Post #94, and the St Joseph's School complex. The Babylon Village Hall, its various Departments and the American Legion Hall were fully engaged in Superstorm Sandy restoration efforts despite having no power for several days.

The microgrid configuration needed to achieve the Village's goals includes:

- Two 500 kW natural gas-fueled engine-generators
- Two photovoltaic arrays with a combined rating of 275 kW
- A microgrid interconnection system including 13.2 kV switchgear, distribution lines transfer switches, and controls
- Energy efficiency improvements in the critical facilities that will help to reduce the size of the necessary supporting generators and other microgrid equipment

In addition to providing power during emergencies, the microgrid will also provide renewable energy from its PV arrays, as well as valuable grid support to the PSEG-LI transmission and distribution systems in the area near the Village of Babylon.

The Village hopes its microgrid will become a model for municipal resiliency and disaster preparedness. In many municipalities, the physical proximity of key emergency response facilities such as fire, schools and public works is very close, as is the case with the Village. These facilities in other municipalities will likely have similar load profiles and will present similar challenges, which include economic viability of a microgrid combining normal and emergency operations capabilities.

2. Project Overview

2.1. NY Prize Community Grid Competition

Ameresco gathered facility and utility data for the Village of Babylon through the NYSERDA funded NY Prize Community Grid Competition. Stage 1 is designed to assess a community's needs along with available and required technologies, and to develop a feasibility assessment for a potential microgrid. At the end of the study, there should be a solid understanding of the project and the general timeline, preliminary costs, and structure.

2.2. Community Benefits

The primary benefit the Village is seeking from a microgrid is resiliency – to maintain power at critical municipal sites during storm-related and other outages. The microgrid project will enhance power reliability of key assets within the Village downtown center by providing independent, uninterrupted electrical power if the larger local distribution or regional grids fail. Significant parts of the Village of Babylon were subject to inundation and flooding from Superstorm Sandy and were without electricity for an extended period of time.

Beyond just preserving a resilient power source for critical assets and functions, the Village and the public will benefit from a myriad of secondary benefits described below, many of which support other important policy goals of the State:

- **Energy Efficiency:** Microgrids have the potential to generate and distribute energy more efficiently by avoiding the waste – in generation, transmission, and distribution networks– associated with the traditional grid. It is estimated that transmission and distribution losses account for approximately 5 to 10% of energy between the generation plant and end users. These losses are in addition to thermal losses at conventional thermal power plants, which are typically between 65 and 70% of primary fuel input. In addition, the microgrid offers the opportunity to include energy efficiency measures at the interconnected facilities that help to reduce equipment sizes and associated impacts.
- **Energy Costs:** By reducing waste and delivering energy to end users in close proximity to its generation, the microgrid has the potential to reduce the cost per kWh of electricity.
- **Sustainability/Climate Change:** When incorporating low or no-emission technologies, the microgrid gets to the root problem of climate change by reducing greenhouse gas emissions and dependence on fossil fuels in two important ways – by making renewables, such as solar power, more feasible; and reducing energy waste. One of the Village's goals is to provide a significant portion of its energy needs with renewable resources.
- **Energy Security/Local Control:** Microgrids provide greater energy security by putting energy provision in the hands of the community that is affected by it. By providing consistent electricity and heat supply during a utility outage, emergency response operations can be sustained and a safe shelter area can be provided to local residents during a time of emergency.
- **Economic Benefits:** By maintaining power during storms and other outages, the microgrid will allow for continuous and significant emergency services, thereby facilitating business restoration and minimizing economic impact. (Economic losses due to power outages are estimated at between $26 and $150 billion nationwide each year.

- **State Policy Reform and Market Formation:** We believe a microgrid developed in the Village will help inform regulatory/statutory changes and economic models for future microgrids across the state and specifically the utilization and integration of microgrids under the NY REV proceeding.
- **Macrogrid/PSEG-LI Efficiency:** Depending on the system configuration, the resources contained within the microgrid could provide benefit to the local utility and/or NYISO during normal operation. These benefits could include: offering capacity to the utility to relieve congestion or defer the costs of transmission and distribution equipment upgrades; reducing demand behind the meter of sites within the micro-grid, thereby reducing the need for the utility grid to provide that capacity; or offering ancillary services such as frequency regulation to the NYISO to help maintain grid reliability. The results of this feasibility study will help determine which of these value streams are feasible now or recommend improvements that could be made to realize these potential values for PSEG-LI and NYISO.

3. Facilities and System Requirements

3.1. Overview of Included Facilities

The Village of Babylon is located on the south shore of Long Island, and has experienced numerous storm-related utility outages through its history, most recently including Superstorm Sandy. The facilities considered in this study are important in day-to-day operations, but from experience during Superstorm Sandy, are critical during emergency situations. They are:

- Babylon Junior-Senior High School
- Village Hall (housing operations, firefighting, and emergency medical services)
- Department of Public Works
- American Legion Post #94
- St. Joseph's School

The largest natural risk to the Village of Babylon is flooding, which causes physical damage to homes and businesses, and disruption of electric service. The southern end of Babylon is within the 100-year flood zone, and was developed on top of low lying filled lands that were former wetlands. The water table in this area is generally very high, which leads to drainage issues throughout the Village. Additionally, the landscape gradually slopes north to south towards the Great South Bay which brings flooding from the Carlls River watershed. As a result, the Village of Babylon faces numerous flooding threats during storm events that include heavy rainfall accumulation, high tides, or both.

Through the course of Superstorm Sandy, it is estimated that nearly a third of the Village's population was displaced. Due to severe flooding, a mandatory evacuation was issued for the 1,700 homes located South of Montauk Highway in the Village of Babylon. Residents in an additional 2,300 homes, or about 50% of the Village, were left without power or had to leave due to damage or threat of damage. The Village's Fire, Emergency Medical Services (EMS), and Department of Public Works (DPW) teams coordinated various emergency response functions, such as fire-fighting, health care, flood rescue, communication, and transportation. The Babylon Junior-Senior High School opened up space for housing and shower facilities for displaced residents. The American Legion became a donation center for clothes, canned goods, and other basic needs for residents. The St. Joseph facilities opened to allow temporary relief and allow people access to power to charge necessities, such as cell phones for communication.

Table 1 and Figure 1 provide additional information about the size, type and location of each facility.

Table 1 Facility Type, Addresses and Gross Square Footage

Facility	NAICS Code/Facility Type	Address	Sq. Ft.
Babylon Village Hall/Fire/EMS	999300 (Local Government)	153 W. Main St.	25,000
Babylon Dept. of Public Works	999300 (Local Government)	153 W. Main St.	9,500
Babylon Junior-Senior High School	611110 (Elementary/Secondary Schools)	50 Railroad Ave.	220,000
American Legion Post #94	813410 (Civic/Social Organizations)	22 Grove Place	12,750
St. Joseph's School	611110 (Elementary/Secondary Schools)	39 North Carll Ave.	98,000

Figure 1 Facility Locations

3.2. Roles of Facilities and Microgrid Requirements During Emergency Operations

The facilities included in the proposed microgrid are expected to continue functioning in the roles they played during Superstorm Sandy.

- The Village Hall/Fire/EMS complex contains Village government office along with critical fire, medical, and police services.
- The Department of Public Works facility maintains Village infrastructure, and houses emergency vehicles that can provide resident and supply transportation, obstacle removal, and rescue operations. Emergency vehicles include high water vehicles which were used during Sandy to evacuate residents who were stranded in their homes.
- The American Legion Hall would be expected to provide services for distributing at least some of the necessities for displaced residents.
- St. Joseph's is expected to provide supplemental shelter and other services during emergencies.

- The Junior-Senior High School is a key educational facility for the Village, and would be able to provide shelter for residents who are displaced by power outages or natural events.

The ability to operate local shelters that this project would support is likely most critical for low-to-moderate income residents of large multi-resident complexes who have no other options when evacuating their homes.

The microgrid design proposed in this study includes all of the facilities shown in Figure 1. The following technical requirements for the microgrid are based largely on experience with emergency operations during Superstorm Sandy and will define many of the detailed design features and operational characteristics:

- The microgrid must maintain continuous electric power to critical public safety facilities during a major, prolonged utility outage to ensure the ability to respond to police, fire or medical emergencies.
- The microgrid must maintain continuous electric power to facilities capable of providing shelter for a large number of displaced residents during storms and other events that may cause prolonged utility outages.
- The microgrid must permit unrestricted, extended, simultaneous, interconnected operations of the facilities isolated from the electric utility. This means that the microgrid must be capable of providing all of the electric power requirements for each of the facilities around the clock.
- Ensure that the microgrid facilities are resilient and outside of areas likely to be affected by flooding.
- Provide the controls and communications systems needed to ensure safe, automatic operation of the microgrid equipment during emergency events.
- Provide additional benefits including local utility grid support and renewable energy during normal operations.

The intent of the proposed microgrid is to provide stable, reliable power to important facilities within the Village of Babylon, and to create a hub for disaster response. The certainty that these facilities would be fully operational permits better preparation for providing emergency services and temporary housing during an emergency. This will also provide residents with the assurance that services and facilities would be available, and the encouragement to use them when needed. This will relieve significant stress on emergency services to deal with evacuations and rescues for residents who may be reluctant to leave their homes. The emergency response functions would be ensured, and could be counted on in emergency planning. Furthermore, the Village's emergency services could respond to emergencies from surrounding communities who may be without power and have limited capabilities.

4. Characterization of Facility Electricity Usage

4.1. Electric Rates and Usage

Table 2 shows each facility's rate classification under current PSEG-LI tariffs, annual usage (kWh) and peak demand (kW) from 2014 utility billing information. Annual energy usage and peak loads differ substantially between the facilities. The Junior-Senior High School is the largest electricity end user by a wide margin, with a peak load of 299.8 kW and an annual consumption of 1,054,560 kWh.

Table 2 Facility PSEG-LI Rate Classifications and Usage

Facility	PSEG-LI Rate Class	No. of Meters	Annual kWh	Peak kW[1]
Babylon Village Hall	Commercial Large General Use (Rate 281)	1	169,600	58.5
Babylon Department of Public Works	Commercial Large General Use (Rate 281)	1	71,556	18.0
Babylon Junior-Senior High School	Commercial Large Multiple Periods (Rate 285)	1	1,054,560	299.8
American Legion Post # 94	Residential Voluntary Multiple Periods (Rate 188)	1	61,920	38.3 (est.)
St. Joseph's School[2]	Residential Voluntary Multiple Periods (Rate 188)	2	195,020	102.5 (est.)

Because each facility is different in terms of size, occupancy, usage, and age of equipment, it is not surprising that there is wide variability in total annual usage and peak demand. PSEG-LI's rates include seasonal components, which causes at least some of the variability in average electric rates for each facility. Rates 281 and 285 include both seasonal and time of use demand and energy charges. Rate 188 is primarily a residential, non-demand rate, but is available for social religious organizations, and has a seasonal energy charge adjustment. Table 3 shows seasonal average energy rates (blended with demand charges for Rates 281 and 285), and the percentage of total annual electricity usage during the corresponding seasons.

Table 3 Facility Seasonal Average Rates and Seasonal Usage

	Seasonal Average Rate ($/kWh)	% of Annual Energy Usage

[1] Peak demand for the American Legion Post #94 and St. Joseph's are estimated. Both facilities are on non-demand rates.
[2] St. Joseph's School consists of two separately metered facilities. The information provided is for the combined facilities.

Village Hall		
June through September	$0.1830	44%
October through May	$0.1917	56%
Department of Public Works		
June through September	$0.1871	32%
October through May	$0.1854	68%
Babylon Junior-Senior High School		
June through September	$0.2121	30%
October through May	$0.1719	70%
American Legion Post #94		
June through September	$0.2294	42%
October through May	$0.1836	58%
St. Joseph's		
June through September	$0.2499	29%
October through May	$0.1684	71%

4.2. Baseline Facility Energy End Use

Ameresco performed site energy assessments as part of this study. Major facility end uses and estimates of end use electricity consumption are shown in Table 4 below. As expected, lighting and HVAC are the largest electric end uses for all facilities. The predominant HVAC end use is air conditioning. However, both Babylon Junior-Senior High School and St. Joseph's School utilize natural gas-fueled boilers to provide space heating. In the case of Babylon Junior-Senior High School, a portion of HVAC load is shown as major motors, which are used to operated hot water pumps, boiler primary air fans, and other auxiliaries during the heating season.

Table 4 Estimated Electricity End Usage

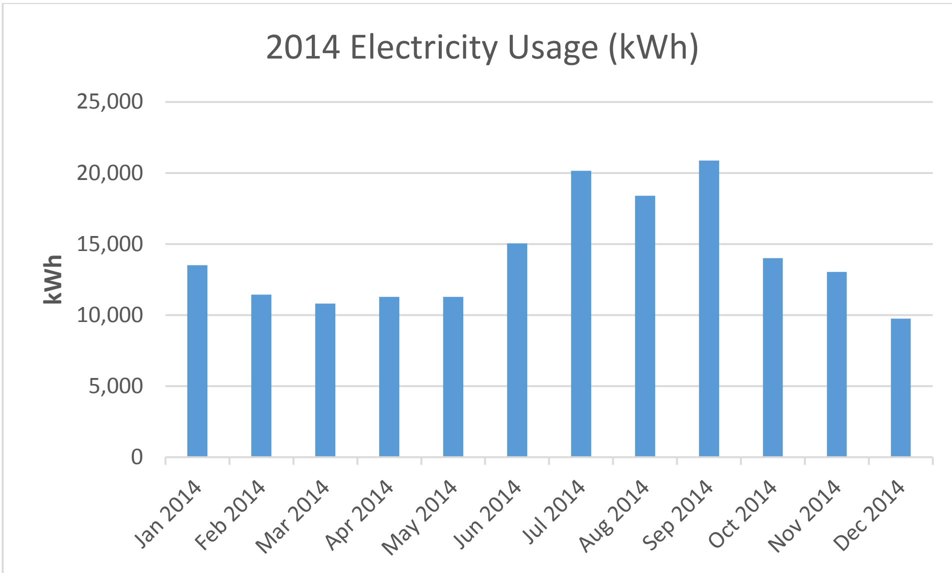
Facility	Estimated End Use Consumption (kWh)					% of Total
	Billed Usage	HVAC	Lighting	Major Motors	Total Baseline	
Babylon Village Hall	169,600	65,494	69,235	-	134,729	79%
Babylon Dept. of Public Works	71,556	-	30,220	-	30,220	42%
Babylon Junior-Senior High School	1,054,560	135,310	335,848	167,652	638,810	61%
American Legion Post #94	61,920	18,593	43,507	-	62,100	100%
St. Joseph's School	195,020	44,898	150,634	-	195,532	100%
Total	1,552,656				1,061,392	68%

4.3. Facility Load Shapes and Peak Demand Estimates

The main purpose of analyzing the load shapes is to estimate the peak load requirements for equipment sizing, particularly primary generators. Since detailed interval data is not available for the facilities, there are two uncertainties concerning peak loads:

1. For Babylon Junior-Senior High School, Village Hall and DPW, the magnitudes of the highest peak loads are available, but the frequencies and exact times of peak are not known
2. For St. Joseph's and the American Legion Hall, the magnitudes, frequencies and times of peak are unknown.

For Babylon Junior-Senior High School, Village Hall and DPW, the peak loads from billing information are used "as-is." Although the exact time of peak cannot be established in any given month, the highest peak values determine peak demands for sizing purposes. For the American Legion Hall and St. Joseph's, which are on non-demand rates, peak loads had to be estimated using a load factor. For estimating purposes, the load factor used in both cases was 0.25, which is conservative. Figures 2 through 7 show monthly energy and demand data for each of the facilities, and combined energy and demand.



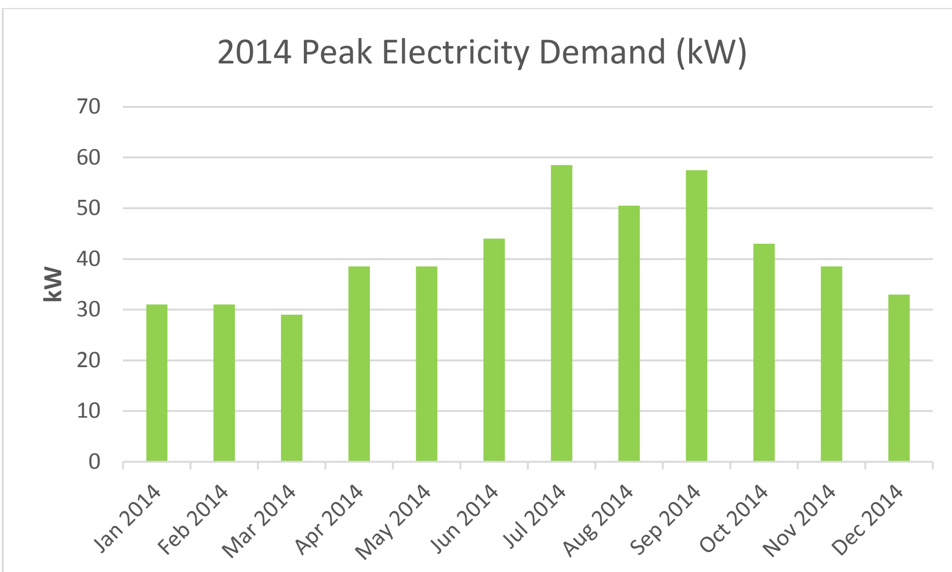
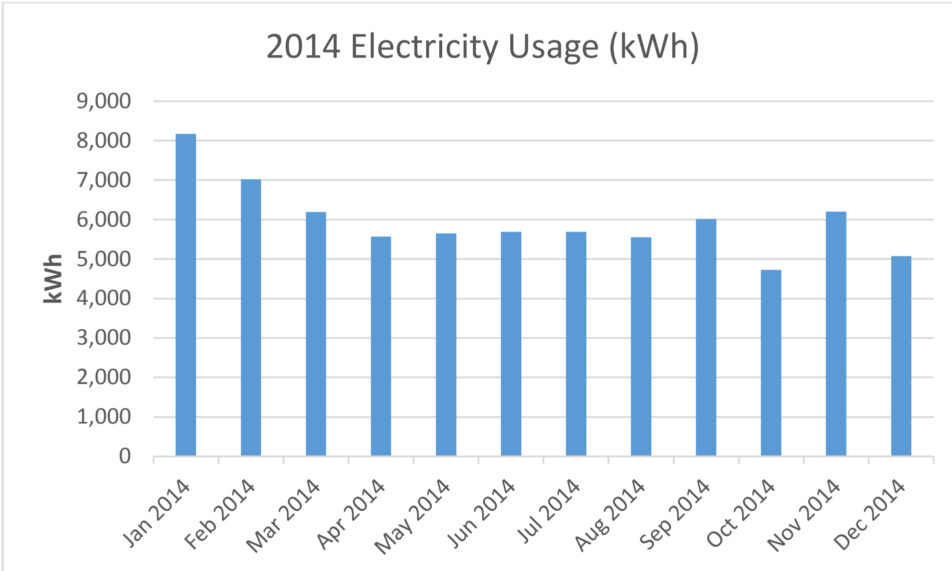


Figure 2 Babylon Village Hall Monthly Energy and Demand



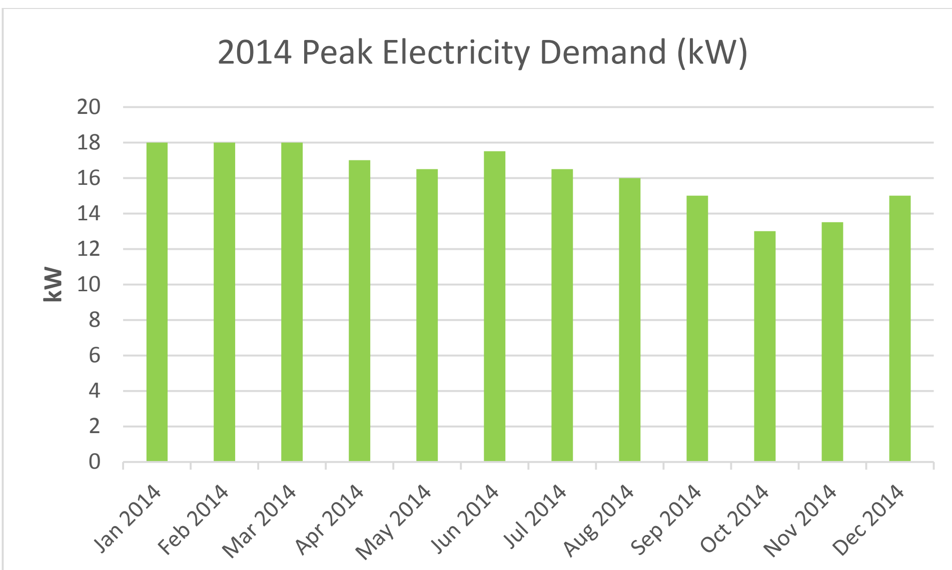
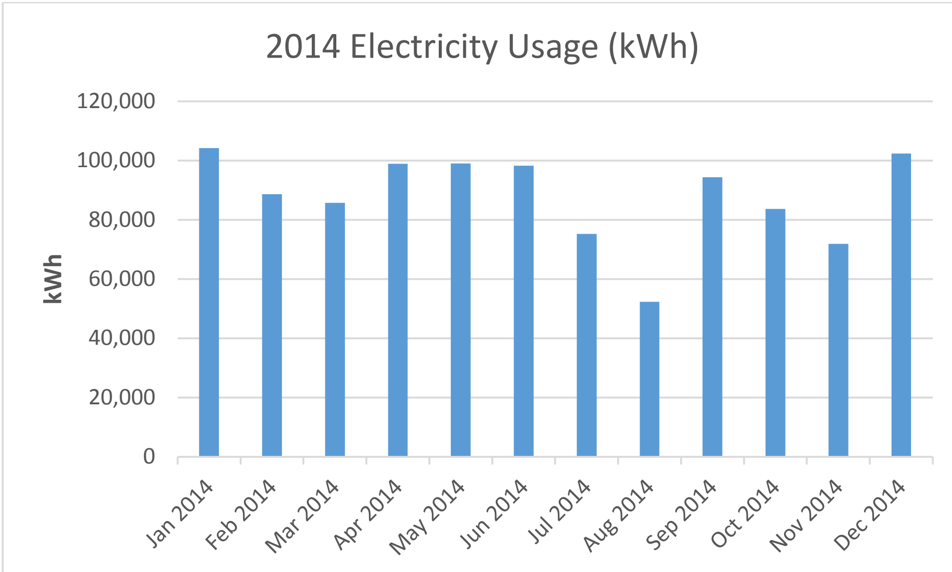


Figure 3 Babylon Department of Public Works Monthly Energy and Demand



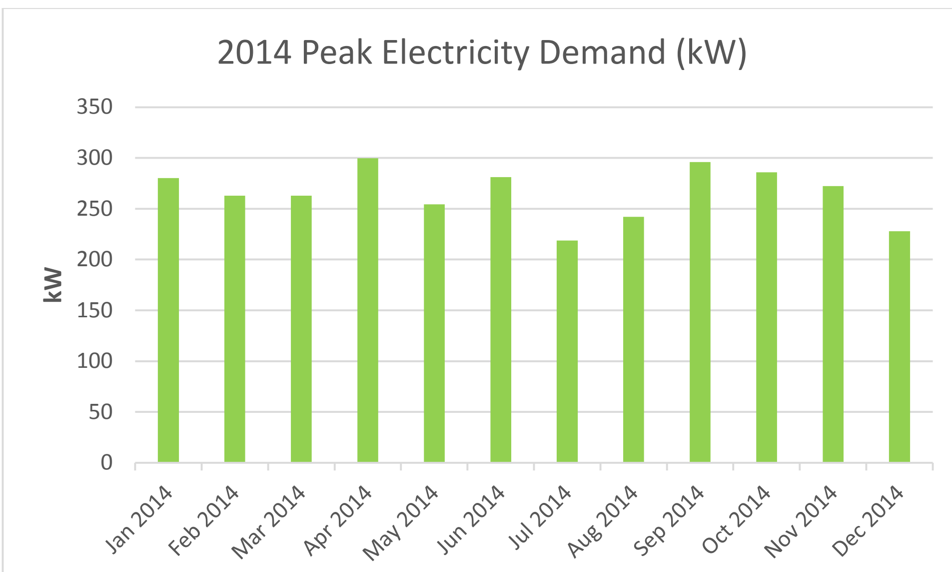
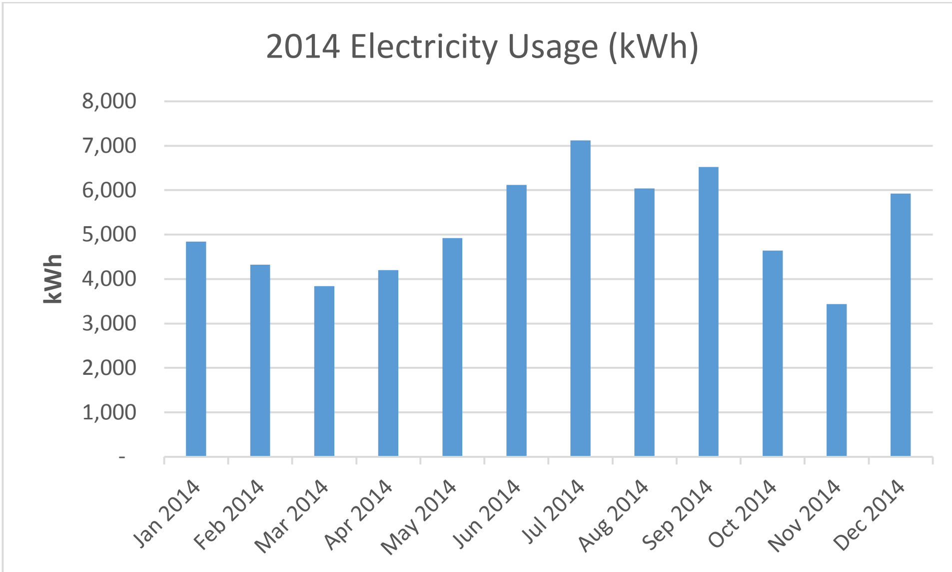


Figure 4 Babylon Junior-Senior High School Monthly Energy and Demand



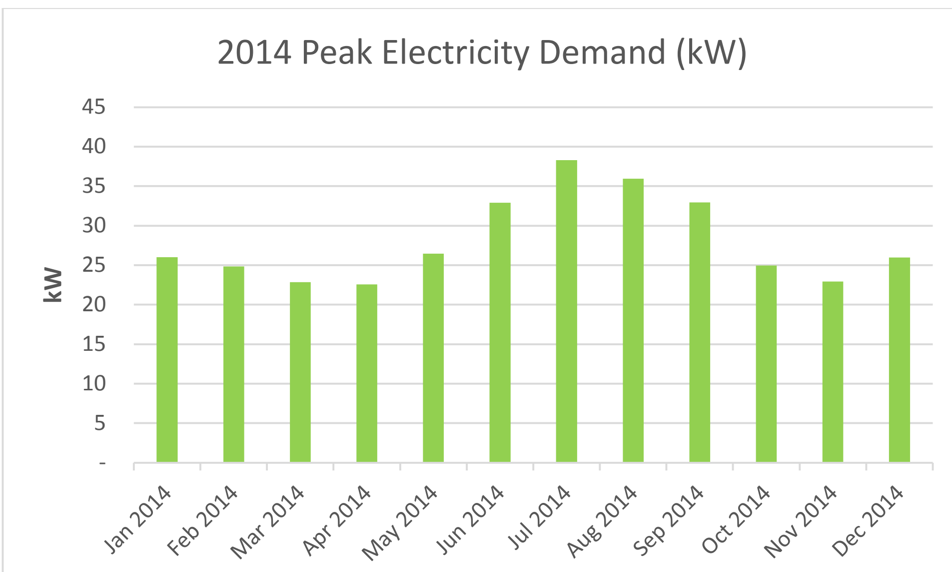
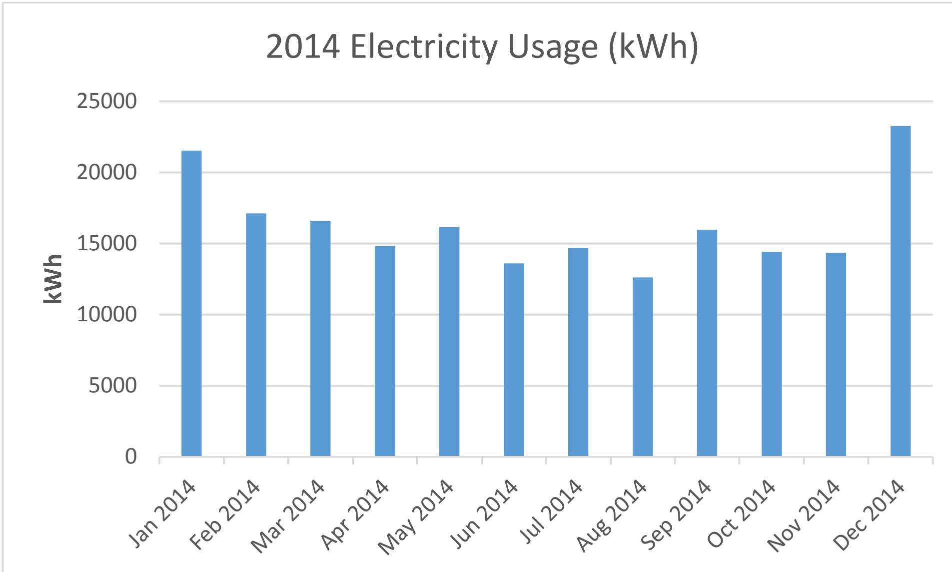


Figure 5 American Legion Hall Post #94 Monthly Energy and Demand



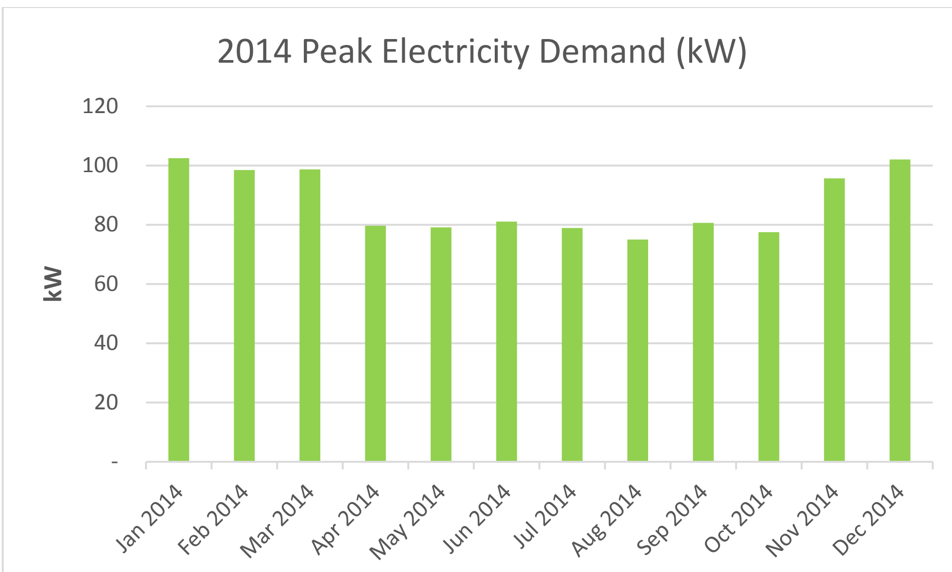
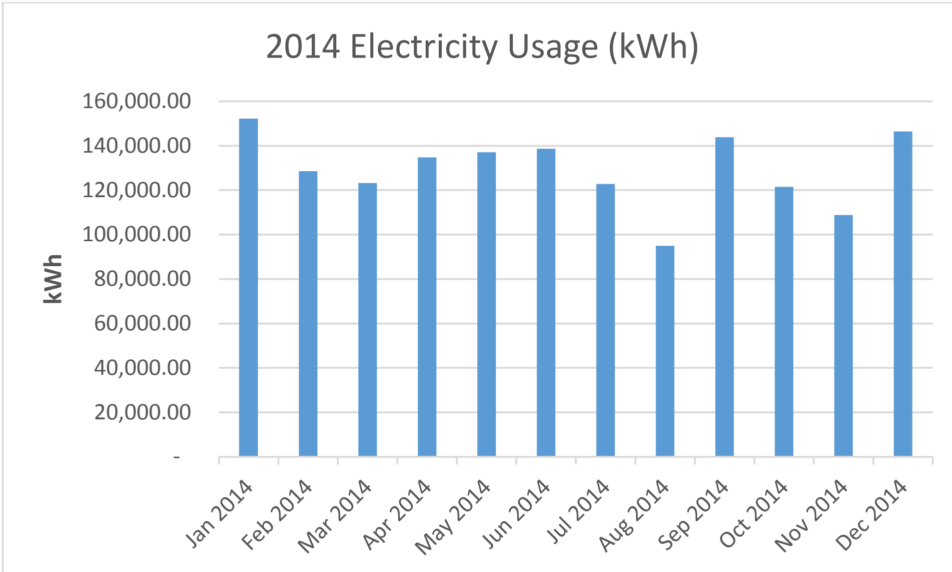


Figure 6 St. Joseph's Monthly Energy and Demand



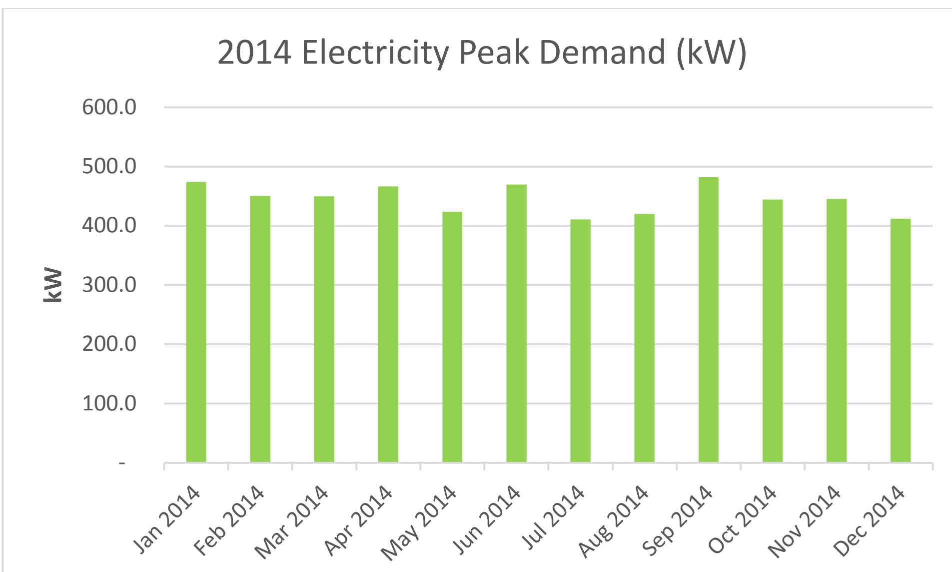


Figure 7 Combined Facilities Monthly Energy and Demand

Several observations can be made from the billing review and the preceding figures:

- Under normal circumstances, combined energy usage is highest during the months of January, September and December, and lowest in August. The lowest combined usage in August is expected since both schools have their lowest monthly usage during this month, and they are the largest facilities. Although the schools operate year-round, air conditioning is limited during the summer months, and occupancy is down.
- Combined peak loads fall within a narrow range between approximately 400 and 500 kW year-round. This indicates good load diversity under normal operating conditions. The highest combined peak load occurs during September when both schools are fully occupied, and air conditioning loads are still high.
- Given the operating characteristics of the facilities, it can be reasonably assumed that the peak loads at each facility occur during normal, weekday school and business hours. Since none of the facilities have electric heat, it is improbable that nighttime peaks occur, although both schools peak during the winter months.
- The combined monthly peak loads shown in the figures above are non-coincident, i.e., it cannot be assumed that they all occur at the same time. In fact, no conclusions can be drawn about the coincident peak loads of the combined facilities, although the non-coincident combined peak load represents a worst case scenario.

The analysis indicates that, with no changes to equipment within the facilities, the combined peak load that needs to be served by the microgrid is nearly 500 kW. The utilization of some facilities is likely to extend beyond normal working hours during emergency conditions, but peak loads are not expected to vary significantly in comparison to peak loads during normal operations.

4.4. Potential Energy Efficiency Upgrades

Site assessments were conducted for all of the facilities included in the proposed microgrid to identify potential energy efficiency and/or combined heat and power (CHP) opportunities. Since none of the facilities have significant combined coincident thermal and electric loads, CHP was eliminated from further consideration. However, efficiency opportunities were identified in all of the facilities.

Efficiency upgrades could potentially provide reductions in both annual electricity usage, as well as demand reductions. Significant demand reductions also affect generator sizing. Upgrades are grouped into three categories: Lighting, HVAC, and Variable Frequency Drives (VFDs). Each of these are described below.

HVAC Upgrades

The majority of the HVAC units across all of the microgrid facilities are 15 years old or older. Older units have lower efficiencies in comparison to new units due to significant improvements in equipment design. In addition, the rated efficiency of the older equipment degrades due to age and weathering effects. It is estimated that these units operate at an efficiency of 8 EER (8 BTUs/Watt-hour). Comparable new units are required to achieve a minimum efficiency of 10-11 EER, an improvement of 25 to nearly 40%. By upgrading rooftop units and window units to current models, yearly energy consumption for space cooling can be reduced by nearly 80,000 kWh.

Lighting Upgrades

The majority of the lighting at the Village Hall facility consists of T8 fixtures in office and general areas. The truck bays in the Fire/EMS and Public Works departments are illuminated by T12 fixtures. The American Legion building has T12 fixtures installed in most general purpose areas, with halogen and incandescent fixtures for spot lighting. St. Joseph's School has been built in multiple stages, and the lighting in the buildings reflects the age. While some areas are lit with more energy efficient T8 fixtures, a large number of T12 fixtures still exist, along with halogen and incandescent fixtures. The Babylon Junior-Senior High School underwent an energy efficiency retrofit in 2008, and is the most efficiently lit building among the microgrid facilities. The lighting consists of T8s and CFLs throughout classrooms, hallways, general areas, and gymnasiums.

In order to reduce demand on the microgrid as well as minimize energy expenditures for microgrid customers, lighting efficiency upgrades are recommended. Retrofitting T8/T12 fixtures with LED linear tubes and replacing incandescent, halogen, and CFL lamps with LED lamps would save the facilities a combined 368,519 kWh per year.

Variable Frequency Drives (VFDs)

Babylon Junior-Senior High School is heated by three boilers, which circulate steam and hot water through the facility. Upon analysis, the hot water pumps, condensate pumps, and boiler burner fan motors integral to the system operate at fixed speed. Installing variable frequency drives will allow the pumps and motors to operate at a lower speed during periods of reduced demand, which will result in energy savings and increased life expectancy.

The school also has two gyms, which are served by ventilation and exhaust fans to provide outside air. The fans that serve these two areas are currently operated continuously and at full speed. By installing VFDs and controls, the fans can be controlled by timer set points, occupancy, or CO_2. Energy savings will be realized by the modulated speed of the fans and reduced operating hours. Installing VFDs on fans, pumps, and motors in the Junior-Senior High School can save 45,434 kWh annually.

Energy and demand savings estimates for energy efficiency upgrades are shown in Tables 5 and 6 below by end use and facility.

Table 5 Estimated Energy Savings by End Use and Facility

Facility	kWh Savings			
	HVAC	Lighting	VFD Retrofits	Total Annual Savings
Village Hall/Fire/EMS	13,099	57,034	-	70,133
Babylon Dept. of Public Works	-	23,121	-	23,121
American Legion Post #94	4,747	34,778	-	39,525
Babylon Junior-Senior High School	44,651	139,379	45,434	229,464
St. Joseph's School	17,179	114,209	-	131,388
Total	79,676	368,521	45,434	493,630

Table 6 shows potential demand savings by season since demand savings are not additive. HVAC savings occur during the summer months when air conditioning usage is high. Conversely, lighting usage is lower during the summer months at the schools. With adjustments, demand savings exceed 190 kW during the summer, and 150 kW during the winter. These figures are used to estimate generator size for the microgrid.

Table 6 Non-Coincident Demand Savings by End Use and Facility

Facility	kW				
	HVAC	Lighting	VFD Retrofits	Total Winter Demand Savings	Total Summer Demand Savings
Village Hall/Fire/EMS	12	21	-	20	32
Babylon Dept. of Public Works	-	7	-	7	7
American Legion Post #94	8	11	-	11	19
Babylon Junior-Senior High School	43	46	18	63	66 (includes 50% of lighting savings)
St. Joseph's School	42	51	-	51	68 (includes 50% of lighting savings)
Total				152	192

Estimated bill savings for each utility customer due to efficiency improvements are summarized in Table 7 below:

Table 7 Estimated Bill Savings by End Use and Facility

	Seasonal Average Rate ($/kWh)	% of Total Energy Usage	Seasonal Allocated Savings						Total
			HVAC Savings		Lighting Savings		VFD Savings		
			kWh	$	kWh	$	kWh	$	$
Babylon Junior-Senior High School									
June through September	$0.2121	0.30	33,488	$ 7,102	42,315	$ 8,974	-	$ -	$ 16,077
October through May	$0.1719	0.70	11,163	$ 1,919	97,064	$ 16,683	45,434	$ 7,809	$ 26,410
Village Hall									
June through September	$0.1830	0.44	9,824	$ 1,798	25,047	$ 4,584	-	$ -	$ 6,382
October through May	$0.1917	0.56	3,275	$ 628	31,987	$ 6,133	-	$ -	$ 6,761
Department of Public Works									
June through September	$0.1871	0.32	-	$ -	7,414	$ 1,387	-	$ -	$ 1,387
October through May	$0.1854	0.68	-	$ -	15,707	$ 2,912	-	$ -	$ 2,912
American Legion Post #94									
June through September	$0.2294	0.42	3,560	$ 817	14,491	$ 3,325	-	$ -	$ 4,142
October through May	$0.1836	0.58	1,187	$ 218	20,287	$ 3,725	-	$ -	$ 3,943
St. Joseph's									
June through September	$0.2499	0.29	12,884	$ 3,220	33,291	$ 8,320	-	$ -	$ 11,540
October through May	$0.1684	0.71	4,295	$ 723	80,918	$ 13,627	-	$ -	$ 14,351
TOTAL ESTIMATED ANNUAL SAVINGS									**$ 93,904**

4.5. Configuration Options Considered

Based on the locations, existing electric loads and other characteristics of the included facilities, the configuration of the proposed microgrid was narrowed from three separate options. The options are summarized in Table 8 as follows:

Table 8 Summary of Configuration Options

Option	Description
Option 1	All facilities are physically interconnected via a separate microgrid circuit. Two-natural gas fueled generators are centrally located to provide power during outages, in parallel with PV arrays. The generators are also capable of providing grid support during normal grid operations.
Option 2	All facilities are physically interconnected via a separate microgrid circuit. No central generation is provided, and partial power is provided during grid outages using emergency gas and diesel generators located at four sites (Village Hall, American Legion Hall, St. Joseph's, and Babylon Junior-Senior High School), in addition to PV arrays and battery energy storage.
Option 3	None of the facilities would be physically interconnected. Instead, local generation would be controlled centrally as a "virtual microgrid." Power would be supplied to each facility by Diesel or natural gas emergency generators located at each of the six facilities, in addition to PV arrays and battery energy storage.

Of the three options, Option 1 provides the most flexibility, and would be capable of providing uninterrupted power indefinitely to each facility, as well as grid support. Option 2 is limited by the capacity of local emergency generators, and would be capable of providing only partial electric service during outages. In addition, Option 2 would require retrofits to emergency generators to allow parallel operations when interconnected with the utility grid, or with each other during outages. It is also likely that the emergency generators would be de-rated to allow continuous operation for extended periods of time. Option 3, while relatively low in cost, requires each facility to operate independently during outages, and does not allow interconnected operation. Both Options 2 and 3 would require battery energy storage in order to provide buffer storage for the PV arrays and excitation for the PV inverters. A detailed description of Option 1 is provided in Section 5, Technical Description of the Microgrid, in more detail.

4.6. Estimated Generator Sizing

The primary generators are sized using the information developed in the preceding sections, including potential demand savings from energy efficiency measures. The highest combined peak load before energy efficiency measures are included is approximately 500 kW. Demand reductions are expected due to the implementation of energy efficiency measures, especially lighting and HVAC. Demand savings vary by season and facility, but in aggregate are between 150 kW (winter) and 190 kW (summer).

Taking these adjustments into account, peak winter load on the microgrid after efficiency upgrades is expected to be approximately 350 kW. Peak summer loads are expected to approximately 310 kW. Generators are typically sized with a margin of 25% to 40% to allow for motor startup and other sudden changes in loads. The additional margin on the highest expected peak load of 350 kW increases the required generator size to approximately 440 kW to 490 kW. On this basis, a single 500 kW generator is sufficient to support all of the loads at the combined facilities with adequate margin.

Due to the critical loads served, two primary generators rated at 500 kW each are selected for sizing and redundancy purposes in this analysis.

5. Technical Description of the Microgrid

5.1. Overview

The proposed microgrid design includes two primary, natural gas-fueled engine generators to provide continuous power to all of the interconnected facilities during emergency operations. The facilities will be interconnected through a separate 13.2 kV microgrid distribution system that will be electrically separated from the existing PSEG-LI distribution system.

The facilities considered in the microgrid are located in the central section of the Village away from the worst flood zones. This positioning prevents damage to the buildings and equipment so they can remain functional during natural disasters. This provides resiliency during heavy flood events.

During periods of physical isolation due to flooding, the microgrid will be capable of operating since the natural gas-fueled generators are connected to the gas distribution system, and will be supplemented by photovoltaic generation.

5.2. Generating Sources and Interconnection

Figure 8 provides a simplified, single line drawing for the proposed microgrid based on Option 1. A separate 13.2 kV microgrid interconnection would connect all facilities during emergency operations via ground-mounted Automatic Throw-Over (ATO) switches. Power would be supplied to the microgrid by central generating units, and by local grid interactive PV arrays. The central generating units can also provide peak shaving or other grid support functions during normal operations.

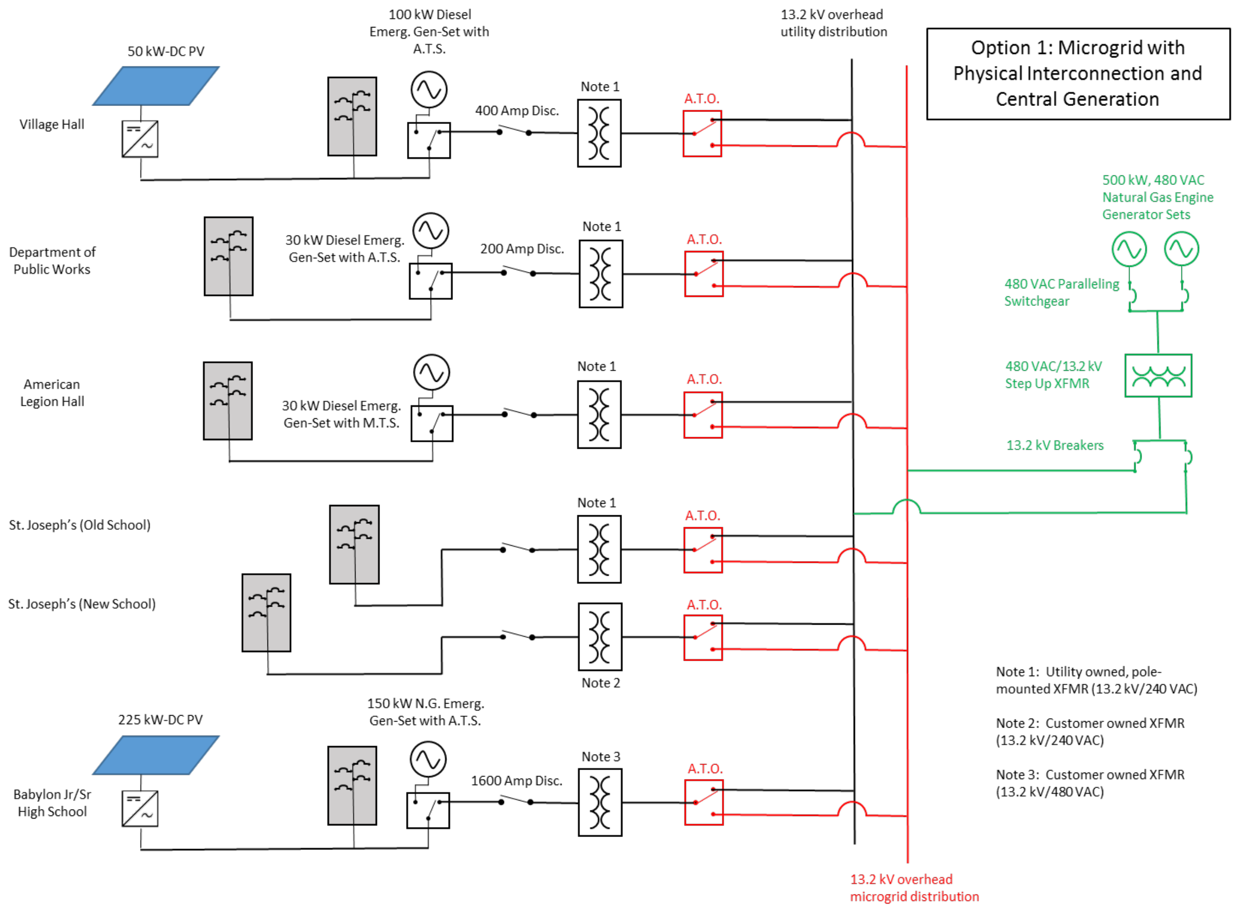


Figure 8 Simplified One Line Diagram

Primary microgrid generating units will be natural gas fueled, 500 kW reciprocating engine-generators. A final location has not yet been selected for these units. The primary generators will be natural gas fueled, and are connected to the gas line operated by National Grid. The gas line is expected to provide an uninterruptible fuel supply. Generators and controls will be capable of black-start operations, and will be equipped with stand-alone battery back-up systems for starting purposes. This will allow the units to start and synchronize without utility power, along with operation of switches and other controls necessary for microgrid operation during a utility outage.

In addition, at the Village Hall/Fire/EMS and Department of Public Works location, it is proposed to install 50 kW of solar photovoltaics. Two emergency generators will be separately installed by the Village. Although final specifications have not been determined, the unit located at the Village Hall is expected to be approximately 100 kW, and the unit at the DPW is expected be approximately 30 kW. At the Babylon Junior-Senior High School, a 225 kW photovoltaic array is proposed. The school is also planning to install a separate 150 kW natural gas fired standby generator.

Planned standby generating units at the Village Hall, DPW, American Legion Hall, and Babylon Junior-Senior High School would function as generators of "last resort" and would be isolated from the microgrid interconnection by automatic or manual transfer switches. Standby generators located at these facilities would not be required to function in parallel with the utility grid, and therefore would not require paralleling switchgear. St. Joseph's and the American Legion Hall would be interconnected only as loads on the microgrid. No generation would be installed at these facilities.

The microgrid's PV arrays, a total of 275 kW, represent a significant renewable resource. Assuming standard weather conditions for the Village of Babylon, the solar arrays will produce over 350,000 kWh per year, or about 27% of the total combined annual electricity usage of the Village Hall, Department of Public Works, and Junior-Senior High School. At maximum generating capacity, the photovoltaic arrays could provide more than half of the estimated coincident peak load of the facilities, as well as reduce fuel consumption by the primary generating units during a prolonged utility outage.

A summary of all generating units and PV arrays is provided in Table 9 below.

Table 9 Summary of Generating Equipment by Facility

Location	Type	Rating	Fuel	Purpose
Central Generators	Continuous-Duty Reciprocating Engine-Generator	2 @ 500 kW each	Natural Gas	Grid support and primary microgrid generation during emergency operations. Capable of parallel operation
Village Hall & DPW	Standby Reciprocating Engine-Generator	150 kW	Diesel	Standby duty only. Not capable of parallel operation.
Village Hall & DPW	Photovoltaic	50 kW	Renewable/ Solar	Capable of grid interactive operation for energy and demand savings. Also capable of parallel operation with primary generators during emergency operations.
Jr.-Sr. High School	Standby Reciprocating Engine-Generator	150 kW	Natural Gas	Standby duty only. Not capable of parallel operation.
Jr.-Sr. High School	Photovoltaic	225 kW	Renewable/ Solar	Capable of grid interactive operation for energy and demand savings. Also capable of parallel operation with primary generators during emergency operations.

5.3. Preliminary Equipment and Infrastructure Locations

Follow a walk-down of the local distribution system infrastructure, and a review with PSEG-LI, a preliminary map of microgrid equipment and interconnection equipment was developed. The locations of existing PSEG-LI facilities are shown in Figure 9, provided by PSEG-LI. Tentative facility locations and preliminary routing of the microgrid interconnection are provided in Figure 10, and largely follow existing distribution system rights-of-way.

In all cases, locations are tentative, pending further discussions with the Village, PSEG-LI, and final equipment sizing. In particular, the installation of the 13.2 kV microgrid interconnection lines and ATO switches will be subject to negotiating an acceptable agreement with PSEG-LI for co-locating facilities within its right-of-way.

Resiliency of the proposed microgrid is extremely important, and is strongly related to the siting of proposed facilities. The generating units and microgrid interconnection lines within the selected area are protected from storm events for two reasons. First, the areas are resistant to flooding due to their elevations. Throughout Superstorm Sandy, all of the proposed facilities were above the flooded areas. Second, the distribution rights-of-way in the area are largely free of trees which caused much of the damage to other parts of the local distribution systems. Natural gas service was interrupted during Superstorm Sandy because much of the gas distribution system operated at low pressure, and low pressure systems are prone to water infiltration. However, following Sandy, the gas distribution system in the Village was converted to high pressure distribution, which will prevent water infiltration. For these reasons, we believe that the proposed microgrid will be resistant to problems during major storm events. Preliminary discussions with PSEG-LI indicated that they are willing to explore co-location of the microgrid interconnection with existing PSEG-LI distribution lines. Since resiliency is a major factor, all of these issues will be reviewed and changes will be made during the Stage 2 design process.

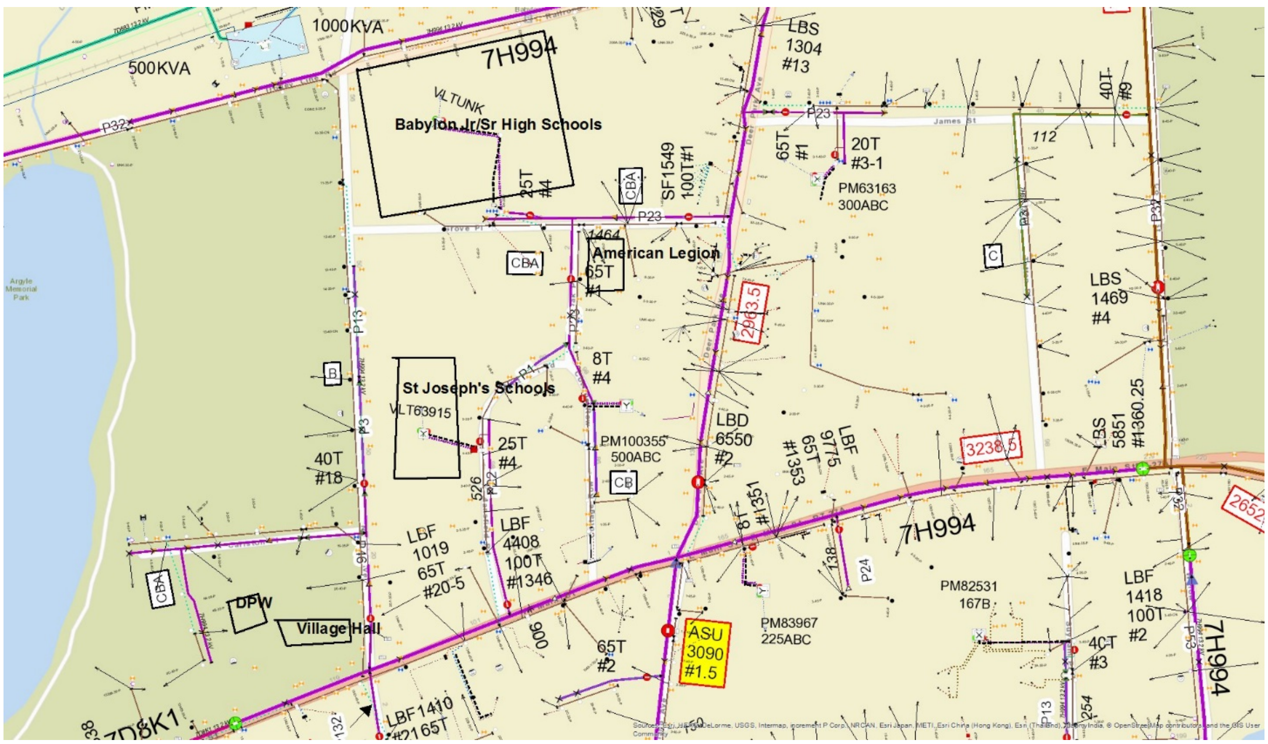


Figure 9 Locations of PSEG-LI Distribution Infrastructure in the Village of Babylon

Figure 10 Preliminary Locations of Generating Equipment and Microgrid Interconnection

5.4. Microgrid Operating Sequence and Controls

During normal grid operations, all of the facilities would be connected to the utility distribution system through their ATO switches. The PV arrays will normally operate in the grid-interactive mode, and will displace a portion of the grid supplied electricity at the Village Hall and the Babylon Junior-Senior High School. Depending on regulations and existing markets, the generators would be able to supply PSEG-LI and NYISO with frequency regulation and/or demand reduction within the Village of Babylon through the 13.2 kV grid interconnection circuit breaker. The advanced microgrid control system also provides a platform for targeted load monitoring and potential demand response at the connected facilities.

During a utility outage, an automated control sequence would initiate the following steps:

1. The outage condition would be automatically verified by the microgrid controller, specifically:
    a. Both 13.2 kV circuit breakers at the microgrid generator site are open
    b. All ATO switches are in the "utility" position
    c. All emergency generators and PV arrays are isolated from the grid and are off (not back feeding).
2. One of the 500 kW generators will be started, and its associated 480 V circuit breaker will be closed.
3. The second generator will start and its associated 480 V breaker will close, paralleling the two generators
4. The 13.2 kV microgrid interconnection circuit breaker will close and energize the microgrid interconnection.
5. Loads will be added to the 13.2 kV interconnection by transferring ATO switches to the "microgrid" position in the following preliminary sequence (subject to detailed design considerations):
    a. Village Hall
    b. DPW
    c. Junior/Senior High School
    d. American Legion Hall
    e. St. Joseph's New School
    f. St. Joseph's Old School
6. Once all facilities have been connected to the energized 13.2 kV microgrid interconnection, PV arrays will be allowed to parallel with the microgrid.
7. During parallel operation, at least one of the generators will be used to follow load changes. Depending on total load and available PV generation, one of the generators could be shut down.

Upon restoration of utility service, ATO switches will be transferred to the "utility" position in the opposite sequence. Once all facilities have been reconnected with the utility, the 13.2 kV microgrid interconnection breaker will open, followed by the 480 V generator breakers. Generators will then follow the engine manufacturer's cooling and shut down sequence.

5.5. Microgrid Control and Communications System Description

The microgrid control system (MCS) is a critical aspect of the proposed Village of Babylon microgrid architecture. The MCS holds the responsibilities of coordinating the islanding process described above to allow the buildings within the village to operate independently during Loss of Utility (LOU). When in islanded mode, the MCS is also responsible for monitoring and control of the distributed energy resources within the microgrid to be able to serve the islanded loads. Finally, during normal utility operation, the MCS can be designed to aggregate and dispatch the distributed resources for provision of capacity or ancillary services to PSEG/NYISO or for demand and energy management for the facilities within the microgrid.

At the heart of the MCS is the CPU which will receive inputs and telemetry from the resources and control points within the microgrid, perform any necessary high speed logic calculations, and provide control signals to the generators and storage assets. As shown in the below schematic, a feeder controller would receive a trip signal from the utility connection and subsequently send command signals to the generation and storage resources to match the load requirements. While the village is islanded, loads would continually be monitored and status and power commands would continue to be sent to the generation assets to continue operation. The CPU will also feed information to the Human Machine Interface (HMI) to allow Village personnel to monitor and control the status of the microgrid.

The proposed MCS architecture, which is represented in Figure 11, will coordinate the generation assets to provide the following services to the Village:

- Automatically island the selected loads during loss of utility, and re-connect when it is safe to do so
- In Grid-Tied mode, the MCS will the MCS receives scheduled PQ set points for the grid tie point from the Microgrid Operator. The MCS determines the generation and load shed components (depending on the load control mode) of the scheduled set point value. The MCS U90plus determines the optimal dispatch between the various power generation sources and the grid to meet the generation set point.
- When in islanded mode, it is expected that the generation assets will provide the grid forming signal needed to set frequency and voltage within the microgrid. During grid-tied mode, the MCS can be configured to monitor frequency and voltage if desired.
- During grid-tied mode, the MCS can be configured to coordinate generation resources to provide energy management services to the Village, and/or capacity or ancillary services to PSEG and/or NYISO.
- The MCS will include an HMI/SCADA to display system status and alarms, provide the operator to control the power system and to collect power system data to allow for analysis of power and energy use.
- Detailed design of the MCS would be necessary at a later stage to determine exact locations of the controls, relays, and electrical and communications feeds necessary. This design would ensure the MCS is implemented in such a way where the system will not be impacted by severe weather conditions and will continue to operate to ensure resiliency for the Village.

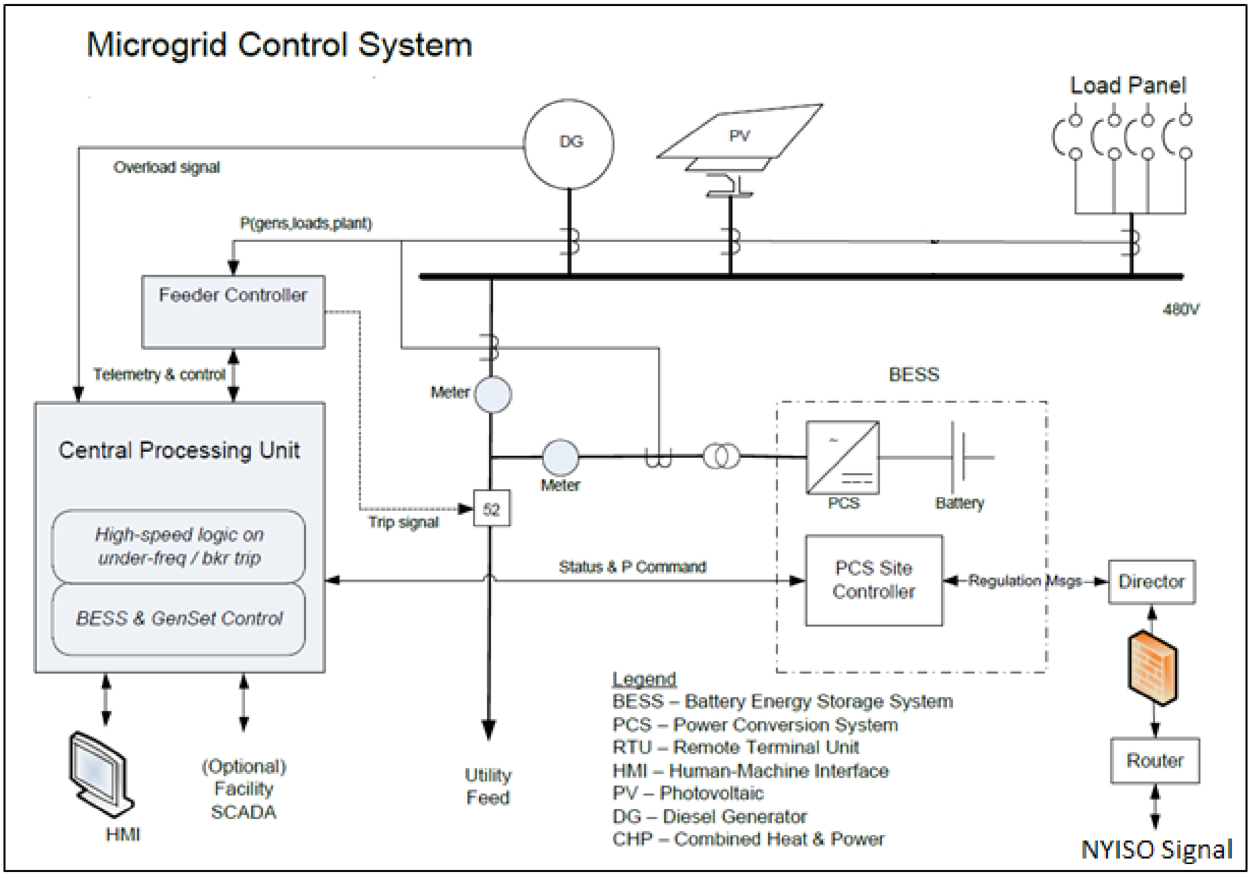


Figure 11 Microgrid Control System

As shown in Figure 11, communications are critical for optimal operation of the MCS. The likely communication method would be to install 100 Mbps Ethernet communications feeds and switches throughout the microgrid to integrate metering and control points. More sophisticated communications options could be considered, such as DNP 3.0, Modbus TPC/IP, or fiber optic communication, depending on the degree of seamless transition and performance requirements of the Village.

The communications architecture is self-contained within the MCS, allowing for operation when there is Loss of Utility (LOU). This self-sufficiency allows for the MCS communications to maintain resiliency to utility outages to provide the Village with the electrical resiliency and security it desires.

Besides communications, the MCS will contain the computing hardware, software and monitoring equipment required for logic calculations and the HMI. It would also include the GPS based synchronization clock need to synchronize control throughout the system during loss of connection to the utility. All of these features allow for independent operation of the microgrid during loss of utility.

5.6. Preliminary Capital Cost Estimate

A preliminary capital cost estimate was developed based on the configuration described in the preceding sections. The following tables provide supporting information. Table 10 provides a summary of all costs, including estimated contingency and engineering at the project level. Tables 11 through 14 provide more detailed supporting information for each major component.

Table 10 Preliminary Cost Summary

Cost Summary	Estimated Cost
Subtotal - Generating Plant and Switchgear	$ 1,943,100
Subtotal - Microgrid Distribution	$ 264,500
Subtotal - Renewables and Controls	$ 915,000
Subtotal - All Energy Efficiency Measures	$ 585,749
Subtotal	$ 3,708,349
Contingency (15%)	$ 556,252
Engineering (10%)	$ 370,835
Total Project Cost	**$ 4,635,436**

Table 11 Preliminary Costs – Microgrid Generators and Switchgear

Generating Plant and Switchgear	Cost Reference	Cost Basis	Estimated Cost
2 x 500 kW natural gas engine generators (480 VAC)	EPA Catalog of CHP Technologies, March 2015, Table 2.4	$400/kW	$ 400,000
Exhaust gas treatment	EPA Catalog of CHP Technologies, March 2015, Table 2.4	$500/kW	$ 500,000
480 VAC paralleling switchgear and controls	Massachusetts DOER Community Clean Energy Resiliency Initiative Microgrid Interconnection Cost Analysis, Cadmus Group	$400/kW	$ 400,000
1,500 kVA, 480/13.7kV, dry type metal enclosed step-up transformer	R.S. Means 2015 Electrical Cost Data (Section 33 73 23.20)	$29,400/MVA	$ 44,100
2 x 13.2 kV air circuit breakers	R.S. Means 2015 Electrical Cost Data (Section 33 75 13.13)	$74,500 per unit	$ 149,000
Generating plant and switchgear foundations, underground conduit, ground mat, grounding, other mechanical and electrical installation	EPA Catalog of CHP Technologies, March 2015, Table 2.4	$450/kW	$ 450,000
Subtotal - Generating Plant and Switchgear			**$ 1,943,100**

Table 12 Preliminary Costs – Microgrid Distribution Interconnection

Microgrid Distribution System	Cost Reference	Cost Basis	Estimated Cost
2,500 feet, 3 conductor, 15 kV, 1/0 aluminum XLP on existing poles	R.S. Means 2015 Electrical Cost Data (Section 26 05 13.16)	$580/hundred feet	$ 43,500
Option 1 (6 x 13.2 kV auto throw over switches installed)	Based on R.S. Means 2015 Electrical Cost Data (Section 33 71 39.13 2300) for 69 kV sectionalizing switches	$28,500 each	$ 171,000
Terminations and other distribution system installation			$ 50,000
Subtotal - Microgrid Distribution			**$ 264,500**

Table 13 Preliminary Costs – PV Arrays

Village Hall PV Array and Controls	Cost Reference	Cost Basis	Estimated Cost
Solar PV	Internal	50 kW-DC	$ 165,000
Microgrid Controls	Internal		$ 120,000
Subtotal - Village Hall			**$ 285,000**
Babylon Junior/Senior High School PV Array			
Solar PV	Internal	225 kW-DC	$ 630,000
Subtotal - Babylon Junior/Senior High School			**$ 630,000**
Subtotal - Renewables and Controls			**$ 915,000**

Table 14 Preliminary Costs – Energy Efficiency Retrofits

Village Hall	Cost Reference	Cost Basis	Estimated Cost
Lighting Retrofit	Internal	Site assessment	$ 15,401
HVAC Retrofit	RS Means 2015 (Mechanical)	Site assessment	$ 40,500
Subtotal - Village Hall			**$ 55,901**
Dept. of Public Works			
Lighting Retrofit	Internal	Site assessment	$ 9,259
Subtotal - Village Hall			**$ 9,259**
Babylon Junior/Senior High School			
Lighting Retrofit	Internal	Site assessment	$ 268,060
HVAC Retrofit	RS Means 2015 (Mechanical)	Site assessment	$ 59,020
VFD-Motor Retrofit	Based on recent quote	Site assessment	$ 45,250
Subtotal - Babylon Junior/Senior High School			**$ 372,330**
St. Joseph's			
Lighting Retrofit	Internal	Site assessment	$ 77,151
HVAC Retrofit	RS Means 2015 (Mechanical)	Site assessment	$ 40,350
Subtotal - St. Joseph's			**$ 117,501**
American Legion			
Lighting Retrofit	Internal	Site assessment	$ 10,158
HVAC Retrofit	RS Means 2015 (Mechanical)	Site assessment	$ 20,600
Subtotal - American Legion			**$ 30,758**
Subtotal - All Energy Efficiency Measures			**$ 585,749**

5.7. Maintenance and Operations

Maintenance will follow the manufacturer's scheduled requirements for the engine generators and PV system components. For the generators, these normally include annual preventive maintenance, cleaning, oil and filter changes, and other required maintenance. In addition, it is expected that the engine-generators will be required to operate at least monthly to verify readiness for outages and grid support. PV maintenance is generally minimal, but may include annual inspections of PV modules and other electrical components.

Responsibility for maintenance and operations will depend largely on the final determination of the business model in Stage 2. A more detailed description of the anticipated business model is provided in Section 6, Assessment of Microgrid's Commercial and Financial Feasibility.

6. Assessment of Microgrid's Commercial and Financial Feasibility

6.1. Summary of Benefit-Cost Analysis and Value Proposition

The commercial and financial feasibility of the proposed microgrid project is tied directly to the anticipated costs and benefits. Industrial Economics Incorporated (IEc) furnished benefit-cost analyses to support this study using inputs provided by the project team. IEc's written report is attached in Appendix A based on information provided in separate questionnaires.

Two benefit-cost analysis scenarios were provided:

- Scenario 1: Microgrid without major power outages
- Scenario 2: Microgrid with major power outages

Scenario 2 was developed from Scenario 1, and was intended to determine the value of Major Power Outage Benefits needed to achieve a benefit-cost ratio of 1.0. It is not intended to represent the actual occurrence and value (costs) of outages in the Village of Babylon.

Both scenarios were compared against a baseline in which no microgrid was available, i.e., benefits and costs were incremental to the baseline. A 7% discount rate was used in both scenarios.

It is important to note that IEc's analysis does not propose or evaluate an ownership model, nor does it distribute the benefits to the potential participants. In some cases, such as the value of Major Power Outages, and Avoided Emission Damages, the benefits are societal and cannot be allocated to a particular participant. The results of the two scenarios are presented in Table 15 below.

The proposed project offers important benefits as part of its value proposition including:

- The microgrid provides resiliency in an area that has significant exposure to hurricane and flood-related prolonged utility outages. Approximately half of the Village of Babylon is within the 100-year flood zone, although the proposed facilities are outside of this zone.
- This resiliency guarantees continuity of important public services including police, fire, emergency medical, and sanitation services during emergencies. It also provides power to important shelter facilities, and helps to minimize the impacts of evacuations from affected areas.
- During non-emergencies, the microgrid is capable of providing significant grid support and ancillary services to PSEG-LI, including peak shaving and local distribution system support.
- The microgrid includes two PV arrays that will displace conventional fossil-fueled power generation, reducing emissions, and transmission and distribution line losses.

Table 15 IEc Benefit-Cost Analysis Summary

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	
	Scenario 1 (No Major Power Outages)	Scenario 2 (Major Power Outages Averaging 3 Days Per Year)
Costs		
Initial Design and Planning	$312,000	$312,000
Capital Investments	$3,590,000	$3,590,000
Fixed O&M	$302,000	$302,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$0	$0
Total Costs	**$4,210,000**	**$4,210,000**
Benefits		
Reduction in Generating Costs	$276,000	$276,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$1,170,000	$1,170,000
Distribution Capacity Cost Savings	$414,000	$414,000
Reliability Improvements	$118,000	$118,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$127	$127
Avoided Emissions Damages	$189,000	$189,000
Major Power Outage Benefits	$0	$2,050,000
Total Benefits	**$2,170,000**	**$4,220,000**
Net Benefits	**-$2,040,000**	**$15,200**
Benefit/Cost Ratio	**0.5**	**1.0**
Internal Rate of Return	**-1.6%**	**6.9%**

6.2. Ownership Model and Customers

In order to assess financial and commercial viability, it is necessary to propose an ownership model, assign benefits and costs to participants, and estimate potential project revenue from the available benefits to repay the owner.

Table 16 shows cost and benefit distribution to each of the participants, as well as potential revenue. Table 16 is intended to be indicative of overall costs and benefits, but is not intended to be a pro-forma financial analysis.

In this case, it is assumed that the microgrid's assets will be owned and operated by a private entity in order to take advantage of tax credits and other tax benefits. In addition to the costs and benefits analyzed by IEc, the costs and benefits of potential energy efficiency improvements and tax credits were also included. Major power outage benefits were pro-rated using SAIFI criteria to determine a more realistic value for the Village of Babylon.

Table 16 Benefit-Cost Allocations

Asset	NPV Capital Cost	NPV Operating Cost	Benefit	NPV Benefits	Benefit Allocation	NPV Microgrid Revenue	Notes
Generators and Microgrid Interconnection	$ 2,760,000	$ 302,000	Emissions	$ 189,000	Societal	Not monetized	From IEC Benefit-Cost Analysis
			Major Power Outage Benefits	$ 492,000	Societal	Not monetized	Pro-rated using SAIFI events per year (0.71)
			Reliability Improvements	$ 118,000	Societal	Not monetized	From IEC Benefit-Cost Analysis
			Distribution Capacity Savings	$ 414,000	PSEG-LI	$ 414,000	
			Generation Capacity Savings	$ 1,170,000	PSEG-LI	$ 1,170,000	
			Tax Benefits	$ 200,000	Microgrid Owner/Operator	$ 200,000	Estimate
PV Arrays	$ 1,144,000		Reduction in Generating Costs	$ 276,000	PSEG-LI	$ 276,000	From IEC Benefit-Cost Analysis
			Tax Benefits	$ 90,000	Microgrid Owner/Operator	$ 90,000	Estimate
Energy Efficiency Improvements	$ 81,400		Bill Savings	$ 257,100	Village of Babylon	$ 128,550	Internal estimate of costs. Benefits estimated from customer avaerage winter/summer rates using IEC energy cost escalation and 7% discount rate
	$ 465,500			$ 626,200	Babylon Union School District	$ 313,100	
	$ 38,400			$ 119,100	American Legion Post #94	$ 59,550	
	$ 146,900			$ 381,600	St. Joseph's Parish	$ 190,800	
TOTAL	**$ 4,636,200**	**$ 302,000**		**$ 4,333,000**		**$ 2,842,000**	
					NPV NET BENEFIT SHORTFALL	**$ (2,096,200)**	

With a private ownership model, it is assumed that investment capital will be supplied through external sources, including commercial lenders, or through resources available from the owner.

The key finding from the benefit-cost analysis and Table 16 above is that the net present value of benefits is approximately 68% of the project's capital and operating costs. This indicates that a subsidy will be required, and/or societal benefits will have to be monetized. The value of the subsidy necessary to support the investment in this case has a net present value of approximately $2,100,000.

Figure 12 provides a graphic representation of how the owner and participants are related.

- The Microgrid Asset Owner would be responsible for financing, installing, operating and maintaining the generation equipment and PV arrays
- Ancillary benefits would be sold to PSEG-LI from the installed equipment through an Ancillary Services Contract. The value of the services is assumed to be equal to the avoided generation and distribution capacity, and the avoided energy costs (reduction in generating costs).
- A separate agreement would be necessary to co-locate the microgrid interconnection equipment on PSEG-LI poles and rights-of-way
- Separate contracts would be executed with individual customers. The contracts would stipulate participation in emergency recovery operations as part of the microgrid in return for energy efficiency investments in their facilities. Efficiency investments would be at no cost to the participants, but

approximately 50% of the energy bill savings would be returned to the microgrid owner. For the Babylon Union School District this agreement would also include terms for installation of the PV array. For the Village of Babylon, terms would include the PV array as well as the use of any Village-owned property for the installation of the primary generating units and switchgear.

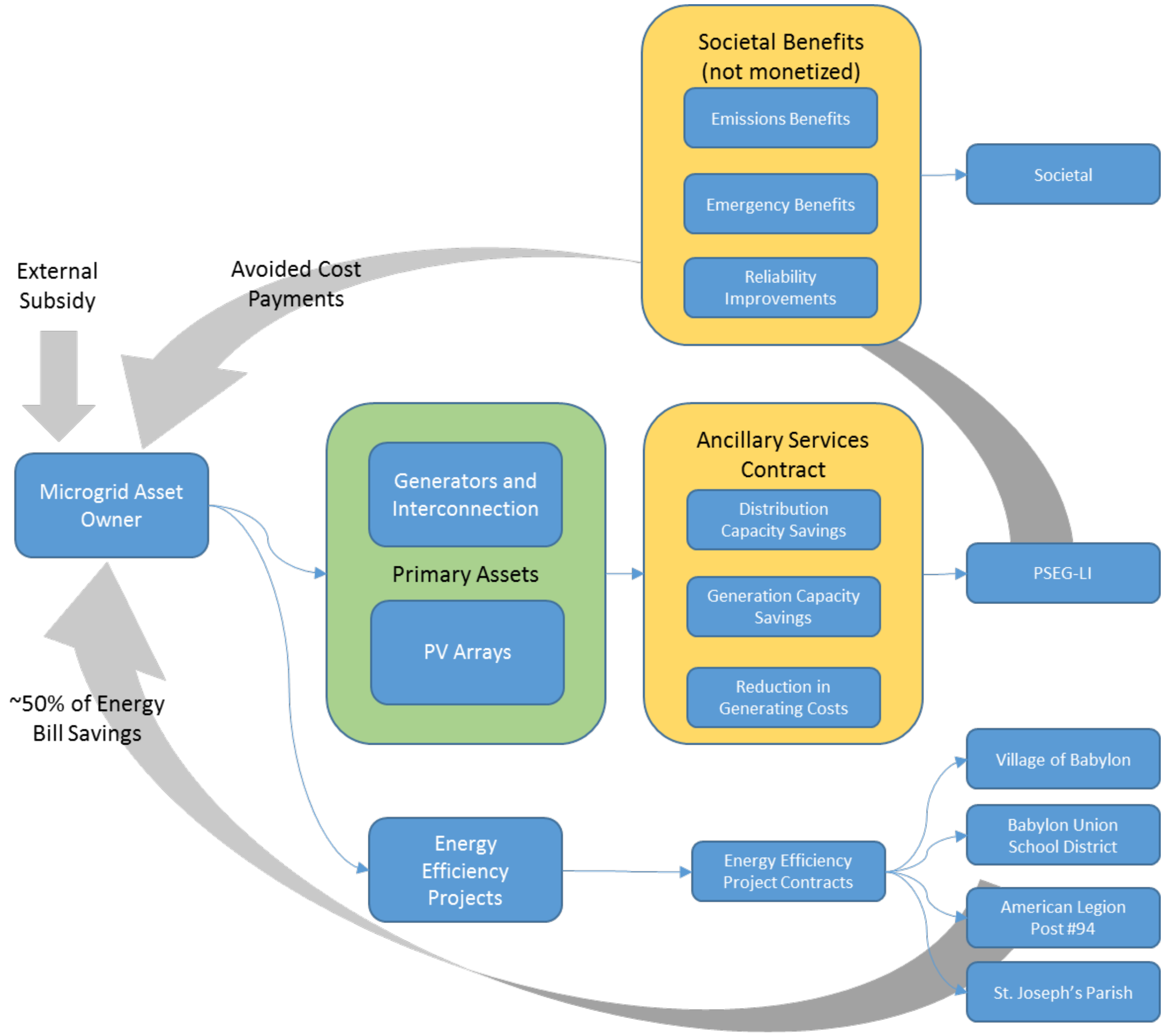


Figure 12 Proposed Relationships Between Participants

6.3. Project Team and Financial Strength

A project team has not been formed at this stage. However, it is anticipated that Ameresco or an operating unit of Ameresco would form the team and become the project owner/operator. Contract structures have not been developed, and there have been no contract discussions with PSEG-LI or the other participants. Potential designers, suppliers, and installation sub-contractors will be identified in Stage 2.

Ameresco is the largest independent energy services organization in the United States, and has provided financing for numerous performance contracts, PV and generator installations since 2001. Ameresco is capable of financing this project through its third-party lending sources as long as a credit-worthy counterparty and/or credit guarantees are available. These requirements are expected to be defined in Stage 2 as part of a detailed business plan. The availability of external subsidies and credit guarantees are expected to be very important is the financial viability of the project.

Ameresco retains all of the necessary legal, contracting and procurement, and project management resources needed to execute this project.

6.4. Overall Financial and Commercial Viability

The overall viability of the proposed microgrid is based on four factors:

- Technical viability
- Commercial approach
- Financing
- Legal and regulatory factors

Each of these is discussed below based on the preceding sections.

Technical viability is very strong, and technical risk is low. The technologies that will be employed have very long, reliable track records. These include natural gas engine-generators, PV arrays and equipment, and utility distribution equipment. No new or untried technologies will be utilized.

The commercial approach is also strong. The proposed ownership model is one that Ameresco has executed successfully for many generation projects, and for energy savings performance contracts, but there are several risks that must be addressed:

- The largest external risk is uncertainty about project ownership and access to potential subsidies. At this time, it is unknown if HUD funding will be allowed under the private ownership business model.
- The largest effort and the highest internal project risk is expected to be in negotiating contracts with PSEG-LI for purchasing ancillary services, and co-location of facilities. The commercial and financial viability depend heavily on securing reasonable value for the services provided by the microgrid assets.
- Some risk is expected in securing the individual participants. An important factor is that all of the participants have recent experience with storm-related outages, particularly Superstorm Sandy. The approach is to incentivize them with energy efficiency improvements that enhance their facilities and yield significant savings. However, energy efficiency improvements do not affect the financial performance of the project.

Financing is viable, but is highly dependent on two items:

- The availability of a subsidy to offset the capital and operating expenses or monetize the value of major power outage benefits.

- Access to a credit-worthy counterparty and/or credit guarantees.

Legal and regulatory issues related to microgrids are expected to arise. Although some of these may be addressed as part of New York REV, it is worth summarizing them:

- Microgrids that serve campus-type facilities under common ownership do not conflict with historical utility franchise areas. However, the proposed microgrid configuration for the Village of Babylon includes generation and distribution systems that is capable of serving multiple facilities operated by different owners. This is expected to bring up issues related to the definition of a utility franchise.
- A related issue is how microgrid interconnections are treated when co-location of lines and equipment is necessary. PSEG-LI and other utilities routinely co-locate lines and other equipment with telephone and cable TV utilities. However, co-location of power infrastructure is not common practice.
- Valuation of major power outage benefits is difficult, but is critical to understanding the economics of microgrids intended to support emergency operations. IEc's analysis helped to define these benefits, but additional work is required to determine how they can be monetized. Without these benefits, the economic justification for microgrids without CHP hosts is difficult.

7. Conclusions

The study team has concluded that the proposed microgrid is technically and commercially feasible, and would provide significant benefits to the Village of Babylon and the surrounding communities during emergencies similar to Superstorm Sandy. Based on this study, Stage 2 would include the development of detailed engineering designs and specifications, as well as finalization of the business model, and formation of the project team. From both technical and commercial perspectives, the project represents relatively low risk as it depends on established technologies, commercial practices and contracting.

The highest uncertainty facing the project is its financial viability. It is important to recognize that the financial viability of the proposed project depends on access to external funding or additional revenue streams to offset approximately half of the expected investment costs. The valuation and monetization of major power outage benefits potentially play key roles in achieving financial viability, and providing a model for future microgrid investments.

The most significant issue facing microgrid development in New York and elsewhere is the lack of a consistent legal and regulatory framework. This must be addressed for the emergence of a stable microgrid business environment. For specific projects, including the Village of Babylon, these issues can be addressed on a case-by-case basis, and help develop policy models and experience for more systematic implementation of future projects. However, a case-by-case approach will limit the growth of microgrids. Although microgrids are inherently "local," there are common issues that require legal and regulatory solutions for the development of a consistent framework:

- **Definition of microgrid and utility franchise**: The NY PRIZE Stage 1 awards used a definition of a microgrid that would violate utility franchises is put into general practice. Except for campus facilities, the traditional definition of utility franchise areas would prevent the development of non-utility owned microgrids serving multiple utility customers. Re-definition of a utility franchise will be needed at the state level. In particular, it should not be a violation of the utility franchise when a non-utility microgrid is installed, subject to reasonable limitations. Limitations might be based on geography, purpose, number and/or types of customers, and other factors.
- **Cost recovery**: This is also related to the ownership of the microgrid infrastructure. Utilities may be able to recover microgrid costs under conventional rate-based regulation. Non-utility microgrid owners may will require standard tariffs and/or other types of contracts with utilities to insure reasonable cost recovery and recognition of benefits, such as capacity, energy, and renewable energy benefits.
- **Infrastructure and interconnection**: Technical issues are likely to arise related to the interconnection of multiple microgrid systems within a utility-owned distribution system. The means to quickly identify and analyze potential problems and opportunities will help to greatly accelerate siting.
- **Value of reliability**: A key benefit of microgrids is increased system resiliency, however, the value resiliency is not universally defined or quantified. A consistent approach to defining and valuing resilience is going to be very important to the economics of many microgrid projects.

Appendix A: IEc Benefit-Cost Summary Report

Benefit-Cost Analysis Summary Report

Site 1 – Village of Babylon

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Village of Babylon has proposed development of a microgrid that would serve the following five facilities:

- Babylon Village Hall, including offices that support the operations of the community's fire, emergency medical, and police services;
- St. Joseph nursery school;
- American Legion Post #94;
- The Babylon Department of Public Works; and
- Babylon Union Free Junior/Senior High School.

The microgrid would be powered by two solar photovoltaic (PV) installations with a combined capacity of 0.275 MW. The microgrid would also incorporate two backup generators, both powered by natural gas. These generators have a combined capacity of 1.0 MW and would operate only during major power outages.[3] During an outage, the project's consultants indicate that the system would fully meet the energy needs of the facilities the microgrid would serve.

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

METHODOLOGY AND ASSUMPTIONS

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

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

[3] The project team notes that the Village Hall and the Junior/Senior High School may also be equipped with backup generators. The analysis does not consider these generators as microgrid components as they would only be relied on should the microgrid fail.

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

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.[4] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[5]

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-

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

[5] 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.

year period analyzed (Scenario 1) the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 3.0 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: 3.0 DAYS/YEAR
Net Benefits - Present Value	-$2,040,000	$15,200
Benefit-Cost Ratio	0.5	1.0
Internal Rate of Return	-1.6%	6.9%

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)

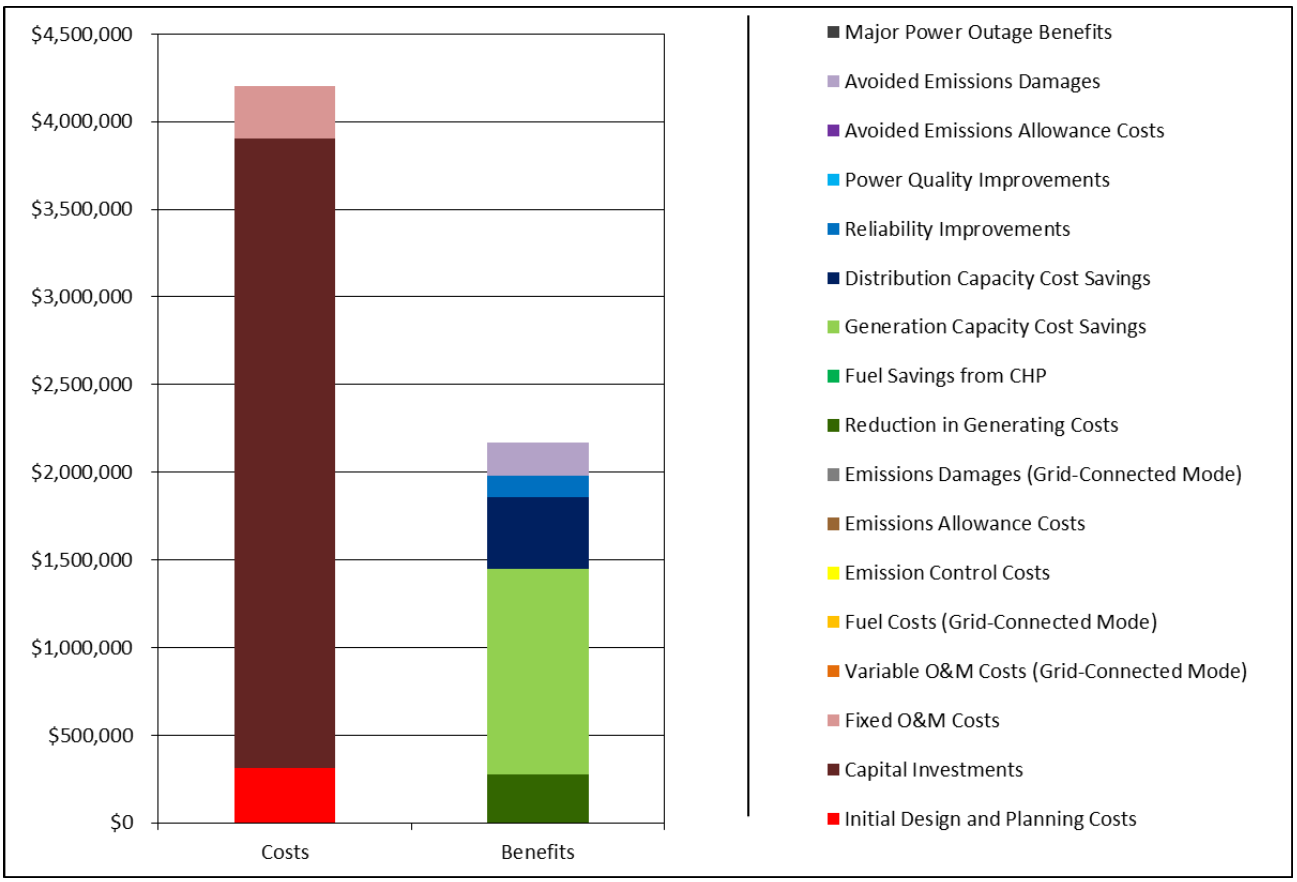


Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$312,000	$27,500
Capital Investments	$3,590,000	$317,000
Fixed O&M	$302,000	$26,700
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$0	$0
Total Costs	**$4,210,000**	
Benefits		
Reduction in Generating Costs	$276,000	$24,400
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$1,170,000	$103,000
Distribution Capacity Cost Savings	$414,000	$36,500
Reliability Improvements	$118,000	$10,400
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$127	$11
Avoided Emissions Damages	$189,000	$12,400
Major Power Outage Benefits	$0	$0
Total Benefits	$2,170,000	
Net Benefits	-$2,040,000	
Benefit/Cost Ratio	**0.5**	
Internal Rate of Return	**-1.6%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $312,000. The present value of the project's capital costs is estimated at approximately $3.6 million, including costs for solar PV, backup generators, transfer switchgear, microgrid control hardware, energy storage, and electric interconnection. The present value of the microgrid' s fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at $302,000, based on an annual cost of $23,000.

Variable Costs

During normal operating conditions, the project would rely solely on renewable energy sources, and would not incur fuel costs. Operation of the solar PV would generate no air pollutants; thus, the emissions damages attributable to the project would be zero.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $276,000. This estimate is based on the assumption that the microgrid's distributed energy resources would generate power during periods representing the peak 65 percent of system-wide demand. The reduction in demand for electricity from bulk energy suppliers would also reduce the emissions of air pollutants from such facilities, yielding emissions allowance cost savings with a present value of approximately $100 and avoided emissions damages with a present value of approximately $189,000.

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.[6] Based primarily upon the potential participation of 1.0 MW of capacity in a demand response program, the analysis estimates the present value of the project's generating capacity benefits to be approximately $1.2 million. Similarly, the project team estimates that the development of the microgrid will reduce the need for local distribution capacity by approximately 1.0 MW. Over a 20-year period, the present value of this benefit is estimated to be approximately $414,000.

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce facilities' 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 $10,000 per year, with a present value of $118,000 over a 20-year operating period. This estimate was developed using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[7]

- System Average Interruption Frequency Index (SAIFI) – 0.72 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 81.6 minutes.[8]

The estimate takes into account the number of residential and small or large commercial or industrial customers the project would serve; the distribution of commercial or industrial customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among 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.[9] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

[7] www.icecalculator.com.

[8] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for PSEG Long Island.

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

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 0.5; i.e., the estimate of project benefits is approximately 50 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 – 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.[10,11]

The Village of Babylon's proposed microgrid project would serve five facilities during an extended outage. The project's consultants indicate that the junior/senior high school is currently served by a backup generator. However, this generator would be insufficient to maintain operation of the school during major outages. Instead, the school, the village hall, the Department of Public Works, the nursery school, and the American Legion post would be served by rental or portable generators. Table 3 summarizes the daily cost of operating the generators at each facility, as estimated by the project team. Table 3 also indicates the loss in service capabilities that would occur while relying on these units, as well as the loss in service capabilities that would occur should these generators fail.

[10] 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.

[11] 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.

Table 3. Costs and Level of Service Maintained by Rental Backup Generators, Scenario 2

FACILITY	OPERATING COSTS ($/DAY)	PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE	
		WITH BACKUP GENERATOR	WITHOUT BACKUP GENERATOR
Babylon Union Free Junior/Senior High School	$3,060	0%	100%
Babylon Village Hall, Fire, EMS and Police Services	$1,540	0%	100%
Babylon Department of Public Works[12]	NA	0%	100%
St. Joseph's School	$810	0%	100%
American Legion Post #94	$1,540	0%	100%

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

- All facilities would maintain full operating capabilities by renting a backup generator. If the rented generator fails, these facilities would experience a 100 percent loss in operating capability.
- The supply of fuel necessary to operate all backup generators 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. The analysis calculates the impact of a loss in the village's fire, police, and emergency medical services using standard FEMA methodologies. The impact of a loss in service at other facilities is based on the value of service estimates shown in Table 4. For the junior/senior high school, the analysis values the facility in its role as an emergency shelter, as indicated by the project team.[13] For the Department of Public Works, St. Joseph school and American Legion post, the value per day was estimated using the ICE Calculator, taking into account the estimated daily use of electricity and the extent of service (hours/day) required during an outage.[14]

Table 4. Value of Maintaining Service, Scenario 2

[12] The project team notes that the Department of Public Works and Village Hall facilities would share a rented generator in the event of a major outage. To avoid double-counting the cost of backup generation, we assign the cost of the rented unit to the Village Hall.
[13] The project team indicates that the area of the school is approximately 220,000 square feet. Using this estimate, we calculate that a maximum of 5,500 individuals would be able to utilize the facility as a shelter in the event of an emergency outage, based on FEMA's *Guidance on Planning for Integration of Functional Support Services in General Population Shelters* (2010). We estimate the per-person value of shelter services at $50 per day, as indicated by guidance issued by the American Red Cross.
[14] http://icecalculator.com/.

FACILITY	VALUE PER DAY
Babylon Department of Public Works	$30,294
Babylon Union Free Junior/Senior High School	$275,000
St. Joseph's School	$18,833
American Legion Post #94	$11,210

Summary

Figure 2 and Table 5 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 3.0 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 3.0 Days/Year; 7 Percent Discount Rate)

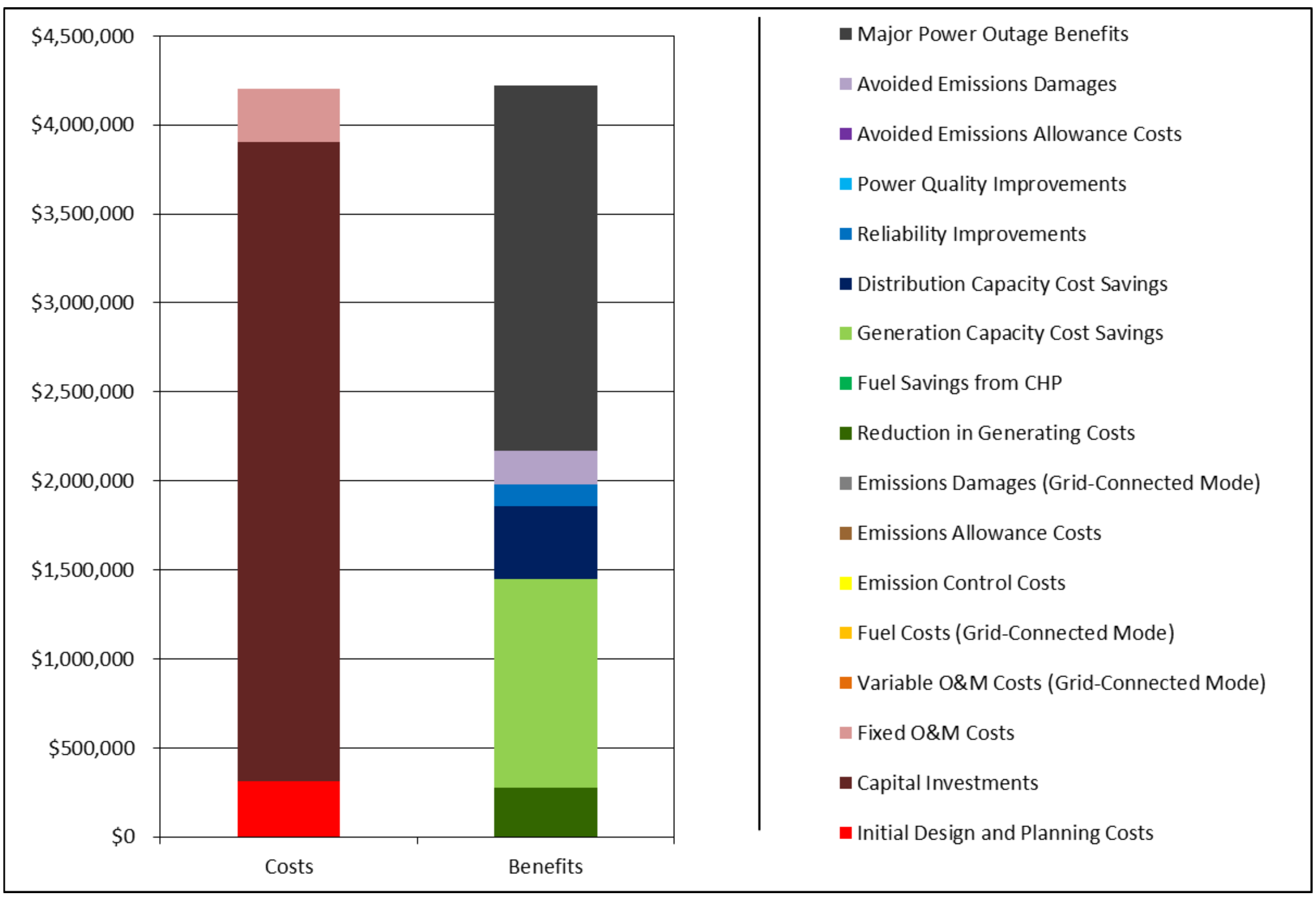

Table 5. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 3.0 Days/Year; 7 Percent Discount Rate)

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Avoided Emissions Allowance Costs	$127	$11
Avoided Emissions Damages	$189,000	$12,400
Major Power Outage Benefits	$2,050,000	$182,000
Total Benefits	**$4,220,000**	
Net Benefits	**$15,200**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.9%**	

CONTACTS:

Ameresco
111 Speen St. #410
Framingham, MA 01701

Bruce Humenik
Executive Vice President
T. 631.881.7117
E. bhumenik@ameresco.com

Ralph M. Nigro, PE
Senior Vice President
T. 302.504.3071
E. rnigro@ameresco.com

ameresco.com

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