13 - Town of Hempstead

Notice

Town of Hempstead – NYSERDA

NYPrize Community Microgrid Study

Task 5 –Final Report

Agreement Number: 64611

Executive Summary

The Town of Hempstead (ToH) has proposed development of a microgrid to serve as a backup generation in case of a utility outage that could critically limit the necessary resources and emergency response systems in place on the island communities of Point Lookout and Lido Beach. The microgrid is proposed to serve several fire stations and facilities associated with the Department of Conservation and Waterways (C&W), including the Department of C&W Administration Building, the Department of C&W East Marina, and the Department of C&W West Marina. In addition, the microgrid would serve both the Point Lookout Fire Department headquarters and the Lido Point Lookout Fire Station as well as two water pump houses, Lido-Point Lookout Water District Well #1 and #2 (Main Treatment Plant), and Lido-Point Lookout Water District Well #3 (Lido Beach Fire Station).

The microgrid would combine 22 existing distributed energy resources (DERs) and 2 new DERs for Well #3. These DERs include: five natural gas-burning generators with a combined nameplate capacity of 0.561 MW; three diesel-burning generators with a combined nameplate capacity of 0.5 MW; 2 wind turbines with a combined nameplate capacity of 0.102 MW; 12 photovoltaic (PV) units with a combined nameplate capacity of 0.148 MW; a propane-burning 60-kW generator; and a gasoline-burning 8-kW generator. Of these, the solar and wind generators would be used under normal operating conditions, while the other DERs would supplement production only during major power outages. The microgrid is intended to provide 1 week (7 days x 24 hours/day) of autonomy in the event of a utility blackout.

As the microgrid is intendent to provide resiliency to a small set of Town assets that support the community, the preliminary costs, as currently configured, are approximately $2.2M for design and construction of the microgrid. The costs and benefits were evaluated by a third-party economic analysis group (Industrial Economics, Inc. (IEc)) who determined the economic benefit of the system under two scenarios; with zero days/year when the utility grid is down providing a -15.8% rate of return on investment, and with 2.2 days/year when the utility grid is down providing a 7.5% rate of return on investment. The following report provides the major observations, findings and recommendations from each of the Tasks throughout the project development. The full reports for each Task are included as Appendices to this report.

Lessons Learned

Throughout the course of this project, the design of the project, progress of the work and meaningfulness of the outcome were subject to the communication effectiveness and openness of the stakeholders. This includes the Town, the utilities, the contractor and NYSERDA. Issues arose where one party required that another work around it's property and regulations without compromise. This created additional design work, lengthened report production time and added additional cost to the project. In an ideal scenario, the development of microgrids would be in parity with the utility and not something built around it.

A larger role from NYSERDA in providing feedback, especially regarding the meaningfulness and project viability (specifically in terms of future funding) would have helped better align Town and utility resources. While this project is viable due to the necessity of resiliency, the Town only would be able to construct if funding through NYPrize were available. More guidance from NYSERDA could have better shaped the project and it's potential for future funding. With this greater confidence, Town resources could have been further committed and utilities further engaged.

1. Microgrid Study Observations and Findings

Each of the Tasks of the microgrid study allowed for a deeper investigation into the necessary aspects of developing this project to the point that it could proceed to an audit-grade analysis (detailed design plus financial and business plan assessment). The following subsections provide the overall findings of each Task including results and lessons learned.

1.1. Task 1 – Description of Microgrid Capabilities

Task 1 of the Microgrid study established the description of the microgrid including its minimum required capabilities and preferred capabilities. In consideration of the Town's needs for critical services required during a storm event that causes a loss of utility service, the following buildings are proposed to be part of the microgrid and are considered the critical loads for the proposed microgrid:

1. The Town of Hempstead (ToH) Department of Conservation and Waterways (C&W) Administration Building
2. The ToH Department of C&W East and West Marinas
3. The Lido and Point Lookout Fire Department Headquarters
4. The Lido Firehouse
5. The ToH Department of Water Lido Point Lookout Water District Well #1 & #2 Main Treatment Plant
6. The ToH Department of Water Lido Point Lookout Water District Well #3

The microgrid is expected to predominantly include a number of currently existing generation sources, both renewable and non-renewable. Additional generation has been evaluated for inclusion of Well #3 that serves the Lido Firehouse. Lido Firehouse and Well #3 are located approximately 2 miles east and across a public right-of-way from the majority of facilities connected to the microgrid (Dept. of Water Wells #1 & #2 and also the Dept. of Conservation and Waterways Administration building). The water treatment plant and wells are also considered to be critical infrastructure facilities as they deliver potable water to the local community.

Given the small number of facilities being served by this microgrid and the small amount of energy consumed and therefore needed to be generated, the form of the microgrid in this study is proposed to be a group of facilities all with their own distributed generation connected via each of their main switchgear. This system is not intended to provide auxiliary services to the utility but, in coordination with the utility, the system can be isolated from the grid and operate independently. The system is designed to operate for 1 week (7 days x 24 hours/day) autonomously utilizing existing and planned fuel storage. 500kWh of ABB Powerstore™ battery storage is included in the design. This storage is not intended for end-use consumption but instead to provide frequency modulation for Black Start capabilities in case the grid goes down.

However, the ABB Powerstore™ system is capable of Demand Response and able to reduce peak demand from the Town facilities behind the meter for potential demand charge savings. Currently 20% of the Towns utility bill charges for the facilities included in this microgrid are from demand charges. The precise amount of peak reduction potential the ABB system could provide would need to be further analyzed in Stage 2 with interval electric demand data for these facilities. Tables 1, 2 & 3 list the existing generation assets that are to be interconnected in the proposed microgrid. Table 4 lists the new generation assets needed to interconnect Well #3.

Table 1 – Department of Water Existing Generation Assets

Town of Hempstead Department of Water, Existing Assets										
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW)	Voltage (V)	Serial Number	Year Installed	Fuel Tank	Power Factor
1	Well #1 & #2	Stamford (Cummins)	QSM11-G4 NR3	Diesel	300	NA	35260955	2009/2010	1300	N/A
2	Well #1 & #2	AC (Detroit Diesel)	HC244C	Diesel	40	240	P3036/7	N/A	1000	0.8
			Total Dept of Water		*340*					

Table 2 – Department of Conservation and Waterways Existing Generation Assets

Town of Hempstead Department of Conservation and Waterways									
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW_{DC})	Installed Capacity (kW_{AC})	Voltage (V)	Serial Number	Year Installed
3	Hydrogen Fueling Station	Generac	QT036224KNAN	NG		36	480	5756027	2012
4	West Marina	Generac	QT06024GVSX	Propane		60	208	9519879	2015
5	Administration	Kohler	150REZGC	NG		150	208	SGM32B3FP	2014
6	Laboratory	Kohler	100RZG	NG		100	208	2147259	2008
	Fossil Fuels		*Subtotal*			*346*			
7	Administration - Roof	Sharp/SMA	SMA Sunny Boy	Solar	9.8	8.7	208	N/A	2003
8	Administration - Ground Mount	Sanyo/SMA	Sunny Boy	Solar	57.2	45.8	208	N/A	2012
9	Administration - Solar House	Sanyo/Enphase	Enphase M210	Solar	14.1	14.1	208	N/A	2012
10	Administration - Solar Shed	Sanyo/SMA	Sunny Boy	Solar	2.4	2.6	208	N/A	2009
11	West Marina - Aquaculture Facility	Sharp/SMA	Sunny Boy	Solar	4.8	5.1	208	N/A	2010
12	West Marina - Aquaculture FLUPSY	Sharp/SMA	Sunny Boy	Solar	4.9	3.7	208	N/A	2010
13	Laboratory - Roof	Sharp SMA	Sunny Boy	Solar	10.4	10.1	208	N/A	2007
14	Administration - Bifacial Carport	Sanyo/SMA	Sunny Boy	Solar	23.4	36.0	208	N/A	2012
15	Administration - EV Carport	Sunpower/SMA	Sunny Boy	Solar	4.9	5.0	208	N/A	2013
16	East Marina - EV Carport	Sunpower/SMA	Sunny Boy	Solar	13.6	12.0	208	N/A	2013
17	Administration - Single Axis Tracker	Sanyo/SMA	Sunny Boy	Solar	1.8	1.7	208	N/A	2011
18	Administration - Dual Axis Tracker	Sanyo/SMA	Sunny Boy	Solar	3.5	3.4	208	N/A	2011
19	Administration - Hydrogen Fueling Station	Nothern Power Systems	Northern Power 100	Wind	N/A	100	480	00184	2012
20	West Marina - Aquaculture Facility	Southwest Windpower	Skystream	Wind	N/A	2.4	208	N/A	2009
	Renewable		*Subtotal*			*250.4*			
			Total C&W			**596**			

Table 3 – Fire Department Existing Generation Assets

Lido and Point Lookout Fire Department								
Item	**Location**	**Make**	**Model**	**Fuel Type**	**Installed Capacity (kW)**	**Voltage (V)**	**Serial Number**	**Year Installed**
21	Lido Firehouse	Generac	XP8000E	Gasoline	8	240	N/A	2011
22	Pt. Lookout Headquarters	Onan	45EM-4R8	Natural Gas	125	120/208	1068069406	1968
			Total Dept of Water		***133***			

Grand Total of Existing ToH Assets ***1,069***

Table 4 - Department of Water Proposed New Generation Assets

Town of Hempstead Department of Water, New Assets						
Item	**Location**	**Make**	**Model**	**Fuel Type**	**Installed Capacity (kW)**	**Voltage (V)**
23	Well #3	HIPOWER	HFW160 T6U	Diesel	160	480/277
24	Well #3	GM	HGM-150 T6U	NG	150	480/277
			Total Well #3		***310***	

Grand Total of Existing + New ToH Assets ***1,379***

1.2. Task 2 – Preliminary Technical Design Costs and Configuration

Task 2 of this project focused on establishing the technical design and detailed configuration in respect to operation and communication capabilities. This technical design development provided the preliminary costs and benefits necessary for proceeding to an audit-grade engineering and business case analysis. This section summarizes the findings of the specific operational and technical considerations from Task 2.

Grid Connected & Islanded Mode - It was determined that re-configuring the electrical interconnection for both the solar and the wind would enable all of the renewables to provide power should the grid go down. Currently just those at the Aquaculture facility, which have batteries, remain operable when the grid goes down as the interconnects for the other renewables are grid-powered. Thus, for all of the renewables and the existing fossil fuel generators to operate both in grid-connected and islanded mode, the electrical system for the facilities needs to be re-configured, such that all generation sources can be connected to one another. That way the fossil fuel generation can help maintain the power quality of the microgrid so that the solar inverters and wind turbine can safely be interconnected.

Intentional Island - In order to conserve fuel and increase resiliency when creating an intentional island, it would be advantageous to have the renewable generation work alongside the fossil fuel generators in an islanded mode, as well as to connect all of the facilities in order to gain resiliency through a diversity of distributed generation sources. By connecting all of these facilities at their respective switchgear or through new panel boards for islanded mode on the distributed generation side of the Automatic Transfer Switches (ATSs), the electrical generation capacity of the distributed generation could be shared.

Load Characterization - As the goal is 1 week of autonomy and it is assumed that the highest recorded demand would be required for 1 week, then (560 kW x 24 hrs/day x 7 days/week) = 94,080 kWh of energy will be necessary for 1 week of autonomy.

N-1 Contingency - The ToH C&W facilities along with the Lido/Point Lookout Fire Headquarters have a total of 411 kW of natural gas powered generators installed that can provide on site power in both grid connected and islanded mode. Thus, in order to have an N-1 contingency, where the electric grid goes down, an extra 150 kW of natural gas generation is to be added (bringing the NG capacity to a total of 561kW) so that if the PSE&G-LI grid is the first point of failure and natural gas supplies are still in operation, the existing natural gas generators, if properly connected, could provide autonomy from the electrical grid indefinitely.

N-2 Contingency - N-2 contingency is where natural gas supply is lost. This happened during Superstorm Sandy due to natural gas regulator stations in areas prone to flooding being shut down in anticipation of the storm. In this scenario with the operation of the proposed microgrid, the diesel generators from the Water Treatment facility, totaling 340 kW, combined with the 60 kW propane generator at C&W, are a little short in meeting the installed capacity necessary to supply the entire demand for the five sites. A new 160 kW diesel generator is proposed to be installed, in order to provide the necessary 560kW. Both the newly proposed 160 kW diesel generator and the 150 kW natural gas generator would be installed at the Water Department's Well #3 as that additional load needs is what necessitates these new generators. These generators otherwise would not be necessary if Well #3 were not included in the microgrid.

New Infrastructure - The major new electrical infrastructure that will be installed in order to build a microgrid are conductors/conduit to connect the different facilities, the ATSs/Controllers to make and break the microgrid, transformers to step up conductor voltages that connect the Fire Department buildings and the ABB PowerStore battery bank that will maintain the microgrid voltage and frequency with increasing and decreasing loads and generation.

Interconnection to Grid - The entire microgrid will be interconnected to the grid via eight different points of connection. All of the generating and storage assets will be connected via a common bus along with these points of connection.

Microgrid Controls - The microgrid control system will consist of the ABB Microgrid Plus (M+) system. This system was chosen because of ABB's unique experience in power and automation technology and its particular applicability this project. The M+ control system will provide all of the functionality for the MG to interact with the main grid and optimize and automate the key functions required to operate it during islanded mode. Key functions include:

- Islanding and resynchronization
- Load shedding and restart prioritization
- Black start
- Economic dispatch of assets with priority on renewable assets
- Demand response
- Frequency and voltage support, data logging and tracking of key generating and storage metrics.

The M+ control system will communicate among the controllers via a dedicated fiber loop that will be installed along with the controls.

1.3. Task 3 – Assessment of Microgrid Commercial and Financial Viability

Task 3 discusses the viability of the project through financial, legal and commercial considerations. The proposed ToH microgrid has unique considerations for commercial and financial viability because it will be a municipally owned and operated system that is being established to ensure operation of critical ToH infrastructure during utility outages caused by storm or other events. The design of the microgrid does not provide a cost/benefit in typical infrastructure project terms in that it's not immediately expected to provide a cost savings. It is a backup system that will allow critical resources to operate in order to maintain the safety and security of the residents of Point Lookout, Lido Beach and nearby communities. An indirect benefit from the installation and operation of this system would be the elimination of importing critical and emergency services during a blackout event from other municipalities, federal sources or the local utility. The system is expected to operate for a week in "Islanded" operation, maintaining water, fire and administrative resources. The costs of emergency services and loss of revenue from the lack of water distribution for a week of operational shutdown would be significant. However, the desired outcome is to not have to use the microgrid to reduce daily operational costs but have it be available when necessary. Table 4 provides the preliminary construction costs for the system as currently configured.

Table 4 – Microgrid Summarized Construction Costs

Item	Cost ($USD)
Storage	$1,164,937.50
Controls	$57,438.72
General Electrical Equipment and Permitting	$990,782.05
Initial Design and Planning	$450,000.00
Total	$2,663,158.27

Of the $2.6M total cost, $408,600 is the cost of connecting Well #3 to the MG. This is a significant cost for a minor amount of generation and should be thoroughly deliberated for the inclusion in the microgrid during the design phase.

1.4. Task 4 – Benefit-Cost Analysis

To assist with completion of the project's NY Prize Stage 1 feasibility study, Industrial Economics, Inc. (IEc) conducted a screening-level analysis of the microgrid's potential costs and benefits (including AECOM's estimate for Initial Design and Planning). The analysis considered 2 scenarios;

- Scenario 1 – where the microgrid operates with 0 major power outages in a year, and
- Scenario 2 – where the microgrid operates with 2.2 major power outages in a year, the minimum scenario for a positive economic outcome.

Both scenarios include the capital and operational costs of the system minus the cost benefits of reliability and power quality improvements in determining the net present value. The results of that analysis are summarized in table 5.

Table 5 – Summary results of IEc economic analysis

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 2.2 DAYS/YEAR

Net Benefits - Present Value	-$2,470,000	$92,000
Benefit-Cost Ratio	0.1	1.0
Internal Rate of Return	-15.8%	7.5%

2. Recommendations

Based on these findings of the Phase 1 Microgrid Study it is evident that there are significant benefits to the development of a microgrid for Point Lookout but also significant cost considerations that may alter the final design of the microgrid if/when it is constructed. Key benefits and implementation considerations are outlined in the following sections.

2.1. Environmental and Economic Benefits

Benefits of the microgrid to the local community come from increasing the operational capabilities of the critical infrastructure that is connected to the microgrid. In this case, the Water Plant that supplies the potable water to the community and the Fire district headquarters would both offer increased resiliency with the microgrid. This benefits the community by increasing the availability of potable water, and the Fire Department to provide emergency services. Powering the Marinas with the microgrid helps to insure alternative means of transportation and delivery of goods and services via the waterways in the cases where the bridge to the mainland is closed (as has occurred under previous events). The C&W facilities have served as a community center in order to provide logistic staging support in the case of emergency. Lastly, under scenarios where the connected load is reduced to where wind, solar and natural gas are sufficient to power the microgrid during a utility outage, the ToH could elect to allocate their diesel storage to emergency vehicles. Should the other generation sources provide all the necessary electricity, pumping of the diesel fuel would be possible.

2.2. Implementation Scenarios

As this microgrid is not intended to be a commercial, revenue generating system, it is anticipated that the Town would either follow a traditional design/bid/build process or an alternative delivery design/build process. One of the key factors in selecting the delivery path will be if the Town decides to build the entire microgrid as a single project or if the work will be phased. If the project were to be constructed in a single phase, the Town could either follow the design/bid/build process, hiring separate design and construction firms or the design/build process and hire a single firm. The design/build approach would be recommended in this instance as it would allow for more direct interaction between the design team, the equipment manufactures, and the contractor but would not be available if further NY Prize funding is utilized as the NYSERDA program is phased and funded in the design/bid/build approach.

If the Town elects to build the microgrid in stages with their own funding, a design/bid/build approach would be used with the design of the entire system being developed in a single process but broken into separate bid packages for construction that the Town could procure in stages as funding became available. The design would integrate input from equipment vendors to determine performance specifications for key project elements but the construction would be competitively procured after the design is complete.

After system commissioning, the intent is for the Town to own and operate the microgrid (as it currently owns and operates the majority of the microgrid assets) though the design phase will need to include a more detailed interaction with PSEG LI to develop the specifics of the interconnection and how the microgrid will ensure safe interaction with the larger grid.

If PSEG LI programs evolve to include net metering or demand response, the Town could use the microgrid to participate in those programs in addition to its primary resiliency function, which could add economic benefits which were not included in this analysis due to the availability of current programs.

2.3. Conclusion

This island community is particularly threatened by major storm events because of its barrier island location, reliance on mainland resources and its low-lying infrastructure. Given the resiliency drivers and that the project has a positive economic outcome if it offsets 2.2 day-long utility outages annually, AECOM recommends the Town consider pursuing an audit-grade assessment, either through NY Prize Stage 2 funding (requiring a 15% cost share by the Town) or via other funding mechanisms. It is also recommended that during the next stage, the impacts of the additional generation needed to include Well #3 be further deliberated in order that the microgrid provide the greatest benefit to the community while making the system as economically feasible as possible.

Appendices

Appendix A – Task 1 Final Report

Appendix B – Task 2 Final Report

Appendix C – Task 3 Final Report

Appendix D – Task 4 Economic Analysis Results Report

APPENDIX A

Town of Hempstead – NYSERDA
NYPrize Community Microgrid Study
Task 1 – Description of Microgrid Capabilities

Agreement Number: 64611

1 Executive Summary

The following report is the first task in a Feasibility Assessment for a microgrid for the Town of Hempstead (ToH) as part of the NY Prize Community Grid Competition (NYPrize). The goal of NYPrize is to promote community grids that increase the electrical distribution system performance and resiliency both in normal operation and during grid outages. Task 1 of this project provides for the description of the microgrid capabilities, including the minimum required capabilities and the preferred microgrid capabilities.

A significant number of generation sources, renewable and non-renewable, already exist at the sites considered for the micro-grid proposed in this study. The critical infrastructure facilities, Point Lookout Fire Department Headquarters, and the Lido Firehouse, are located a quarter-mile and 2 miles, respectively across public right-of-ways from the East Marina. The water treatment plant and wells can also be considered to be a critical infrastructure facility as they deliver potable water to the local community. Given the small number of customers being served by this microgrid and the small amount of energy consumed and needed to be generated, the form of the microgrid in this study is proposed to be a group of facilities all with their own distributed generation that can be connected via each of their main switchgear when the grid fails. This system does not provide auxiliary services to the utility but, at the utility's request, the system can be isolated from the grid and operate independently. It may be easier to think of it as a single larger facility with stand-alone capabilities.

2 Project Boundaries and Existing Assets

The following section describes the facilities included in the proposed microgrid as well as the current generation assets that the Town currently owns.

2.1 Proposed Buildings for Microgrid

The following buildings are proposed to be part of the micro-grid:

- **The Town of Hempstead (ToH) Department of Conservation and Waterways (C&W) Administration Building**
  Lido Blvd. Hempstead, NY 11550, Sec 60, Block E, Lot 794
- **The ToH Department of C&W East and West Marinas**
  Lido Blvd. Hempstead, NY 11550, Sec 61, Block A, Lot 349 (East Marina), Sec 60, Block E, Lot 29 (West Marina)
- **The Lido and Point Lookout Fire Department Headquarters**
  102 Lido Blvd. Point Lookout, NY 11569, Sec 61, Block 026, Lot 16
- **The Lido Firehouse**
  Corner of Lido Blvd and Regent Dr. Lido, NY 11561, Sec 60, Block 069, Lot 1
- **The ToH Department of Water Lido Point Lookout Water District Well #1 & #2 Main Treatment Plant**
  330/350 Lido Blvd. Hempstead, NY 11561, Sec 60, Block E, Lot 29

- **The ToH Department of Water Lido Point Lookout Water District Well #3**
  630 Lido Blvd. NY 11561

The West Marina, the Water District Wells #1 and #2 and the Administration building are all on contiguous properties, while the East Marina and the Laboratory are separated from the Administration building by Loop Pkwy. The Laboratory is located next to the East Marina. The Lido and Point Lookout Fire District Headquarters are located east of the East Marina by about a quarter-mile down Lido Blvd. The Lido Fire Station is located west of Wells 1 and 2 by about 2 miles down Lido Blvd with Well 3 in between. The Water District facilities, the Fire District headquarters and the Firehouses may all be considered critical facilities. The Water District facilities provide potable water to the community, and the Firehouse provides emergency services typical of a fire department. The Laboratory performs water quality testing, sample storage, and houses the District's weather station. Though it does not provide direct support during initial emergency, the water samples are refrigerated and require 24/7 temperature control. The Laboratory load will be considered if there is excess generation capacity. A map of the sites is shown in Figure 1 and Figure 2 and a vicinity map is shown in Figure 3.

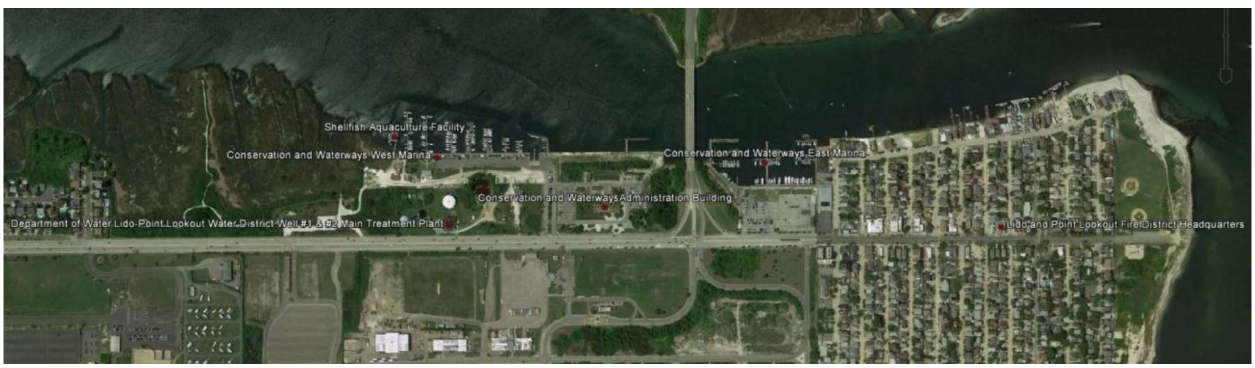

Figure 1. Map of Facilities to be interconnected in Proposed Micro-grid (Eastern Half)

Figure 2. Map of Facilities to be interconnected in Proposed Micro-grid (Western Half)

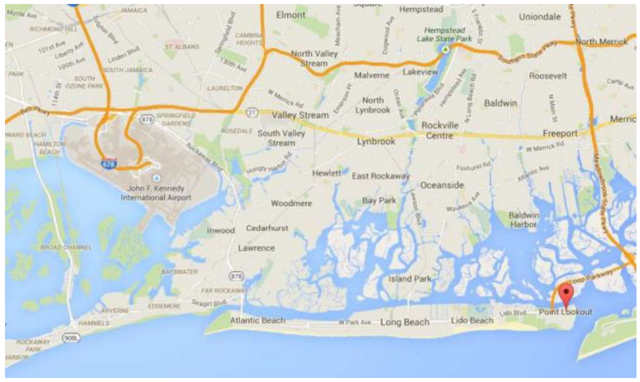

Figure 3. Vicinity Map with JFK Airport in relation

2.2 Existing Generation Equipment

The ToH for years progressively procured renewable and non-renewable distributed generation assets. Tables 1, 2 & 3 list the generation equipment currently operational at the sites above. Additionally, there are approximately 200 kW of solar PV modules owned by the ToH Dept. of C&W waiting to be installed at the site; as of this report no location or date for their installation is available.

Table 1. Department of Water, Wells #1 and #2, Generation Equipment

Town of Hempstead Department of Water, Existing Assets										
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW)	Voltage (V)	Serial Number	Year Installed	Fuel Tank	Power Factor
1	Well #1 & #2	Stamford (Cummins)	QSM11-G4 NR3	Diesel	300	NA	35260955	2009/2010	1300	N/A
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			Total Dept of Water		*340*					

Table 2. Department of Conservation and Waterways, Generation Equipment

Town of Hempstead Department of Conservation and Waterways									
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW_{DC})	Installed Capacity (kW_{AC})	Voltage (V)	Serial Number	Year Installed
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4	West Marina	Generac	QT06024GVSX	Propane		60	208	9519879	2015
5	Administration	Kohler	150REZGC	NG		150	208	SGM32B3FP	2014
6	Laboratory	Kohler	100RZG	NG		100	208	2147259	2008
	Fossil Fuels		*Subtotal*			*346*			
7	Administration - Roof	Sharp/SMA	SMA Sunny Boy	Solar	9.8	8.7	208	N/A	2003
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9	Administration - Solar House	Sanyo/Enphase	Enphase M210	Solar	14.1	14.1	208	N/A	2012
10	Administration - Solar Shed	Sanyo/SMA	Sunny Boy	Solar	2.4	2.6	208	N/A	2009
11	West Marina - Aquaculture Facility	Sharp/SMA	Sunny Boy	Solar	4.8	5.1	208	N/A	2010
12	West Marina - Aquaculture FLUPSY	Sharp/SMA	Sunny Boy	Solar	4.9	3.7	208	N/A	2010
13	Laboratory - Roof	Sharp SMA	Sunny Boy	Solar	10.4	10.1	208	N/A	2007
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15	Administration - EV Carport	Sunpower/SMA	Sunny Boy	Solar	4.9	5.0	208	N/A	2013
16	East Marina - EV Carport	Sunpower/SMA	Sunny Boy	Solar	13.6	12.0	208	N/A	2013
17	Administration - Single Axis Tracker	Sanyo/SMA	Sunny Boy	Solar	1.8	1.7	208	N/A	2011
18	Administration - Dual Axis Tracker	Sanyo/SMA	Sunny Boy	Solar	3.5	3.4	208	N/A	2011
19	Administration - Hydrogen Fueling Station	Nothern Power Systems	Northern Power 100	Wind	N/A	100	480	00184	2012
20	West Marina - Aquaculture Facility	Southwest Windpower	Skystream	Wind	N/A	2.4	208	N/A	2009
	Renewable		*Subtotal*			*250.4*			
			Total C&W			**596**			

Table 3. Lido and Point Lookout Fire, Generation Equipment

Lido and Point Lookout Fire Department								
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW)	Voltage (V)	Serial Number	Year Installed
21	Lido Firehouse	Generac	XP8000E	Gasoline	8	240	N/A	2011
22	Pt. Lookout Headquarters	Onan	45EM-4R8	Natural Gas	125	120/208	1068069406	1968
			Total Dept of Water		*133*			

Grand Total of Existing ToH Assets ***1,069***

2.3 New Generation Equipment

In order to supply the entire demand in an N-1 and N-2 contingency as explained next, two new generators will need to be installed at the Water Department's Well #3.

Table 4 Department of Water, Well #3, Generation Equipment

Town of Hempstead Department of Water, Well #3						
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW)	Voltage (V)
23	Well #3	HIPOWER	HFW160 T6U	Diesel	160	480/277
24	Well #3	GM	HGM-150 T6U	NG	150	480/277
			Total Well #3		*310*	

3 Minimum Capabilities for Proposed Microgrid

3.1 Analysis for One Week Autonomy

In order to determine the autonomy that could be provided by integrating the existing equipment into a microgrid, electricity usage data needs to be analyzed. To provide a constructible design, interval data containing 10 min or hourly data points would be required for both generation and consumption. This is necessary since generators have ramp rates, a time constraint to produce differing levels of power, where the site loads may change more frequently. Interval data is also useful to capture daily and seasonal generation and consumption patterns, especially in the case where a significant generating source is solar and wind energy, both of which have clearly defined hourly patterns. Lastly, interval data can be useful for helping determine demand response strategies by providing usage and generation patterns.

Unfortunately, interval data for consumption is not currently being collected by the electric utility. In order for interval data to be collected, the ToH and the Fire Department would have to sign up for a Remote Meter Reading (RMR) electric tariff. At that point, the existing meters would be changed. Although this cost was only estimated to be between $500-1500 per meter, given the number of meters for this project, and the budget for this task, this will have to be considered at a later date. Shark Meters were installed at the Administration building but a useable dataset was not available at the time of this report. Until interval data is available, electric bill data will be used, which for the purposes of Task 1, may be considered sufficient as the bill data is conservative. For example, the maximum demand may be during the day or during windy periods and thus may be offset by solar or wind generation, but in order to perform this analysis accurately in the absence of interval data, it will be assumed that additional renewable generation cannot contribute to demand shortfall, only energy shortfalls. Electric bills for the seven PSEG-LI electrical accounts shown in Table 4 were analyzed. The Admin Building, the Water District Wells #1 and #2, the East Marina and the West Marina were analyzed for the period of January 2013 to March 2015. The Lido and Point Lookout Fire District Headquarters and Fire Stations were analyzed for the period of July 2014 to June 2015 based on available data. Energy consumption data for Well #3 was not available because that pumping station has been out of service for some time, however in March of 2015, D&B Engineers and Architects performed a load summary of on-site equipment. In total, when Well #3 is expected to resume operation, it is anticipated that 199 kVA of equipment be operational.

Table 5. Electric Account Bills Analyzed

Electrical Account Number	Site
1750136802	Administration
1750136551	Water
1750139650	East Marina
1750136681	West Marina
1750135401	Wind Turbine/H2
1750518551	Fire Headquarters
1761080000	Firehouse

Both demand (kW) and energy (kWh) are provided for these electrical accounts given their rate structure. All solar energy generation is already captured in the electric bill results since the systems are net metered and connected to the Administration Building. During the period January 2013 to March 2015, combining all sites, the highest recorded demand was 360 kW which took place in July 2013. To this, about 200 kW of demand from Well #3 needs to be added. During the same period, combining all sites, the highest monthly energy consumption was 129,260 kWh, which took place during the August 2013. Since the data provided and analyzed for the Fire Station and Fire Headquarters was from July 2014 to June 2015, the July 2014 and August 2014 value for kW and kWh were added to 2013 totals to account for all sites. This consumption is excluding wind generation, which for those two months averages 23 kW with a weekly energy generation of about 3,622 kWh. Wind will not be considered as contributing to this requirement because it is not only variable but during wind speeds in excess of 56 mph, the wind turbine will shut down and cease production. Such wind speeds were easily reached during Hurricane Sandy. As the goal is 1 week of autonomy, it is assumed that one-quarter of the highest monthly energy consumption would be required, or 32,220 kWh. If it is assumed that the highest recorded demand would be required for 1 week, then (560 kW x 24 hrs/day x 7 days/week) = 94,080 kWh. This will be the assumed requirement for 1 week of autonomy in lieu of any future energy efficiency measures.

3.2 Generation Capacity

The ToH C&W facilities along with the Lido/Point Lookout Fire house have a total of 411 kW of natural gas powered generators installed that can provide on site power in both grid connected and islanded mode. Thus, in order to have an N-1 contingency an extra 150 kW of natural gas generation is to be added so that if the PSE&G-LI grid is the first point of failure and natural gas supplies are still in operation, the existing natural gas generators, if properly connected, could provide autonomy from the electrical grid indefinitely. During an N-2 contingency, where natural gas supply lines are lost, the diesel generators from the Water Treatment facility along with the propane generator at the ToH are a little short in meeting the installed capacity necessary to supply all the demand for the five sites. An extra 160 kW diesel generator is proposed to be added in order to compensate. Both the newly proposed 160 kW diesel generator and the 150 kW natural gas generator are proposed to be installed at the Water Department's Well #3 as that additional load needs to be served by these new generators. The storage capacity of the diesel tanks (2,300 gallons) supplying the existing diesel generators (340 kW of total capacity) could then provide 4 days of autonomy if consuming 25 gal/hr at full load. An extra diesel tank at the contiguous properties with a 2,000 gallon capacity would then need to be installed to provide a full 7 days of autonomy. While the total existing diesel capacity of 340 kW is a 20 kW shortfall of the 360 kW peak, not including Well #3, there is a 60 kW propane generator that could assist in meeting that final 20 kW. There is currently a 1,000 gallon capacity storage tank being installed to serve the 60 kW propane generator. This should be able to run the generator at full capacity for 4.5 days as at full load the fuel consumption is about 9 gal/hr. Since only an extra 20 kW is needed from the propane generator on top of the diesel generators, the new 1,000 gallon storage tank would supply about 12 days of the diesels shortfall (the Lido Firehouse has an underground diesel tank with a 1,000 gallon capacity). The new diesel generator would also need a 1,000 gallon tank to supply 7 days of autonomy.

It should be noted that the 40kW Detroit Diesel generator installed at the water pump station is fairly old and it's reliability is questionable. The cost of replacing this generator will be considered in Task 2 of this project.

In addition of the conventional fossil fuel sources, the town also has a small scale renewable energy powered hydrogen generator producing hydrogen and compressed natural gas (CNG) for the fleet vehicles. Given a potential for continuous hydrogen and CNG production through renewable energy (wind and solar), the system's CNG/ hydrogen storage can be expanded to maximize the generation capabilities and to provide additional fuel source for on-site generation. The cost and benefits of this system will be considered in Task 2 of this project.

3.3 Power Quality

Because some of the facilities included in this study are critical, a fast transition between the electrical grid and backup power may be seen as necessary. In order to accomplish this, power conditioning equipment may be required to interface between the renewable energy inverters and the fossil fuel based generators, as well as dedicated batteries for controls and ignition systems to facilitate the transition for the generators to get up and running. How the specific power electronics and controllers will maintain voltage and frequency within ANSI c84-1 standards will be determined in the design stage.

3.4 Micro-grid Communication

The communication systems for this proposed microgrid is limited to that between the ATSs, the generation components, and loads at the facilities. Control will not be provided to the local distribution utility, as this micro-grid is essentially an extension and upgrade of the on-site back up generation currently in place. The microgrid proposed in this study is not meant to be an extension of the local electrical utility, but rather a connection of the facilities via their switchgear, to essentially create one facility (electrically) when in islanded mode. This is done for simplicity and cost savings, as the sites in this study are already very well equipped with distributed generation. The renewables will be acting in parallel, as they are today during normal conditions and in island mode during an “event’. However, the fossil fueled generators would only operate when in island mode. The ToH can still implement demand response initiatives upon direction of the utility, but the utility cannot remotely impose, such as turning of A/C units or pumps or water heaters.

As the communication network is not proposed to have any external links, cyber-intrusions would need to be made while physically standing at the equipment at each of the sites. While the solar inverters have remote monitoring which enables the acquisition of digital data, the inverters cannot be controlled remotely.

3.5 Network Control Systems

The disconnection of each of the facilities from the utility will be done by ATSs. These will be controlled by a computer network with associated hardware such as that from the manufacturer IPERC. Their system has the capacity to disconnect all the facilities from the grid, and to connect each of the generation sources as necessary. The exact control algorithm to decide priority of generators and when they are to be connected/disconnected has not been determined at this time. In order to run the microgrid, IPERC’s system monitors demand and generation components of the microgrid in real time. Each demand or generation components has its own piece of IPERC hardware/software. These IPERC devices communicate with each other, and the grid, to optimize the generation and decrease demand if necessary, constantly adjusting to changing load patterns or generation equipment deterioration, by controlling the ATSs or other switching devices. IPERCs software may also interface with the fossil fuel generation controllers in order to tailor generation to load.

3.6 Installation, Operations and Maintenance

Construction of an electrical connection between the switchgear at the contiguous sites all owned by the ToH would involve trenching through unpaved ground to a depth of a few feet. This construction would be governed by the National Electrical Code, with few authorities having jurisdiction besides the ToH. Connecting the contiguous parcels to the Fire Department’s Headquarters would require using public right of ways and traversing city streets and properties owned by various entities. Preliminary discussions with PSE&G-LI indicated that using their poles for running the connection overhead was a possibility.

Maintenance of fossil fuel generators would be conducted to manufacturers requirement’s for scheduled maintenance, and would be performed in good weather if possible, giving the sites a better chance of avoiding a loss of the electrical grid. The solar energy inverters and solar panels typically have minimal maintenance besides a walk-around inspection, cleaning and checking electrical connections. The wind turbine's maintenance would be performed during expected non-windy times. This scheduling will be determined from the analysis of long term energy production.

4 Preferred Capabilities for Proposed Microgrid

4.1 Improving Resiliency with an Innovative Electrical Configuration

Three of the facilities to be included in the microgrid currently have islanding capabilities. By connecting all facilities together, multiple-element contingencies can be accounted for, drastically increasing the resiliency of the specific sites. Furthermore, by utilizing renewables to the greatest extent possible, autonomy is increased as fuel store longevity is increased. Connecting the switchgear of the different sites to leverage existing assets as described is an innovative, cost effective design that greatly improves the resiliency of all sites. While New York's Reforming the Energy Vision (REV) NYPrize work may have an emphasis on providing auxiliary services to the local electrical grid such as reactive power compensation and voltage control, the microgrid that is the subject of this report is not proposed to provide such services. The microgrid would have a self-black-start capability, but is not intended to be used to black-start the local grid. The reason for this, again as described above, is to maintain a low cost for retrofitting these facilities to work together autonomously in islanded mode. Furthermore, the total installed capacity required at any time does not exceed 560 kW. The amount of reactive power compensation that could be provided is very small and negligible for the utility.

4.2 Inclusion of Renewable Generation

4.2.1 Current Grid-Connected and Islanded Mode

Across the facilities in question, roughly 200 kW of renewable generation are currently connected and net metered, or operational in a 'grid-connected' mode. Small amount are currently connected in 'grid-connected' and 'islanded mode', those at the Shellfish Aquaculture Facility. According to UL 1741, the solar inverter design standard for the US, inverters may not feed power back onto the grid, thus the remaining solar inverters are always and only 'grid-connected.' However, the solar inverters are blind to the source of grid. It can be the electric utility, PSE&G-LI, or on-site generators that establish the same voltage and frequency, such as those that are currently at the facilities. The solar inverters control structure is such that they automatically go offline and online as the grid does. Thus if they can be electrically connected to a generator they will function. Similarly, the wind turbine is connected to the Hydrogen Fueling Station behind an Automatic Transfer Switch (ATS) such that the wind turbine is directly tied to the grid. Should the grid go down, the ATS switches from the Wind/Utility side to the Generator Side, thus the wind turbine does not operate if the grid is down. Re-configuring the electrical interconnection for both the solar and the wind would enable all of the renewables to provide power should the grid go down, as opposed to just those at the Aquaculture facility, which have batteries. Thus for all of the renewables to operate both in grid-connected and islanded mode, the electrical system for the facilities needs to be re-configured, such that all generation sources can be connected to one another. That way the fossil fuel generation can help to turn on the solar inverters. Additional battery storage may be added to extend the renewable energy source capability. The exact configuration and design for each site that enables a dual connection for the renewables, grid-connected and islanded mode, will be determined in the design phase. It may involve two automatic transfer switches for each set of renewables, or new switchgear for islanded mode however this will not be known until a detailed study of the electrical systems for each facilities are known.

4.2.2 Intentional Island

The Administration (admin) building for the ToH Department of C&W, the Water Treatment (Wells #1 and 2) plant for the ToH Department of Water and the Fire Department Headquarters (Lido firehouse is manual) all currently have an ATS that disconnects the facilities from the grid during an outage and engage their on-site fossil fuel generation. Therefore, these facilities already have the ability to create an intentional island. The renewable energy generation is currently not connected on the facility side of the ATS and each facility is separated electrically. In order to conserve fuel and increase resiliency when creating an intentional island, it would be advantageous to have the renewable generation work alongside the fossil fuel generators in islanded mode, as well as to connect all of the facilities in order to best take advantage of the different distributed generation sources. By connecting all of these facilities at their respective switchgear or on new panelboards for islanded mode on the distributed generation side of the ATSs, the electrical generation capacity of the distributed generation could be shared. These connections would be made likely via underground conductors between contiguous sites and overhead conductors for the Fire Department facilities and Well #3 which are some distance away. The exact configuration and design of the new electrical systems will be determined in the design phase.

In the worst case scenario considered above, it is assumed that for one week of autonomy a total of 32,220 kWh is required to power all the facilities. During that timeframe, if that wind turbine remains in operation, it is expected to produce 3,622 kWh in one week. As mentioned above, the reason for the wind turbine to remain off would be because of wind speeds being higher than the safe operational wind speed of the wind turbine. However, such strong wind speeds are typically only sustained for a few hours, or 24 hours at the most. The month of July was investigated for solar production. Based on collected data, on average, all of the solar systems produce roughly 4,000 kWh. The solar PV typically peaks in July with lower production in winter months. Renewables can then be expected to produce roughly 20-25% of the consumed energy. If the 200 kW of solar panels that the ToH owns that are currently sitting idle were to be installed and used, the contribution from renewable energy would increase and the required size of the new diesel fuel tank may decrease. Additional energy storage may be added to extend the renewable energy source capability. This analysis will be included in Task 2 and 3 of this project.

An N-3 contingency which may integrate battery storage has not been analyzed.

4.3 Energy Efficiency

In order to decrease the energy demands on microgrid generation, energy efficiency upgrades and demand response can be useful tools. The Dept. of C&W has already completed two energy efficiency projects, high efficiency lighting and ground source heat pumps at the Administration Building. AECOM would also recommend replacing the pumps at the water treatment plant with high efficiency motors as these were identified to be a large component of the Town's electrical consumption during their Energy and Sustainability Master Plan in 2011. In order to increase the autonomy provided by the existing fuel supply, lighting and other non-critical loads may be turned off. Additionally, set points for air conditioning systems may be adjusted during islanded mode in order to decrease energy consumption. In order to more closely determine the amount of demand/energy that could be shed from non-critical loads, a detailed data-logging campaign would need to be undertaken. Implementing the "demand response" in island mode would decrease the load on the generators and thus extend the time between re-fueling.

4.4 Microgrids Serving Public Facilities

The development of the ToH microgrid is not a commercial venture or meant to demonstrate the commercial viability of a microgrid, as its purpose is solely to provide power to critical facilities, whose operation cannot be quantified like a commercial venture. There are community benefits related to safety and security, potable water, and fire protection. These will be further evaluated and attempted to be quantified in Task 3. During that task, PSE&G LI will also be consulted to investigate if there are costs/benefits to them. Public facilities, however, often remain at their specific property for a significantly longer time than do private facilities. This can make an infrastructure investment more reasonable. Given its public nature, neither private capital nor a developer are intended to be utilized in this project. As this project is not meant to be third party owned or financed there will be no cost/benefit associated with those types of entities.

4.5 End User Information Access

A cost-effective and simple way to provide actionable information to the end users of the microgrid (both the Town employees who operate and work within these facilities but also the general public) would be to provide energy information dashboards at the community center that display real-time generation from renewable assets and demand from the connected facilities. This dashboard could display specific building usage during normal times and/or specific building usage during "events".

4.6 Tangible Benefits

With a microgrid that supports the facilities mentioned above, the Hamlets of Lido Beach and Point Lookout would have a more reliable source of drinking water, a better equipped Fire department, and a community gathering point in emergency situations.

APPENDIX B

Town of Hempstead – NYSERDA

NYPrize Community Microgrid Study

Task 2 – Preliminary Technical Design Costs and Configuration

Agreement Number: 64611

Executive Summary

The following report is the second task in a Feasibility Assessment for a microgrid (MG) for the Town of Hempstead (ToH) as part of the NY Prize Community Grid Competition (NYPrize). The goal of NYPrize is to promote community grids that increase the electrical utility grid distribution system performance and resiliency both in normal operation and during grid outages. Task 2 of this project is focused on establishing the design to calculate costs and benefits of proceeding to an audit-grade engineering and business case analysis.

1. Proposed Microgrid Infrastructure and Operations

As previously discussed in Task 1, the ToH currently has significant distributed generation resources throughout the contiguous sites that can be used for MG operations. This includes both renewable and non-renewable generators. All existing equipment is shown in Table 1, Table 2 and Table 3. Three maps of the sites with the location of the different existing generators are shown in Figure 1, Figure 2 and Figure 3. A single line drawing of the system as it is currently configured, and also including the future MG is shown in Figure 4. The Automatic Transfer Switches (ATS), transformers and cable/conduit routing have not been shown on the site layouts, as that level of surveying and design will not be performed until Phase 2 of NYPrize.

Table 1. Department of Water, Wells #1 and #2, Existing Generation Equipment

Town of Hempstead Department of Water, Existing Assets										
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW)	Voltage (V)	Serial Number	Year Installed	Fuel Tank	Power Factor
1	Well #1 & #2	Stamford (Cummins)	QSM11-G4 NR3	Diesel	300	NA	35260955	2009/2010	1300	N/A
2	Well #1 & #2	AC (Detroit Diesel)	HC244C	Diesel	40	240	P3036/7	N/A	1000	0.8
			Total Dept of Water		*340*					

Table 2. Department of Conservation and Waterways, Existing Generation Equipment

Town of Hempstead Department of Conservation and Waterways									
Item	Location	Make	Model	Fuel Type	Installed Capacity (kW_{DC})	Installed Capacity (kW_{AC})	Voltage (V)	Serial Number	Year Installed
3	Hydrogen Fueling Station	Generac	QT036224KNAN	NG		36	480	5756027	2012
4	West Marina	Generac	QT06024GVSX	Propane		60	208	9519879	2015
5	Administration	Kohler	150REZGC	NG		150	208	SGM32B3FP	2014
6	Laboratory	Kohler	100RZG	NG		100	208	2147259	2008
	Fossil Fuels		*Subtotal*			*346*			
7	Administration - Roof	Sharp/SMA	SMA Sunny Boy	Solar	9.8	8.7	208	N/A	2003
8	Administration - Ground Mount	Sanyo/SMA	Sunny Boy	Solar	57.2	45.8	208	N/A	2012
9	Administration - Solar House	Sanyo/Enphase	Enphase M210	Solar	14.1	14.1	208	N/A	2012
10	Administration - Solar Shed	Sanyo/SMA	Sunny Boy	Solar	2.4	2.6	208	N/A	2009
11	West Marina - Aquaculture Facility	Sharp/SMA	Sunny Boy	Solar	4.8	5.1	208	N/A	2010
12	West Marina - Aquaculture FLUPSY	Sharp/SMA	Sunny Boy	Solar	4.9	3.7	208	N/A	2010
13	Laboratory - Roof	Sharp SMA	Sunny Boy	Solar	10.4	10.1	208	N/A	2007
14	Administration - Bifacial Carport	Sanyo/SMA	Sunny Boy	Solar	23.4	36.0	208	N/A	2012
15	Administration - EV Carport	Sunpower/SMA	Sunny Boy	Solar	4.9	5.0	208	N/A	2013
16	East Marina - EV Carport	Sunpower/SMA	Sunny Boy	Solar	13.6	12.0	208	N/A	2013
17	Administration - Single Axis Tracker	Sanyo/SMA	Sunny Boy	Solar	1.8	1.7	208	N/A	2011
18	Administration - Dual Axis Tracker	Sanyo/SMA	Sunny Boy	Solar	3.5	3.4	208	N/A	2011
19	Administration - Hydrogen Fueling Station	Nothern Power Systems	Northern Power 100	Wind	N/A	100	480	00184	2012
20	West Marina - Aquaculture Facility	Southwest Windpower	Skystream	Wind	N/A	2.4	208	N/A	2009
	Renewable		*Subtotal*			*250.4*			
			Total C&W			**596**			

Table 3. Lido and Point Lookout Fire, Existing Generation Equipment

Lido and Point Lookout Fire Department								
Item	**Location**	**Make**	**Model**	**Fuel Type**	**Installed Capacity (kW)**	**Voltage (V)**	**Serial Number**	**Year Installed**
21	Lido Firehouse	Generac	XP8000E	Gasoline	8	240	N/A	2011
22	Pt. Lookout Headquarters	Onan	45EM-4R8	Natural Gas	125	120/208	1068069406	1968
			Total Dept of Water		***133***			

Grand Total of Existing ToH Assets 1,069

Table 4. Department of Water, Well #3, Proposed New Generation Equipment for Microgrid

Town of Hempstead Department of Water, New Assets						
Item	**Location**	**Make**	**Model**	**Fuel Type**	**Installed Capacity (kW)**	**Voltage (V)**
23	Well #3	HIPOWER	HFW160 T6U	Diesel	160	480/277
24	Well #3	GM	HGM-150 T6U	NG	150	480/277
			Total Well #3		***310***	

Grand Total of Existing + New ToH Assets 1,379

Figure 1. Site Layout: Distributed Generator Locations at Water Department and Conservation and Waterways Department, Contiguous Properties

Figure 2. Site Layout: Distributed Generator Locations at East Marina and Fire Department Headquarters

Figure 3. Site Layout: Distributed Generator Locations at Water Department, West Marina and Fire Department Firehouse

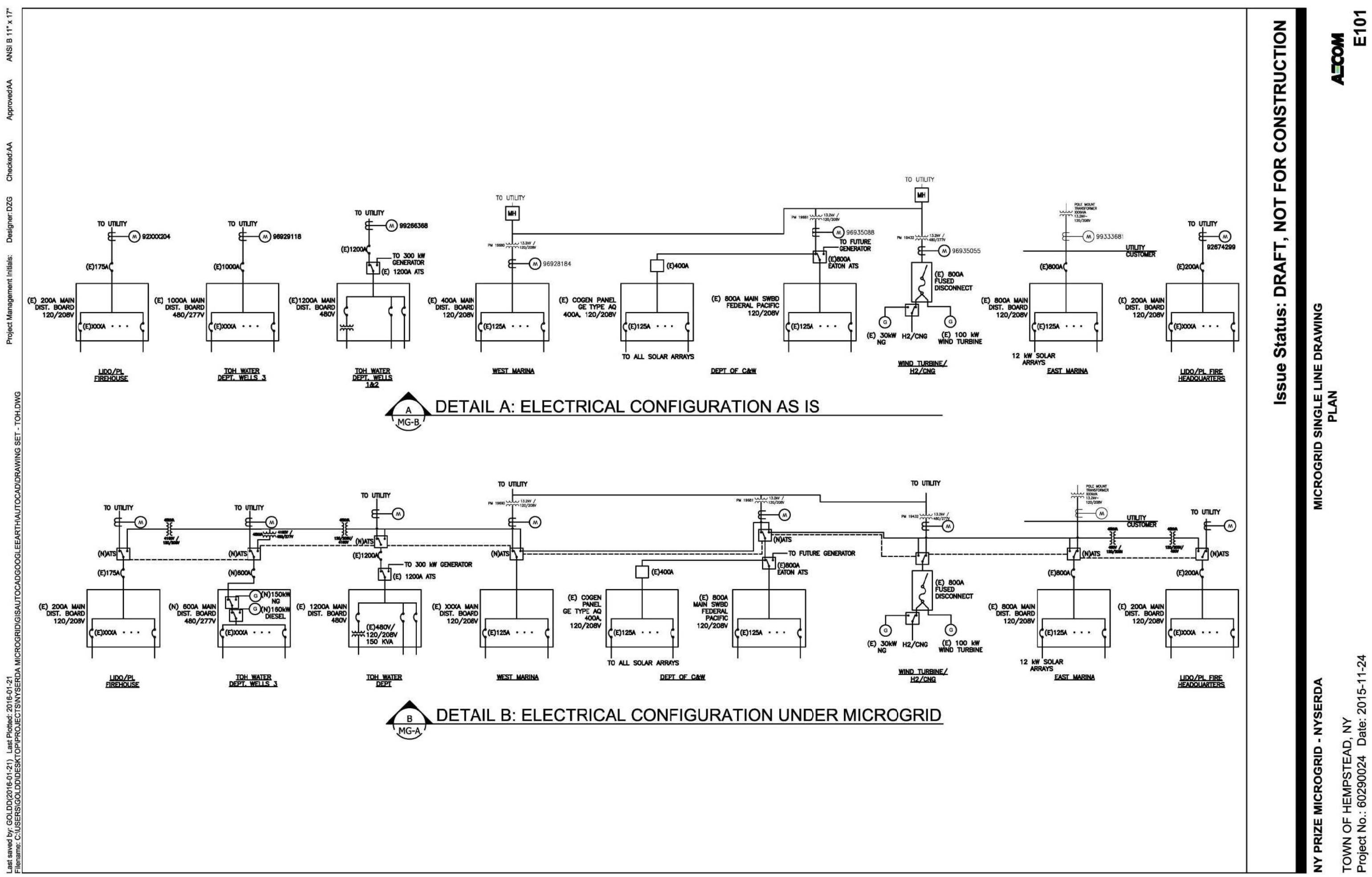


Figure 4. Single Line Drawing of Main Switchgear A) Before and B) Interconnected as a MG

The points of interconnection to the electric utility are shown as they currently exist and are not intended to change.

A description of how the proposed MG is to operate under both normal circumstance and under emergency conditions was already described in Task 1, however the modes of operation are repeated below.

1.1. Current Grid-Connected and Islanded Mode

Across the facilities under evaluation, approximately 250 kW of renewable generation are currently connected and net metered, or operational in a 'grid-connected' mode. A very small amount of on-site resources are currently connected in 'grid-connected' and 'islanded mode', namely those at the Shellfish Aquaculture Facility. According to UL 1741, the solar inverter design standard for the US, inverters may not feed power back onto the grid, thus the remaining solar inverters are always and only 'grid-connected', meaning they can only operate in the presence of an energized grid. However, the solar inverters are blind to the source of grid power. It can be the electric utility, PSE&G-LI, or on-site generators/power electronic devices that establish the same voltage and frequency, such as those that are currently at the facilities. The solar inverters control scheme is such that they automatically go offline and online as the grid is de-energized or energized. Thus if they can be electrically connected to a continuous source of voltage and frequency they will continue to operate. Similarly, the wind turbine is connected to the Hydrogen Fueling Station behind an ATS such that the wind turbine is directly tied to the grid. Should the grid go down, the ATS switches from the Wind/Utility side to the Generator Side, thus the wind turbine does not operate if the grid is down. Re-configuring the electrical interconnection for both the solar and the wind would enable all of the renewables to provide power should the grid go down, as opposed to just those at the Aquaculture facility, which have batteries. Thus for all of the renewables, and the existing fossil fuel generators to operate both in grid-connected and islanded mode, the electrical system for the facilities needs to be re-configured, such that all generation sources can be connected to one another. That way the fossil fuel generation can help maintain the MG for the solar inverters and wind turbine to follow and feed into. The exact configuration and design for each site that enables a dual connection for the renewables, grid-connected and islanded mode, will be determined in the design phase. It may involve two automatic transfer switches for each set of renewables, or new switchgear for islanded mode, however this will not be known until a detailed study of the existing electrical systems for each of the facilities are known. For the purpose of this feasibility study, the configuration as shown in the single-lines in Figure 4 will be considered.

1.2. Intentional Island

The Administration (Admin) building for the ToH Department of C&W, the Water Treatment plant for the ToH Department of Water and the Fire Department Headquarters (Lido firehouse is manual) all currently have an ATS that disconnects the facilities from the grid during an outage and engage their on-site fossil fuel generation. The West Marina also has islanding capabilities for specific functions. Therefore, these facilities already have the ability to create an intentional island. The renewable energy generation is currently not connected on the facility side of the ATS, with the exception of the West Marina. Each facility is separated electrically. In order to conserve fuel and increase resiliency when creating an intentional island, it would be advantageous to have the renewable generation work alongside the fossil fuel generators in an islanded mode, as well as to connect all of the facilities in order to gain resiliency through a diversity of distributed generation sources. By connecting all of these facilities at their respective switchgear or through new panel boards for islanded mode on the distributed generation side of the ATSs, the electrical generation capacity of the distributed generation could be shared. These connections would be made likely via underground conductors between contiguous sites and overhead conductors for the Fire Department facilities that are some distance away. The exact configuration and design of the new electrical systems will be determined in the design phase.

2. Load Characterization

2.1. Profile Description and Data Analysis

In order to determine the autonomy that could be provided by building a microgrid around the existing equipment, energy usage data needs to be analyzed. To produce a construction ready design, interval data containing 10 min or hourly data points would be required for both generation and consumption. This is necessary since generators have ramp rates, a time constraint to produce differing levels of power, where the site loads may change more frequently. Interval data is also useful to capture daily and seasonal generation and consumption patterns, especially in the case where a significant generating source is solar and wind energy, both of which have clearly defined average hourly patterns. Lastly, interval data can be useful for helping determine demand response strategies by providing usage and generation patterns and looking for potential disparities between the two.

Unfortunately, interval data for consumption is not currently being collected by the electric and gas utilities. In order for electrical interval data to be collected, the ToH and the Fire Department would have to sign up for a Remote Meter Reading (RMR) electric tariff. At that point, the existing meters would be changed. RMR costs between $500 and $1500 per meter. Given the number of meters in this study and the limited budget allocated to this study, changing the meters will not be done at this time. Shark Meters were installed at the Administration building but a useable dataset was not available at the time of this report. Until interval data is available, data from electric bills will be used, which for the purposes of Task 2, may be considered sufficient as the data from the electric bills is conservative. For example, the maximum demand may be during the day or during windy periods and thus may be offset by solar or wind generation, but in order to perform this analysis accurately in the absence of interval data, it will be assumed that additional renewable generation cannot contribute to demand shortfall, only energy shortfalls. Electric bills for the seven PSEG-LI electrical accounts shown in Table 5 were analyzed. The Admin Building, the Water District Wells #1 and #2, the East Marina and the West Marina were analyzed for the period of January 2013 to March 2015. The Lido and Point Lookout Fire District Headquarters and Fire Stations were analyzed for the period of July 2014 to June 2015 based on available data. Energy consumption data for Well #3 was not available because that pumping station has been out of service for some time, however in March of 2015, D&B Engineers and Architects performed a load summary of on-site equipment. In total, when Well #3 is expected to resume operation, it is anticipated that 199 kVA of equipment be operational. Gas interval data is not as of much value since combined heat and power is not proposed to be included in the MG design. As there are not any major thermal loads at these facilities beyond space heating, thermal loads will not be investigated.

Table 5. Electric Account Bills Analyzed

Electrical Account Number	Site
1750136802	Administration
1750136551	Water
1750139650	East Marina
1750136681	West Marina
1750135401	Wind Turbine/H2
1750518551	Fire Headquarters
1761080000	Firehouse

Both demand (kW) and energy (kWh) are provided for these electrical accounts given their rate structure. All solar energy generation is already captured in the electric bill results since the systems are net metered and connected to the Administration Building. During the period January 2013 to March 2015, combining all sites, the highest recorded peak demand was 360 kW which took place in July 2013. To this, about 200 kW from Well #3 needs to be added. During the same period, combining all sites, the highest monthly energy consumption was 129,260 kWh, which took place during the August 2013. Since the data provided and analyzed for the Fire Station and Fire Headquarters was from July 2014 to June 2015, the July 2014 peak demand (kW) and August 2014 peak consumption (kWh) values were added to 2013 totals to account for all sites. This consumption is excluding wind generation and H2 consumption, which for those two months averages 23 kW with a weekly energy generation of about 3,622 kWh. Wind will not be considered as contributing to the requirement of 7 days of autonomy from the microgrid because it is both variable and not available during wind speeds in excess of 56 mph, as the wind turbine will shut down and cease production. Such wind speeds were easily reached during Hurricane Sandy. While solar energy may also be considered variable, the likelihood (availability) of solar production on any given day is substantially higher than wind. Wind inevitable contribution will only increase the autonomy of the microgrid beyond seven days, however for the sake of a conservative analysis, wind is not considered. As the goal is 1 week of autonomy, it is assumed that one-quarter of that energy would be required, or 32,220 kWh. If it is assumed that the highest recorded demand would be required for 1 week, then (560 kW x 24 hrs/day x 7 days/week) = 94,080 kWh. This will be the assumed requirement for 1 week of autonomy without regard of any future energy efficiency measures or increases in load.

Table 6. Statistics Across All Sites

Statistic	
Annual Peak Demand	559 kW
Annual Average Demand	527 kW
Annual Energy Consumption	1,106 MWh*
Monthly Average Energy Consumption	92 MWh*
Weekly Average Energy Consumption	23 MWh*

*Consumption does not include Well #3 as its usage is unkown

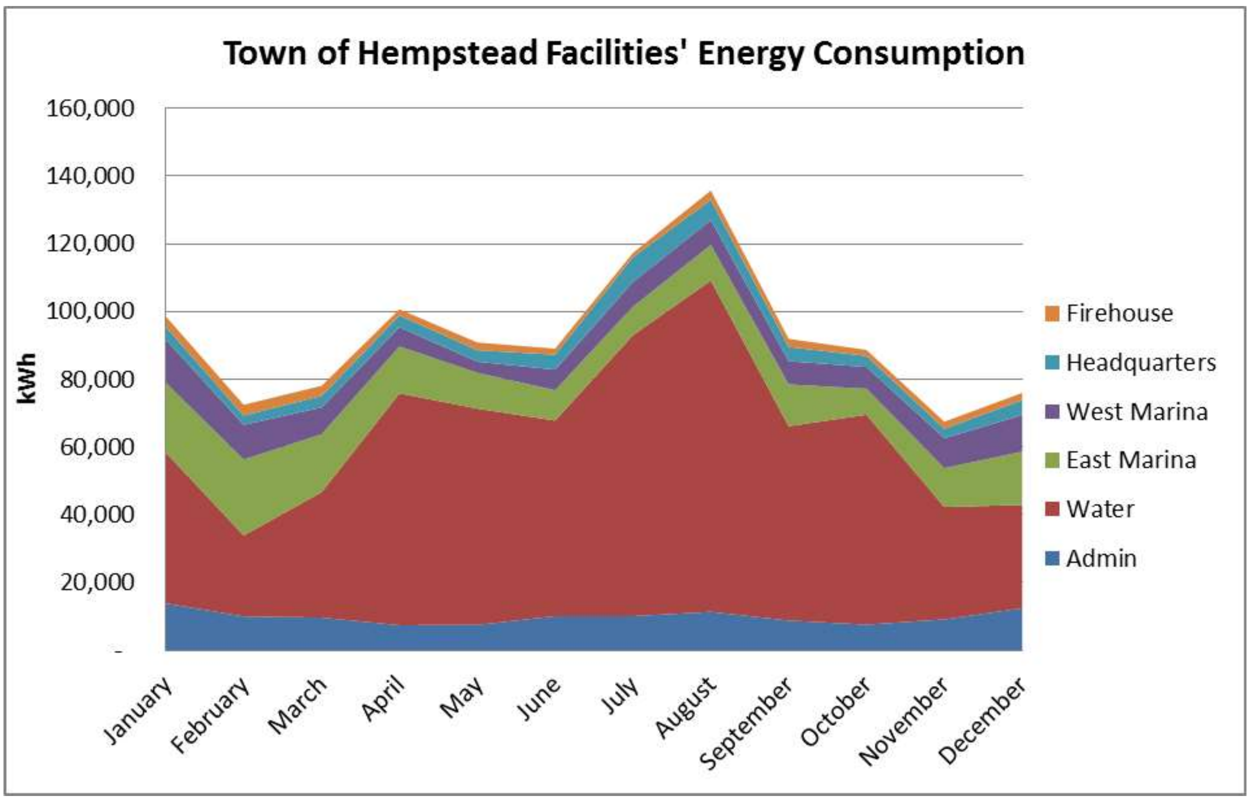


Figure 5. Monthly Energy (kWh) Consumption for ToH Facilities, does not include Well #3

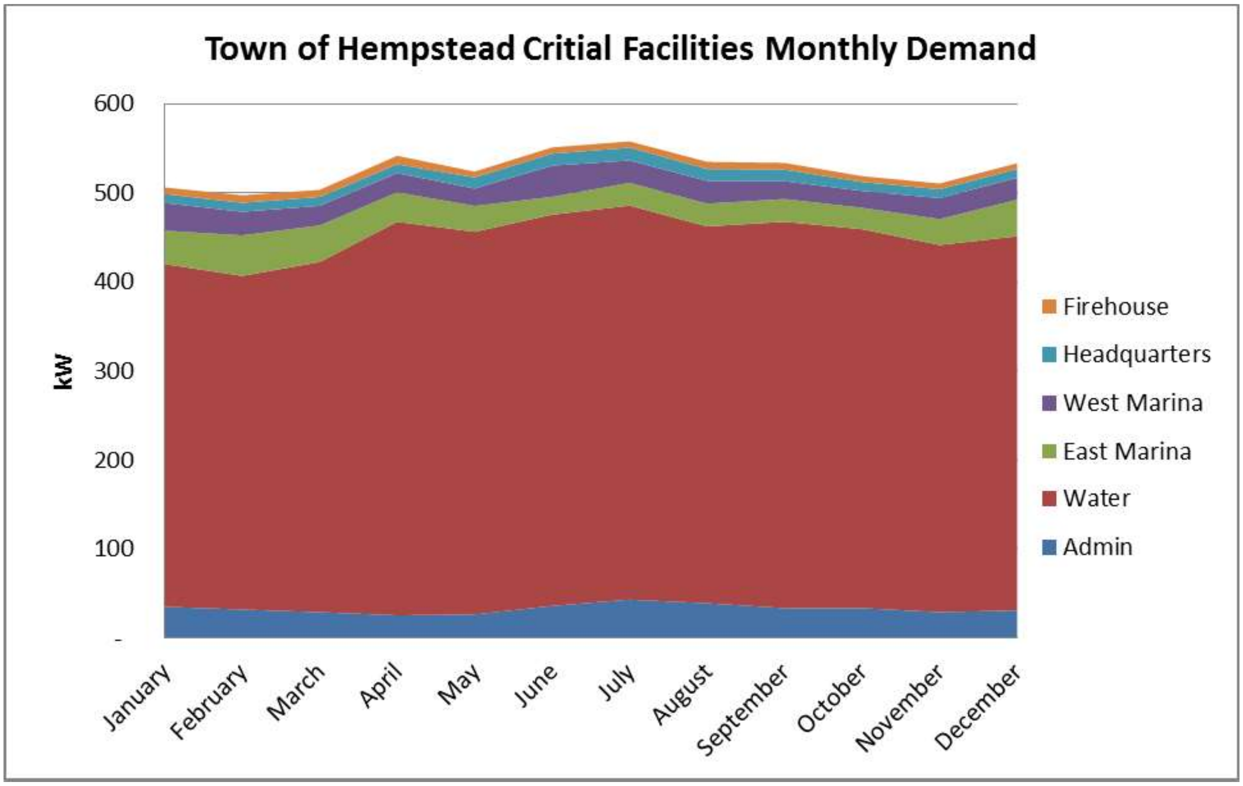


Figure 6. Monthly Peak Demand (kW) for ToH Facilities

2.2. N-1 Contingency

The ToH C&W facilities along with the Lido/Point Lookout Fire Headquarters have a total of 411 kW of natural gas powered generators installed that can provide on site power in both grid connected and islanded mode. Thus, in order to have an N-1 contingency, where the electric grid goes down, an extra 150 kW of natural gas generation is to be added so that if the PSE&G-LI grid is the first point of failure and natural gas supplies are still in operation, the existing natural gas generators, if properly connected, could provide autonomy from the electrical grid indefinitely. During an N-2 contingency, where natural gas supply lines are lost, the diesel generators from the Water Treatment facility, totaling 340 kW, combined with the 60 kW propane generator at C&W, are a little short in meeting the installed capacity necessary to supply the entire demand for the five sites. A new 160 kW diesel generator is proposed to be installed, in order to compensate. Both the newly proposed 160 kW diesel generator and the 150 kW natural gas generator are proposed to be installed at the Water Department's Well #3 as that additional load needs is what necessitates these new generators. These generators otherwise would not be necessary if Well #3 were not considered. The storage capacity of the existing diesel tanks (2,300 gallons) supplying the existing diesel generators (340 kW of total capacity), located at the Water Department's Well #1 and Well #2, could then provide 4 days of autonomy if consuming 25 gal/hr at full load. An extra diesel tank at the contiguous properties (Wells #1 & #2, East/West Marina, Admin Building) with a 2,000 gallon capacity would then need to be installed to provide a full 7 days of autonomy. While the total existing diesel capacity of 340 kW is a 20 kW shortfall of the 360 kW peak, not including Well #3, there is a 60 kW propane generator at the West Marina that could assist in meeting that final 20 kW. There is currently a 1000 gallon capacity storage tank being installed to serve the 60 kW propane generator. This tank should be able to run the propane generator at full capacity for 4.5 days, as at full load the fuel consumption is about 9 gal/hr. Since only an extra 20 kW is needed from the propane generator on top of the diesel generators, the new 1000 gallon propane storage tank along with the propane generator would supply about the diesels' shortfall (the Lido Firehouse has an underground diesel tank with a 1000 gallon capacity). The new 160 kW diesel generator would also need a 1,000 tank to supply 7 days of autonomy of Well #3's load.

In addition to the conventional fossil fuel sources, the town also has a small scale wind energy powered hydrogen electrolyzer producing hydrogen via electrolysis and also compresses utility-provided natural gas (CNG) for fleet vehicles. Given a potential for continuous hydrogen production and CNG compression/storage through renewable energy (wind and solar) integration into a microgrid, the system's CNG/ hydrogen storage can be expanded to maximize the generation capabilities. As the current electrolyzer produces hydrogen at a rate of 0.5 kg/hr, hydrogen production can be further maximized through the addition of a second electrolyzer.

An N-3 contingency, which may integrate battery storage to supply in excess of one week of autonomy should all on-site diesel and propane fuel be used under the N-2 contingency, has not been analyzed.

3. Distributed Energy Resources Characterization

Table 1, Table 2 and Table 3 in Section *1 Proposed Microgrid Infrastructure and Operations* detail the characteristics of the distributed generation resources that are proposed to be integrated into the MG. The physical locations of these pieces of equipment are shown in Figure 1, Figure 2 and Figure 3.

3.1. New Equipment

The major new equipment that will be installed as part of the distributed energy resources are the ABB PowerStore® battery and Microgrid Plus control system. The exact location of the battery system has not yet been determined, as it will be optimized during engineering. Additionally ATSs will be added at each of the switchgear locations shown on the single lines in Figure 4. The physical location for the installation of these ATSs would only be determined during detailed engineering, however they would be in close proximity to the switchgear they serve. As the sites all have significant extra land and space to install new equipment should not be a concern. The total size of all ABB equipment amounts to roughly a 20 ft container.

3.2. Resiliency to the Forces of Nature

The different generation sources all have different sensitivities to the various forces of nature. The 100 kW wind turbine will shut down for any wind speed that exceeds 56 miles per hour for more than 10 mins. This means potentially 100 kW can be lost during any storm with high wind speeds, such as a hurricane. Given the high exposure at the ToH site and typical experiences of the wind turbine industry, the wind turbine also has the potential for a fatal failure should wind speeds be sufficiently high enough, such as that found in a Category Four Hurricane (130+ mph). The natural gas generators are fed by the natural gas lines, which typically have self powered compression stations. The extreme cold necessary to freeze gas lines would amount to an extinction level event and not one worthwhile to consider. As each compression station in the natural gas supply system is individually powered, the likelihood of the natural gas system to loose all pressure is extremely low. But like all fossil fuel supply systems, during an emergency event, post natural disaster, a number of infrastructure supply network related issues could occur, crippling natural gas supply. Both diesel and propane generators have on-site storage tanks. As these tanks are load bearing and water tight, flood related weather should not cripple the fuel supply. Besides earth shattering events, there are not normal catastrophic weather events that would lead to a crippling of fossil fuel storage tanks. Solar Energy is perhaps the most resilient for the fact that only a lack of sunlight can cause a stop in production. The most common method of damage to solar panels is hail, however solar panels can be specified with high-pressure glass that can handle all known size and intensity of hail.

All electronics are subject to failure from an electromagnetic pulse or other significant electromagnetic destructions, such as never before experienced in the modern era, but possible, magnetic explosions that occur on the sun could impact electronic hardware. Furthermore, all equipment could be damaged in flooding depending on the height of the water level. All major equipment will be elevated to the same height as existing generators at the C&W Administration building and all new electrical enclosures, where possible, will be of NEMA 6 construction, flood proof, and made of stainless steel or composite construction.

4. Electrical and Thermal Infrastructure Characterization

4.1. Electrical Infrastructure, Old and New

The major new electrical infrastructure that will be installed in order to build a MG are conductors/conduit to connect the different facilities, the ATSs/Controllers to make and break the microgrid, transfomers to step up conductor voltages that connect the Fire Department buildings and the ABB PowerStore battery bank that will maintain the MG voltage and frequency with increasing and decreasing loads and generation.

4.2. Interconnection to the Grid

The entire MG will be interconnected to the grid via eight different points of connection (Figure 4). All of the generating and storage assets will be connected via a common bus along with these points of connection. In order to island the grid, the control system will open the breakers to seven of the eight points of connection in order to have only one point of common coupling from which the system will island. Relays will be installed at each of the eight points in order to carry out the appropriate switching. After opening the seven breakers, the MG control system will then bring appropriate generation online to cover MG load and create a null flow at the remaining point of common coupling. At this point, the last breaker would be opened, thus islanding the system.

During re-synchronization, the control system will be measuring frequency on both sides of the point of common coupling and will slightly accelerate frequency on the MG side to bring it to synch with the grid side. When the two frequencies are in synch, the control system will signal permission to re-synch and the breaker can close at the point of common coupling. Once the breaker is closed, the MG generating assets can power down to allow the main grid to take over supply as needed.

5. Microgrid Characterization

5.1. Microgrid Controls

The MG control system will consist of the ABB Microgrid Plus (M+) system. This is a highly proven system installed in over 30 renewable hybrid projects all over the world. The M+ system works in a distributed, peer-to-peer architecture. This means that the controls actually connect to the individual generating, storage and load assets that are to be integrated in the MG. Each control at each asset then communicates to the others in real time on a dedicated communication network to optimize system dispatch. Because there is no central point of control, there is no single point of failure.

Each controller interfaces to each controlled asset at a high level, essentially sending the asset set point commands. It does not attempt to replace the intrinsic control system of each asset. This makes the control system much more rapid to deploy and commission.

The M+ control system operates under two key priorities. In order of priority, they are:

1) Maintain system stability which essentially means providing grid quality power, and

2) Integrate as much renewable energy as possible at any given time. This allows for the most economically efficient operation.

The system includes an operations Human Machine Interface (HMI) portal, which allows for monitoring, system prioritization and setup and data logging. The operations portal can be set up both locally at the MG site and integrated into a utility SCADA system. The portal allows for operators to interface with individual equipment to send commands and also manage dispatch priorities.

5.2. Microgrid Services

The M+ control system will provide all of the functionality for the MG to interact with the main grid and optimize and automate the key functions required to operate it during islanded mode. Key functions include:

Islanding and resynchronization: The MG will automate the islanding functioning by dispatching generation and storage to create a null power flow at the point of common coupling and then opening the breaker at the point of common coupling. It will also resynchronize the MG in an islanded mode to the main grid and close the breaker when frequency is synchronized.

Load shedding and restart prioritization: Identified loads will be automatically shed based on priority if needed and restarted when the MG capacity allows for it.

Black start: The PowerStore battery system will allow for black start of the MG if the entire grid goes down without warning.

Economic dispatch of assets with priority on renewable assets: The M+ system will dispatch the generating assets in merit order and under a regime to emphasize stability and economics. Additionally, the system will engage as much renewable generation as possible.

Demand response: The PowerStore Battery system and any of the other demand or generating assets can provide demand response through the M+ system as needed while the electric utility grid is operational.

Frequency and voltage support: The system's highest priority is to provide full voltage and frequency stability. This can be achieved by establishing one of the thermal assets in isochronous mode to provide the frequency lead or by using the PowerStore battery in isochronous mode.

Data logging and tracking of key generating and storage metrics: The M+ system operations HMI provides all necessary data logging for the system and assets within the system. It also provides a real time window into performance of the individual assets.

The M+ system is was built specifically with resiliency in mind and has been installed in some of the harshest climate environments in the world. As mentioned before, the M+ system utilizes a distributed peer-to-peer architecture so that there is no single point of failure. In addition, the controls can be installed redundantly at each controlled device so if one fails, the redundant controller can take over.

Severe weather is not likely to disrupt the control system operation as they will be indoors and connected by an underground fiber communications loop.

6. Information Technology (IT)/Telecommunications Infrastructure Characterization

6.1. IT/Telecommunications Infrastructure

The M+ control system will communicate among the controllers via a dedicated fiber loop that will be installed along with the controls. Communication between each control and its controlled asset will depend on the protocol of the actual asset. The M+ controller is capable of communicating with a number of protocols including Modbus, 61850, DNP, hardwire I/O and many others.

6.2. Communication with the Utility Grid

The MG will communicate internally via a dedicated fiber loop between all controlled assets. This will likely be installed underground in order to maximize resiliency. Communication with the utility can be via fiber or other wireless means depending on the goals of the utility. Should the communication between utility and MG be compromised, the MG control system can be operated locally at the MG site.

APPENDIX C

Town of Hempstead – NYSERDA
NYPrize Community Microgrid Study

Task 3 - Assessment of Microgrid Commercial and Financial Viability

Agreement Number: 64611

Executive Summary

The following report is the third task in the Feasibility Assessment for a microgrid for the Town of Hempstead, NY (ToH). This task discusses the viability of the project through financial, legal and commercial considerations. The proposed ToH microgrid has unique considerations for commercial and financial viability because it will be a municipally owned and operated system that is being established to ensure operation of critical ToH infrastructure during utility outages caused by storm or other events. The design of the microgrid does not provide a cost/benefit in typical infrastructure project terms in that it's not immediately expected to provide a cost savings. It is a backup system that will allow critical resources to operate in order to maintain the safety and security of the residents of Point Lookout, Lido and nearby communities. An indirect benefit from the installation and operation of this system would be the elimination of importing critical and emergency services during a blackout event from other municipalities, federal sources or the local utility. The system is expected to operate for a week in "Islanded" operation, maintaining water, fire and administrative resources. The costs of emergency services and loss of revenue from the lack of water distribution for a week of operational shutdown would be significant. However, the desired outcome is to not have to the microgrid but have it be available when necessary.

1. Commercial Viability – Customers

The following section discusses the relationship between the critical loads participating in the microgrid, the utility and the benefits shared by the participants.

1.1. Individuals affected by/associated with critical loads

The following buildings are proposed to be part of the microgrid and are considered the critical loads for the proposed microgrid:

- The Town of Hempstead (ToH) Department of Conservation and Waterways (C&W) Administration Building
- The ToH Department of C&W East and West Marinas
- The Lido and Point Lookout Fire Department Headquarters
- The Lido Firehouse
- The ToH Department of Water Lido Point Lookout Water District Well #1 & #2 Main Treatment Plant

The ToH Department of Water Lido Point Lookout Water District Well #3

Because this is a municipally owned and operated microgrid that is designated to serve critical resource and administrative loads of the ToH during emergency situations, there is no direct paid services generated by this system. Because the system is owned and operated by the expected end-users, there are no contractual agreements between critical and non-critical loads and no customers to solicit. The direct benefit of this system is the continuous operation of critical services, including potable water and emergency services, for this island community[1]. The indirect benefits to community in an event that would require the implementation of the microgrid would be the minimizing or elimination of requiring emergency services from other neighboring towns/villages during a storm event and the continued use of the C&W Administration building as an emergency response hub for the community. Following the utility outage caused by Superstorm Sandy in 2012, the C&W administration building served as a communication hub for emergency response personnel arriving to the island and servicing Point Lookout/Lido as well as the City of Long Beach, Atlantic Beach and other communities. The Marinas, included in the microgrid, could also provide a port for water access between all the island communities. With the microgrid intact, emergency services such as Fire and Rescue would be available sooner and would not diminish those services from a neighboring community in the event the microgrid did not exist and they were called upon. The microgrid would also sustain the potable water supply for this community.

2. Commercial Viability - Value Proposition

The following section describes the value the microgrid is expected to provide directly to its participants, to the community at large, the local electric distribution utility and the state of New York.

2.1. Community Benefits and Costs

As stated previously, this municipally owned microgrid is expressly being designed to benefit the community of Point Lookout and Lido Beach by maintaining critical emergency and administrative services during the event of a grid blackout. The costs associated with the design, construction and permitting of the proposed microgrid aresummarized in Table 1. A detailed cost breakdown is also provided in Appendix A.

Table 1 – Microgrid Summarized Costs

Item	Cost ($USD)
Storage	$1,164,937.50
Controls	$57,438.72
General Electrical Equipment and Permitting	$990,782,.05
Initial Design and Planning	$450,000.00
Total	$2,663,158.27

The microgrid would be able to provide 7 days of continuous operation for the supported facilities during any type of event that would cause grid power to go down. This islanded duration would be an indirect benefit to the utility, which would be able to prioritize more severely affected communities during a blackout event in reestablishing power.

[1] The community includes 1,219 Point Lookout and 2,897 Lido Beach residents.

The indirect benefits of eliminating the deployment of emergency services from neighboring municipalities is estimated with consideration of the 2016 operational budget for the Point Lookout Dept. of Water and the 2016 operation budget of the Point Lookout/Lido Fire District.

- Point Lookout/Lido Fire District - $1,258,697 2016 budget
  - $24,205/week operational budget.
  - Assumed factor of 1.5 to bring in emergency resources.
  - ~$36,308 cost to ToH/community for emergency fire resources in week-long outage
- Point Lookout Water District - $3.1M 2016 budget
  - $59,615/week operational budget.
  - Assumed factor of 1.5 to bring in emergency resources.
  - Cost to community ~$89,420 for emergency water resources in week-long outage
  - Loss of revenue – 442 gallons/day per customer with a cost of $4.63 per thousand gallons – total revenue loss for 7 days of water utility blackout is $17,500.
- Total indirect savings ~$143,228 for week-long outage.

Because this is not a commercial venture, a business model does not easily apply to this proposed system. The project viability in terms of a strengths, weaknesses, opportunities and threats (SWOT) analysis is contingent on funding. Table 2 outlines the SWOT parameters for the proposed microgrid.

Table 2 – SWOT analysis of ToH Microgrid

Strengths	- Town of Hempstead has an excellent track record of installing and operating advanced energy systems including solar PV, and wind turbines. - There is explicit support from PSEG-LI, National Grid and the local community.
Weaknesses	- Little opportunity to monetize microgrid
Opportunities	- The New York State Energy Research Development Administration could potentially fund the proposed system.
Threats	- The system could be cost prohibitive to install without NYSERDA support.

2.2. Utility Benefit

There could be benefits to the utility in episodes where the utility requires load shedding to stabilize the grid. However, with respect to the current utility plans for PSEG-LI, the timeliness of the proposed microgrid for the ToH would not meet the requirements of the current RFI[2] for demand response offered by PSEG-LI and this type of demand response operation is not evaluated in this study.

3. Unique Characteristics of Town of Hempstead Microgrid

Resiliency is of the utmost importance in planning this project. Point Lookout suffered from a two week utility electrical blackout during the 2012 superstorm Sandy. This led to many of the emergency response and critical services becoming inoperable. The ToH C&W administration building was without power which hindered community response. The fire stations at both Point Lookout at Lido Beach were also without power which hindered emergency response. The Department of Water facility at Point Lookout was able to operate pumps because of their natural gas fired generation assets but all of Point Lookout east of the East Marina lost their natural gas supply. Because of this, the supply of natural gas can not be counted on in future blackout events and the microgrid is therefore designed to provide up to one week operation for the connected facilities without use of natural gas.

The design of this microgrid is in consideration of the events of superstorm Sandy. The microgrid will be built to operate in the event of a utility blackout but with design considerations for flooding and high winds. To ensure the microgrid remains operable during emergency scenarios, electronic controls and equipment will be elevated and placed in weather-proof enclosures. Conduit running underground will be buried and sealed from water intrusion. Local fuel storage is provided so that the microgrid can support connected facilities for up to a week without outside resources.

Microgrids may still be considered unique as there are so few in operation worldwide in comparison to conventional large scale utility grid. However, when comparing the ToH microgrid to other microgrids, there are a few aspects that make this one unique. The first is that there already exists a large number of on-site distributed generation sources, thereby adding significant savings to the implementation of a microgrid. The second unique characteristic is diversity in type of distributed generation sources, which adds to the resiliency of the microgrid to withstand the lack of different resources. These sources are also very complementary in terms of volume of energy production, ramp rates and time of generation. The last aspect that makes this microgrid unique is that, as a local government agency, and in area that was significantly affected by Hurricane Sandy, this microgrid may, better than others, be able to assist emergency and other governmental services in the case of a natural disaster or loss of utility grid.

[2] https://www.psegliny.com/files.cfm/RFI-loadrelief.pdf

3.1. Replicability/Scalability of Design

On-site distributed generation is common with local government facilities, especially with the increased adoption of solar energy. However, solar energy also rarely operates in the absence of the utility grid. Microgrids can change that, by allowing solar to operate during blackouts, thereby extending the fuel supply for other distributed generation sources at local governmental facilities. The ToH microgrid has the visibility to demonstrate the success of a microgrid for integrating government facility complexes with reasonable capital costs. AECOM, as part of the ToH microgrid, and with a global presence and over 85,000 staff has the reach within our existing clientele to roll out this technology on a global scale.

3.2. Support State Policy Objectives

The project supports several of the State of New York REV policy objectives towards energy resiliency. The project will:

- Safeguard the Point Lookout community from storm events
- Provide local jobs and business opportunities with the construction of the microgrid
- Help clean energy innovation grow by including the ToH's existing renewable energy systems, ABB's storage technology, and smart, responsive communication and control of these elements within the microgrid

3.3. Promote New Technology

Batteries cannot be considered new technology, however, the use of batteries and controllers to seamlessly integrate fossil fuel based and renewable generation while maintaining high power quality, and maximizing renewable penetration is still a practice in its infancy. Fossil fuels storage by way of tanks of diesel or other liquid fuels are inexpensive when compared to other chemical storage such as batteries, and provides huge savings for the successful development of microgrids. However, small amounts of batteries with abilities to quickly discharge large amounts of power in order to provide that seamless transition from renewables to fossil fuels is necessary. This project can help promote and demonstrate the use and economics of the technologies in this way.

4. Commercial Viability - Project Team

The following section describes the structure of the project team and the roles, strengths and resources of its members and partners. If the microgrid conceptualized during this feasibility study were to be implemented, it is assumed the team members of the feasibility phase would play similar roles. In addition to the study team, qualified contractors and equipment vendors would need to be competitively selected for construction based on the procurement requirements of the funding source.

4.1. Town of Hempstead

The ToH will be the owner and operator of the proposed microgrid. The Department of Conservation and Waterways (C&W) will provide oversight of its operation either directly or through subcontracted services. The ToH, with the leadership of C&W, has instituted a large number of successful advanced energy projects that include 250 kilowatts of solar and wind generation with another 200 kilowatts of solar panels on the ground ready for installation funding. The ToH has a history of developing and executing large, advanced energy projects and energy master plans. Their thought leadership will benefit this microgrid project greatly along with the community support that has been gained through the success of previous projects. Community outreach has been a major component of the renewable energy installations and has included educational programs at the installations and also educational outreach with local schools and the general public.

The ToH has effectively secured funding, mostly through grants, for all previous energy projects. With expected energy savings and paybacks, these projects were financially beneficial to the ToH. The microgrid project would be a major safeguard for storm resiliency but not a financially beneficial project. Funding would need to be provided from an outside funding source, such as a grant from NYSERDA. Alternatively, the ToH could construct the microgrid in phases with funding from the ToH's Capital Budget over a period of time.

Legal and regulatory guidance for the issues related to this project could be sought from local consulting firms with experience in microgrid projects, such as Veolia or Navigant Consulting, Inc. during the design phase of the project.

4.2. AECOM

AECOM is providing the ToH with the conceptual design of the proposed microgrid. AECOM is a world class planning, engineering and construction management firm that is also an accredited energy services company by the National Association of Energy Service Companies (NAESCO).

Ranked #2 in Power, #1 in Solar, #1 in Transmission and Distribution, #1 in Wind Power, and #1 U.S. Design Firm by the Engineering News Record, AECOM has a substantial track record of delivering on both progressive and critical energy projects. We have expertise in the technologies relevant to this work: AECOM has studied, designed, and built cogeneration plants, solar PV, boilers, chillers, emergency generation, substations, switchgear, and controls. In New York alone, AECOM has developed and implemented over $800 million in energy projects that resulted in more than $150 million in annual savings.

Our team has worked with the ToH closely through the development of their Energy and Sustainability Master Plan and understands the site specific constraints.

4.3. ABB

ABB is a 125 year old global supplier of power and grid integration technologies. The proposed design incorporates ABB's battery storage technology to integrate the existing generation assets into the microgrid. They have worked with AECOM to determine the battery storage parameters for this design.

4.4. PSEG-LI

PSEG-LI is the local electric utility that serves the ToH and Point Lookout. PSEG-LI has provided a letter of commitment in support of the microgrid project.

5. Commercial Viability - Creating and Delivering Value

The following section describes the mechanics of ensuring that expected value is delivered to project participants.

5.1. Specific Microgrid Technologies, Benefits, Challenges

The proposed microgrid will use renewable power, solar and wind, along with natural gas and diesel fossil fuel based generation. All of this generation is already in place and is capable of supplying the facilities when the utility grid is down for up to one week with the current storage capabilities and an N-1 contingency. To integrate them, and allow for variability of large amounts of renewable power, the microgrid will use ABB's PowerStore® battery based power supply to insure a smooth supply. The ABB technology was chosen because it is the only known turnkey system that can disconnect all the facilities in question from the utility grid, balance generation with loads, and re-synch the microgrid with the utility once the grid comes back online. This battery bank will not provide long-term energy storage, but rather large amount of power in a short term to allow for maximum renewable energy penetration. Long term (more than a few hours) storage will be provided by natural gas supply lines and diesel fuel tanks. This provides a significant cost advantage to using battery-based storage. Additionally, the autonomy of the system can easily and cheaply be increased simply in the N-2 contingency by adding additional diesel fuel storage. The highest level of engineering expertise involved in implementing this microgrid design stems from the integration of the controllers from the fossil fuel generators from different manufacturers, as well as the large number of nodes, or number of controls, those for each piece of switchgear, and generator, of which there are many. While challenging, this is well within the engineering expertise of AECOM and ABB.

5.2. Assets Currently Owned by the Town of Hempstead

The following tables list the generation assets currently owned by the ToH that will be incorporated into the proposed microgrid.

Table 3. Department of Water, Generation Equipment

Town of Hempstead Department of Water								
Fuel Type	Make	Model	Installed Capacity (kW)	Voltage (V)	Serial Number	Year Installed	Fuel Tank	Power Factor
Diesel	Stamford (Cummins)	QSM11-G4 NR3	300	NA	35260955	2009/2010	1300	N/A
Diesel	AC (Detroit Diesel)	HC244C	40	240	P3036/7	N/A	1000	0.8

Table 4. Department of Conservation and Waterways, Generation Equipment

Town of Hempstead Department of Conservation and Waterways									
Item	Fuel Type	Make	Model	Installed Capacity (kW_{DC})	Installed Capacity (kW_{AC})	Voltage (V)	Serial Number	Year Installed	Location
3	NG	Generac	QT036224KNAN		36	480	5756027	2012	Hydrogen
4	Propane	Generac	QT06024GVSX		60	208	9519879	2015	West Marina
5	NG	Kohler	150REZGC		150	208	SGM32B3FP	2014	Admin
6	NG	Kohler	100RZG		100	208	2147259	2008	East Marina Laboratory
Fossil Fuels			Subtotal		346	kW			
7	Solar	Sharp/SMA	SMA Sunny Boy	9.6	8.7	208	N/A	2003	Admin Building Roof
8	Solar	Sanyo/Enphase	Sunny Boy	57.2	45.8	208	N/A	2012	Ground Mount System in Energy Carport
9	Solar	Sanyo/Enphase	Enphase M210		14.1	208	N/A	2012	NYIT Solar House
10	Solar	Sanyo/SMA	Sunny Boy	2.6	2.6	208	N/A	2009	Shed
11	Solar	Sharp/SMA	Sunny Boy	5.3	5.1	208	N/A	2010	Aquaculture Facility
12	Solar	Sharp/Sma	Sunny Boy		3.7	208	N/A	2010	FLUPSY
13	Solar	Sharp SMA	Sunny Boy		10.1	208	N/A	2007	East Marina Laboratory
14	Solar	Sanyo/SMA	Sunny Boy	23.1	36.0	208	N/A	2012	Admin Carport
15	Solar	Sunpower/SMA	Sunny Boy	4.9	5.0	208	N/A	2013	Energy Park Carport
16	Solar	Sunpower/SMA	Sunny Boy	13.6	12.0	208	N/A	2013	East Marina Carport
17	Solar	Single Axis Tracker	Sunny Boy	1.8	1.7	208	N/A	2011	Energy Park
18	Solar	Dual Axis Tracker	Sunny Boy	3.5	3.4	208	N/A	2011	Energy Park
19	Wind	Nothern Power Systems	Northern Power 100	NA	100	480	00184	2012	Energy Park
20	Wind	Southwest Windpower	Skystream	NA	2.4	208	N/A	2009	Aquaculture Facility
Renewable			Subtotal		250.3	kW			
			GrandTotal		**596**	**kW**			

Table 5. Lido and Point Lookout Fire, Generation Equipment

Town of Hempstead Department of Water								
Fuel Type	Make	Model	Installed Capacity (kW)	Voltage	Serial Number	Year Installed	Fuel Tank	Power Factor
Gasoline	Generac	XP800E	8	240	N/A	2011	N/A	N/A
Natural Gas	Onan	45EM-4R8	125	120/208	1068069406	1968	N/A	N/A

5.3. New Generation Equipment

In order to supply the entire demand in an N-1 and N-2 contingency as explained next, two new generators will need to be installed at the Water Department's Well #3.

Table 1 Department of Water, Well #3, Generation Equipment

Town of Hempstead Department of Water, Well #3						
Fuel Type	Make	Model	Installed Capacity (kW)	Voltage (V)	Serial Number	Power Factor
Diesel	HIPOWER Systems	HFW160 T6U	160	480/277	N/A	N/A
NG	GM	HGM-150 T6U	150	480/277	N/A	N/A

5.4. Balancing of Generation and Load

There are two scenarios envisioned for the operation of the microgrid and the necessary balancing of generation and load.

Scenario 1 – When the utility electric grid is on, the grid itself acts as an infinite source of power, balancing the site load as needed.

Scenario 2 – When the electric grid is down, the microgrid is established by connecting all the facilities' generation assets. The ABB outfitted controllers on the fossil-fuel generators will be responsible for balancing generation with demand. Both wind and solar, under this scenario, would merely be seen as negative load.

5.5. Permitting

For the generation assets, an electrical/building permit will be required. Because the power lines will be crossing a right-of-way/highway in order to connect the East Marina to the Conservation and Waterway building, and to both fire stations and Well #3, consent is needed from PSEG-LI for connecting discontinuous parcels of property with consent provided by the NYS Department of Transportation. This would be required for any microgrid connecting discontinuous parcels of property.

5.6. Developing, Constructing and Operating

As this microgrid is not intended to be a commercial, revenue generating system, it is anticipated that the Town would either follow a traditional design/bid/build process or an alternative delivery design/build process. One of the key factors in selecting the delivery path will be if the Town decides to build the entire microgrid as a single project or if the work will be phased. If the project were to be constructed in a single phase, the Town could either follow the design/bid/build process, hiring separate design and construction firms or the design/build process and hire a single firm. The design/build approach would be recommended in this instance as it would allow for more direct interaction between the design team, the equipment manufactures, and the contractor.

If the Town elects to build the microgrid in stages with their own funding, a design/bid/build approach would be used with the design of the entire system being developed in a single process but broken into separate bid packages for construction that the Town could procure in stages as funding became available. The design would integrate input from equipment vendors to determine performance specifications for key project elements but the construction would be competitively procured after the design is complete.

After system commissioning, the intent is for the Town to own and operate the microgrid (as it currently owns and operates the majority of the microgrid assets) though the design phase will need to include a more detailed interaction with PSEG LI to develop the specifics of the interconnection and how the microgrid will ensure safe interaction with the larger grid.

5.7. Community Benefits and Costs

Benefits of the microgrid to the local community come from increasing the operational capabilities of the critical infrastructure that is connected to the microgrid. In this case, the Water Plant that supplies the potable water to the community and the Fire district headquarters would both offer increased resiliency with the microgrid. This benefits the community by increasing the available of potable water, and the Fire Department to provide emergency services. Powering the Marinas with the microgrid helps to insure alternative means of transportation and delivery of goods and services, via the waterways in the cases where the bridge to the mainland is closed. The rest of the facilities have served as a community center in order to provide logistic staging support in the case of emergency. Lastly, under scenarios where the wind, solar and natural gas are sufficient to power the microgrid during a utility outage, the ToH could elect to supply the significant amount of diesel storage to emergency vehicles. Should the other generation sources provide all the necessary electricity, pumping of the diesel would possible.

5.8. Utility Requirements

In order to connect the Fire District headquarters and Lido fire station and to strengthen the Fire Department's resiliency under emergency situations when the grid is down, the Fire District stations as well as the Well #3 pumping station are proposed to be part of the microgrid. However, since the Fire District headquarters is roughly a quarter-mile down the street from the otherwise contiguous parcels of land, power cables have to be installed through a city Right-of-Way. The Lido fire station and Well #3 are roughly 2.5 miles to the west of the C&W administration building. There are two reasonable options for connecting the Fire District headquarters, the first is trenching through the street from the East Marina to the Fire District Headquarters, and installing new conduit between the two facilities, establishing new infrastructure. The second option is to use the electric utility's poles along the street; this would be a far cheaper option. This would also be the only realistic option for connecting Well #3 and the Lido Point Lookout fire station. If the poles cannot be used, the financial case for integrating the Fire District Headquarters, the Lido fire station and Well #3 into the microgrid cannot be justified in the face of the alternative of providing an N-1 contingency over one week using fossil fuel generators as a stand-alone system at the these locations. For these reasons, in order to provide the best value to the community and the ToH, the electric utility's support in using their poles to install Town owned cables for interconnection between these facilities and generation equipment would be required.

5.9. Microgrid Technologies Maturity

At the time of writing, the technology proposed to control the automatic transfer switches and to control the generators output is designed and manufactured by ABB. The product is called PowerStore® and has been successfully demonstrated in a number of microgrids in Australia, Alaska, Portugal and Kenya[3]. While the exact combination of generating technologies proposed for use in the ToH microgrid has never before been used with PowerStore®, there is no reason to expect such combination is not feasible. The remaining technologies, such as transfer switches, feeders and transformers are already in use and expected to integrate without issue.

5.10. Operational Scheme

In order to make sure this local governmental owned microgrid operates as expected, technical and microgrid management issues must be resolved. Since this is not a commercial microgrid, there are not any financial or transactional issues that must be resolved. The commissioning process, that of turning the system on for the first time, and testing it, is the most important step for resolving technical and management issues. While the normal operation of the microgrid will be by the town, coordination with the utility in the design phase for the interconnection will be necessary. Commissioning of novel and innovative electric technology such as a microgrid involves careful consideration. While the exact details of the commissioning would be worked out only after the detailed design is complete, a simulation of a downed electric grid needs to be undertaken with all entities involved in the commissioning simulation. It is likely impossible for the local electric utility to turn off the local electric grid in order to undertake a commissioning

[3] http://new.abb.com/power-generation/microgrids-solutions/microgrid-and-stabilization-for-mining

simulation as this would likely mean turning off electricity for other customers. Thus it may be required to turn off the main disconnect switch for the service equipment for each facility in order to simulate a downed grid. Again, in order to say with certainty how this will be done can only be done after final design is in place, as the exact location of the microgrid controller is not known at this time. However, once the electrical grid is simulated to have gone down, the microgrid operation, signified by the parallel production of renewable resources and fossil fuel generators, needs to be confirmed. Electrical supply at each of the facilities then needs to be confirmed. Once this is done, a test of the loads to be supplied by the microgrid should be done. The order of activating each load will be determined during the detailed design. The successful operation of the microgrid and supply of the loads by the generators for a limited length of time necessary to see the renewable generators decrease to zero contribution of generation and then return to partial or full generation would be necessary to confirm the microgrid operates as expected.

5.11. End User Purchasing

This proposed microgrid is a local government owned system and is thus not meant to be commercial venture. The cost of the diesel and natural gas that will be used to power the microgrid will be borne by the facility that houses the generator without any anticipated charges from one facility to another. The electricity generated by the solar and wind will be provided by the facilities that house those generators and shared amongst all facilities, without any charges from one facility to another. For these reasons no additional meters will be installed to account for.

5.12. Business/Commercialization and Replication Plans

AECOM provides engineering and design services for a large number of local, regional, and national governments worldwide. This project provides a newfound capability that allows firms such as AECOM the capabilities to meet the needs of governmental agencies worldwide in increasing their resiliency. This project frames the basis of what is needed for a typical community back-up power supply system to be networked and operated to supply power to critical facilities during a utility black out. The system leverages existing assets and proposes interconnection as cost effectively as possible in order to make this a buildable project. The replicability of this system is very possible considering these practical aspects of the design and cost considerations. Advanced energy systems such as the solar and wind generation that was owned by the Town is not necessary in providing the ultimate use of this system but helps promote the larger agenda of energy efficiency and renewables integration. For another town to implement a similar project, all existing distributed generation assets could be considered for integration as advanced technologies aren't necessary.

5.13. Microgrid Market

The potential for further implementation of microgrids such as this size and operating in this capacity is large. Extrapolating this system out to other local municipalities throughout the US, assuming at least one main administrative municipal building with on site generation and several nearby ancillary municipal facilities, it could be surmised that the potential could exist for each of the 89,000 local governments registered in the US.

1.1.1. Market Entry Barriers

For contiguous parcels owned by the same entity where no electricity is being sold, the barrier to entry to microgrids is no larger than for stand-alone emergency back-up power systems. For participants on non-contiguous parcels, there may be legal implications that will be investigated later. As this project did not involve the proposed sale of electricity, the barriers to entry for such a microgrid design will not be analyzed.

1.1.2. Overcoming Barriers

An understanding of the legal implications of connecting non-contiguous parcels of land with electrical power lines is critical to the expansion of these systems. This barrier to market expansion will require a regulatory examination by legal experts to understand the feasibility of connecting these parcels at the macro level (US potential) and the micro level (individual project sites).

6. Financial Viability

The proposed system is designated to be an emergency backup system to protect this island community in events which may cause the utility grid to shut down. This is not a commercial venture and is not expected to provide a revenue stream to the ToH.

7. Legal Viability

The following section describes the legal terms/conditions/requirements necessary to develop and operate the proposed microgrid.

7.1. Access and Privacy Rights

The ToH, owner and operator of the proposed microgrid, is the owner of the facilities and generation assets that will make up the microgrid. Access to these assets is universal for the ToH and because this is a municipal project, all project information and energy information will be public. Privacy laws for the energy data would not apply to this project.

As noted elsewhere in this document, there will need to be further interaction with PSEGLI to determine how control at the interconnection point is managed and what the specific requirements are for use of the PSEG LI utility poles as the details of the distribution are established in the design phase.

AECOM

APPENDIX A

Appendix A - MicroGrid Bill of Materials							
Equipment	**Per Unit Cost**	**Qty**	**Unit**	**Description**	**Manufacturer**	**Model**	**Total**
Storage							$ 1,164,937.50
ABB PowerStore	$ 750,000.00	1	ea	500 kW, 500 kWh, Li-Ion Battery based storage			$ 817,500.00
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 20,437.50
Electrical Labor		1	ea				$ 327,000.00
Controls							$ 57,438.72
800A 120/208	$ 5,246.00	7	ea	New ATSs as shown in 1-line	Generac	Gaurdian RTSN800G3	$ 40,026.98
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 1,000.67
Electrical Labor		1	ea				$ 16,411.06
General Electrical Equipment							$ 990,782.05
Connection of Water District Plant to C&W Admin Building							$ 60,709.39
400 MCM Cu, 3P4W, THHN	$ 5.5610	5560	ft	New Feeder from Water to Admin			$ 33,701.88
3" PVC Sch 40	$ 1.420	5560	ft	New Feeder from Water to Admin			$ 8,604.31
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 1,057.65
Electrical Labor		1	ea				$ 17,345.54
Connection of C&W East Marina to C&W Admin Building							$ 132,020.89
400 MCM Cu, 3P4W, THHN	$ 5.5610	10800	ft	New Feeder from East Marina to Admin			$ 65,464.09
3" PVC Sch 40	$ 1.420	1100	ft	New Feeder from East Marina to Admin			$ 1,702.29
Concrete	$ 90.00	53.47	yd^3	Concrete to repave parking lot, 21"x18"trench			$ 5,245.63
3" HDPE	$ 3.28	540	ft	HDPE			$ 1,930.61
Underground handhole (4'x4')	$ 1,800.00	6	ea	At each end of the HDPE, parking lot, en	Jensen	K44-FP36-05TG	$ 11,772.00
Directional Boring	$ 10.00	540	ft	Labor and Machine Rental			$ 5,886.00
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 2,300.02
Electrical Labor		1	ea				$ 37,720.25
Connection of C&W East Marina to Lido/PL Fire District HQ							$ 63,901.09
400 MCM Cu, 3P4W, THHN	$ 5.5610	5240	ft	New Feeder from L/PL Fire District HQ to East Marina			$ 31,762.21
3" PVC Sch 40	$ 1.420	1310	ft	New Feeder from L/PL Fire District HQ to East Marina			$ 2,027.28
Concrete	$ 90.00	139.03	yd^3	Concrete to repave parking road, 21"x18"trench			$ 13,638.63
Pole Rental, If aboveground							$ -
Transformers	$ 3,470.00	2	ea	120/208 to 277/480 Dry Type Xfrmr	Eaton/CH	V48M28T45	$ 7,564.60
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 1,374.82
Electrical Labor		1	ea				$ 22,547.01
Connection of Lido/PL Fire Station to Well #3							$ 252,350.37
400 MCM Cu, 3P4W, THHN	$ 5.5610	22200	ft	New Feeder from L/PL Fire Station to Water			$ 134,565.08
3" PVC Sch 40	$ 1.420	5550	ft	New Feeder from L/PL Fire Station to Water			$ 8,588.84
Transformers	$ 15,000.00	2	ea	120/208 to 4160	Generic	NA	$ 32,700.00
Pole Rental from PSEG-LI							
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 4,396.35
Electrical Labor		1	ea				$ 72,100.11
Connection of Well #3 to Wells #1 and #2							$ 408,635.70
400 MCM Cu, 3P4W, THHN	$ 5.5610	22200	ft	New Feeder from L/PL Fire Station to Water			$ 134,565.08
3" PVC Sch 40	$ 1.420	5550	ft	New Feeder from L/PL Fire Station to Water			$ 8,588.84
Transformers	$ 15,000.00	2	ea	120/208 to 4160	Generic	NA	$ 32,700.00
NG Generator	$ 58,522.10	1	ea	HGM-150 T6U	GM		$ 63,789.09
Diesel Generator	$ 41,395.00	1	ea	HFW160 T6U	HIPOWER Systems		$ 45,120.55
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 7,119.09
Electrical Labor		1	ea				$ 116,753.06
Connection of West Marina to Water Dept							$ 22,208.20
400 MCM Cu, 3P4W, THHN	$ 5.5610	2400	ft	New Feeder from West Marina to Water			$ 14,547.58
3" PVC Sch 40	$ 1.420	600	ft	New Feeder from West Marina to Water			$ 928.52
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 386.90
Electrical Labor		1	ea				$ 6,345.20
Connection of West Marina to Aquaculture Facility							$ 44,416.40
400 MCM Cu, 3P4W, THHN	$ 5.5610	4800	ft	New Feeder from West Marina to Water			$ 29,095.15
3" PVC Sch 40	$ 1.420	1200	ft	New Feeder from West Marina to Water			$ 1,857.05
Miscellaneoues		1	ea	Conduit bodies, fittings, hose clamps, etc.			$ 773.80
Electrical Labor		1	ea				$ 12,690.40
Permitting							$ 6,540.00
PSEG-LI	$ 1,000.00	1	ea	Interconnection of a Battery Based Source			$ 1,090.00
NY State Dept of Transportation	$ 5,000.00	1	ea	Permit to Direction Bore Under Roadway			$ 5,450.00
					Grand Total		**$ 2,213,158.27**

Benefit-Cost Analysis Summary Report

Site 13 – Town of Hempstead

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, The Town of Hempstead has proposed development of a microgrid serving several fire stations and facilities associated with the Department of Conservation and Waterways (C&W), including the Department of C&W Administration Building, the Department of C&W East Marina, and the Department of C&W West Marina. In addition, the microgrid would serve two water pump houses, Lido-Point Lookout Water District Well #1 and #2 (Main Treatment Plant), and Lido-Point Lookout Water District Well #3 (Lido Beach Fire Station).

The microgrid would combine 24 existing distributed energy resources (DERs): five natural gas-burning generators with a combined nameplate capacity of 0.561 MW; three diesel-burning generators with a combined nameplate capacity of 0.5 MW; 2 wind turbines with a combined nameplate capacity of 0.102 MW; 12 photovoltaic (PV) units with a combined nameplate capacity of 0.148 MW; a propane-burning 60-kW generator; and a gasoline-burning 8-kW generator. Of these, the solar and wind generators would be used under normal operating conditions, while the other DERs would supplement production only during major power outages. The project's consultants also indicate that the system would have the capability of providing ancillary services to the grid.

To assist with completion of the project's NY Prize Stage 1 feasibility study, IEc conducted a screening-level analysis of its 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.

NY PRIZE STAGE 1 BENEFIT-COST ANALYSIS SUMMARY REPORT: SITE 13 – TOWN OF HEMPSTEAD

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.[1] 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.[2]

[1] 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.]

[2] 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 suggest that if no major power outages occur over the microgrid's assumed 20-year operating life, 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 exceed approximately 2.2 days per year (Scenario 2). The discussion that follows provides additional detail on the findings for these two scenarios.

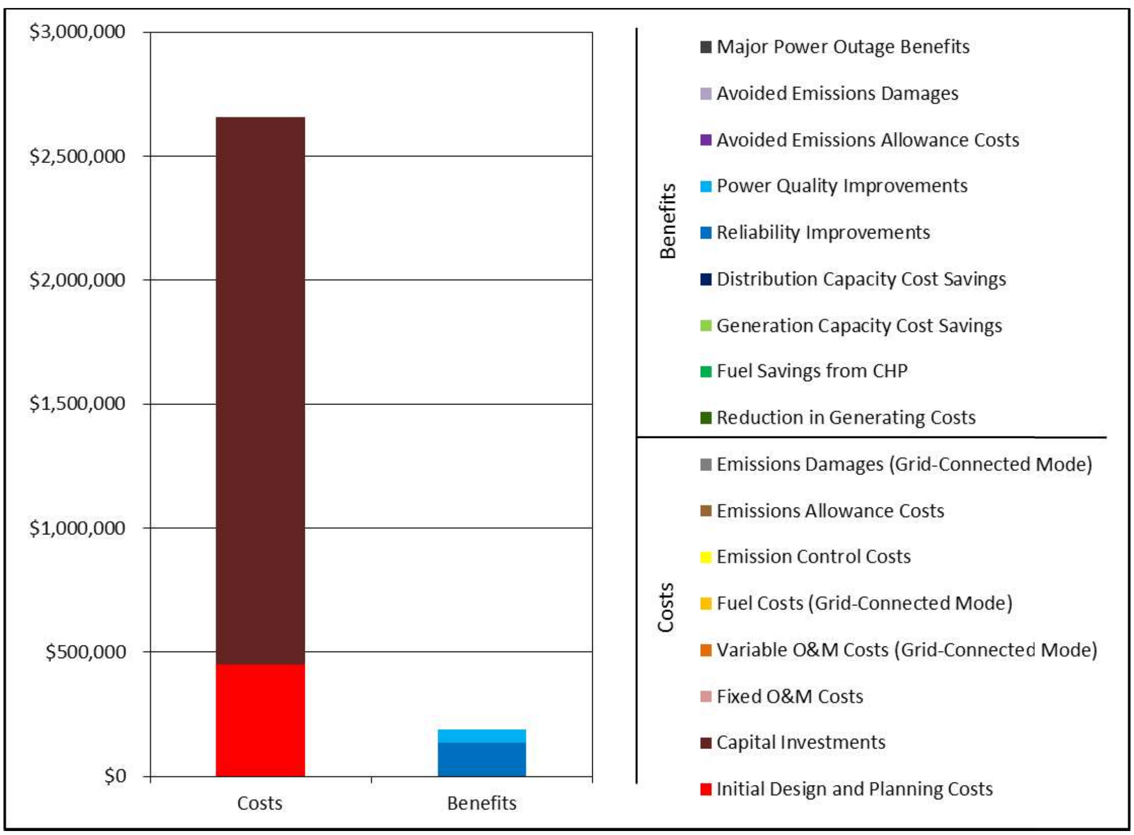
Table 1. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 2.2 DAYS/YEAR
Net Benefits - Present Value	-$2,470,000	$92,000
Benefit-Cost Ratio	0.1	1.0
Internal Rate of Return	-15.8%	7.5%

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)



NY PRIZE STAGE 1 BENEFIT-COST ANALYSIS SUMMARY REPORT: SITE 13 – TOWN OF HEMPSTEAD

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	$450,000	$39,700
Capital Investments	$2,210,000	$195,000
Fixed O&M	$0	$0
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	**$2,660,000**	
Benefits		
Reduction in Generating Costs	$0	$0
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$0	$0
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$134,000	$11,800
Power Quality Improvements	$54,700	$4,830
Avoided Emissions Allowance Costs	$0	$0
Avoided Emissions Damages	$0	$0
Major Power Outage Benefits	$0	$0
Total Benefits	**$189,000**	
Net Benefits	**-$2,470,000**	
Benefit/Cost Ratio	**0.1**	
Internal Rate of Return	**-15.8%**	

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 $450,000, including engineering reports, surveying, geotechnical reports, and design drawings. The present value of the project's capital costs is estimated at approximately $2.2 million, including the costs of battery storage for the PV units, microgrid controls, and connections among the various DERs.

Because the microgrid's DERs are already in place and their utilization would not change with the project's development, no change in the fixed operations and maintenance (O&M) costs for these units is expected. Accordingly, the analysis sets the project's fixed O&M costs at zero.

Variable Costs

Variable costs for microgrid projects typically include fuel costs associated with operating DERs. Because the microgrid's fuel-burning DERs would continue to be used solely in the event of a major power outage, the analysis does not consider the costs associated with their operation to be incremental costs attributable to the microgrid. Similarly, the analysis does not estimate any costs associated with pollutant emissions from operating the microgrid's DERs, because the operating profile of these units is not expected to change.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred, including generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. As noted above, the development of the microgrid is not expected to change the operating profile of the microgrid's DERs. Furthermore, development of the microgrid would have no effect on system-wide generating or distribution capacity. Accordingly, the analysis attributes no energy, fuel, or capacity cost savings to the project's development.

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

Reliability Benefits

The primary 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 $11,800 per year, with a present value of $134,000 over a 20-year operating period. This estimate was calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[3]

- System Average Interruption Frequency Index (SAIFI) – 0.72 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 81.6 minutes.[4]

The estimate takes into account the number of small and 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.[5] 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.

[3] www.icecalculator.com.

[4] SAIFI and CAIDI values were provided by the project team for PSEG Long Island.

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

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. The Hempstead project team estimates that the microgrid would help the facilities it serves avoid less than one power quality event per year; for purposes of analysis, we set this figure to one. The model estimates the present value of this benefit to be approximately $54,700 over a 20-year operating period.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of approximately 0.1; i.e., the estimate of project benefits is approximately 10 percent of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

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.[6,7]

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

- Whether or not backup generators are currently available at the facility;
- Whether the facility would rent a backup generator to supply power during an outage;
- The ability of the facility to operate when using backup power;
- The ability of the facility to operate during a complete loss of power;
- The cost of operating backup generators;
- The extent to which the facility incurs costs for emergency measures (e.g., evacuating personnel); and

[6] The methodology used to estimate the value of selected 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.

[7] 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.

- The economic value of the services that the facility would cease to provide during an outage.

The following descriptions summarize these parameters for the facilities to be supported by the proposed microgrid:

- **Department of C&W Administration Building**: This facility currently has backup generators that would support full provision of services during a major power outage. If these backup generators were to fail, the analysis assumes that the facility would lose 100 percent of its service capabilities. Using the ICE Calculator, the analysis estimates the value of services provided by this facility to be about $37,400 per day.[8]

- **Department of C&W East and West Marinas:** Whereas the West Marina currently has a backup power source, the East Marina does not. During a major power outage, the analysis assumes that the East Marina would rent a backup generator at a cost of $1,679 per day. With backup generators in place, both facilities would experience no loss in service capabilities; they would lose all such capabilities if their backup generators were to fail. Using the ICE Calculator, the analysis estimates the value of services provided by the marinas to be about $76,600 per day.

- **Lido and Point Lookout Fire Department Headquarters**: Both fire stations have backup power that would support full service capabilities during a major power outage. If their backup sources were to fail, these facilities would experience a 50 percent loss in service capabilities. Using a methodology developed by the Federal Emergency Management Agency (FEMA), the analysis estimates the value of services provided by these facilities to be about $1,030 per day (assuming that the stations serve a population of about 4,120 people).

- **Department of Water Lido Point Lookout Water District Well #1 & #2 (Main Treatment) and Well #3 (Lido Beach Fire Station)**: These pump house facilities are supported by backup generation that is expected to support full service capabilities during a major outage; they would not function if their backup generators were to fail. Should that occur, the project team indicates that the Department of C&W would haul water from the Town of Hempstead's nearby Uniondale facility, at a daily cost of about $13,900. Using FEMA methodologies, the analysis estimates the value of the water and wastewater treatment services provided by these facilities to be about $391,000 per day (assuming that they serve a population of about (4,120 people).[9]

In all cases, backup generators are assumed to run 24 hours per day, and each is assumed to have a 15 percent chance of failing.

[8] For the Department of C&W Administration Building and the Department of C&W West Marina, the project team indicated that if the existing backup generator failed, the facilities would obtain additional generators at a cost of $1,679 per day. The analysis employs a standard assumption across all sites, however, that if existing generators fail, the supported facilities would be left without backup generation.

[9] The project team estimates that the water hauled in from the Uniondale facility would be sufficient to meet basic drinking water needs. The FEMA methodology estimates that the value of water for basic needs is about 13 percent of the total value of water treatment services. The BCA takes this into account in estimating the impact of a loss of power at the pump houses.

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 2.2 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 2.2 Days/Year; 7 Percent Discount Rate)

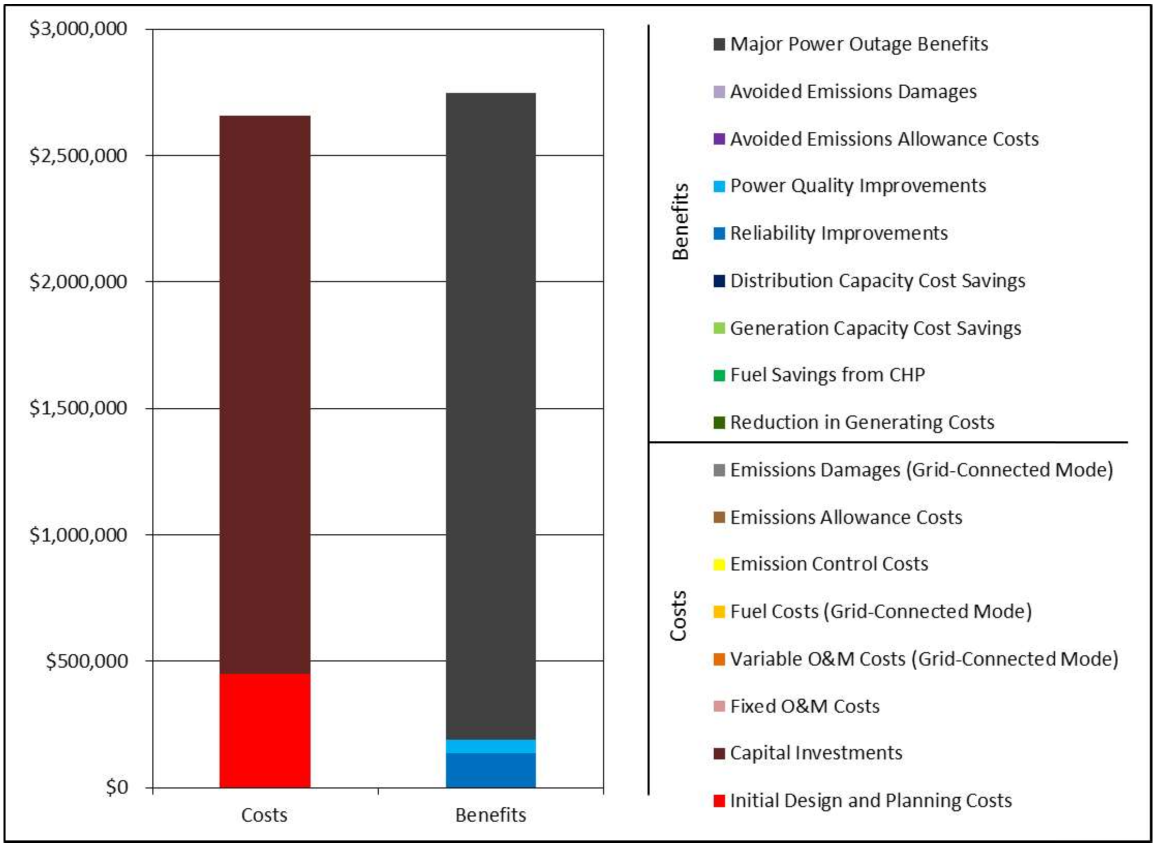


Table 3. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 2.2 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$450,000	$39,700
Capital Investments	$2,210,000	$195,000
Fixed O&M	$0	$0
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	**$2,660,000**	
Benefits		
Reduction in Generating Costs	$0	$0
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$0	$0
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$134,000	$11,800
Power Quality Improvements	$54,700	$4,830
Avoided Emissions Allowance Costs	$0	$0
Avoided Emissions Damages	$0	$0
Major Power Outage Benefits	$2,560,000	$226,000
Total Benefits	**$2,750,000**	
Net Benefits	**$92,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.5%**	