4 - Village of Greenport

Notice

NY Prize Village of Greenport Community Microgrid Stage 1 Feasibility Study

Prepared for: **The Village of Greenport**

Prepared by: **Global Common**

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Legal Notices

Foreword

This report was prepared for the Village of Greenport by Global Common (GC), General Electric International, Inc. ("GEII"); acting through its Energy Consulting group ("GE Energy Consulting") based in Schenectady, NY, D&B Engineers (D&B), and Burns Engineering (Burns) and submitted to the NYSERDA. Questions and any correspondence concerning this document should be referred to:

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EXECUTIVE SUMMARY

Background

The Village of Greenport is located on the east end of the north fork of Long Island, about 100 miles east of Manhattan, and about nine miles west of Orient Point, which is the eastern most point on the north fork of Long Island (LI). The 2010 Census population was 2,197. The population increases to over 3,000 in the summer due to tourism.

Greenport Municipal Utilities (GMU) is a municipal electric utility that serves about 2,000 customers, about 1,000 of which are within the Village. The non-coincident peak demand in the village is approximately 6.6 MW. The Village has its own 6.8 MW power plant that uses Number 2 fuel oil. The plant has three diesel generating units that were installed in 1957, 1965 and 1971. Because of the age of these units, they are only used for back-up power, and their long-term reliability is questionable.

The Village has a full requirements contract with the New York Power Authority (NYPA), and gets about 70% of its power from a hydro allocation from the Mohawk/Niagara facility, at a cost of less than $0.01/kWh. NYPA purchases the remainder of power on the open market at a much higher cost and passes the cost on to GMU's customers. The NYPA agreement runs through 2025. However, GMU does not believe that the proposed microgrid project would have any impact on the hydropower contract, since the DERs supplying GMU loads would not likely exceed the hydro allocation.

Task 5 Report Overview

This Executive Summary summarizes the information contained in the Task 1-4 reports, and addresses the questions presented in the Task 5 Statement of Work. The responses to the specific questions from the Task 5 Statement of Work are presented in the Conclusions and Recommendations sections below. The complete Task 1-4 reports are contained in the relevant Task 5 report sections, and the BCA questionnaires are contained in the Appendices.

Task 1-Description of Microgrid Capabilities

Critical Facilities and Loads

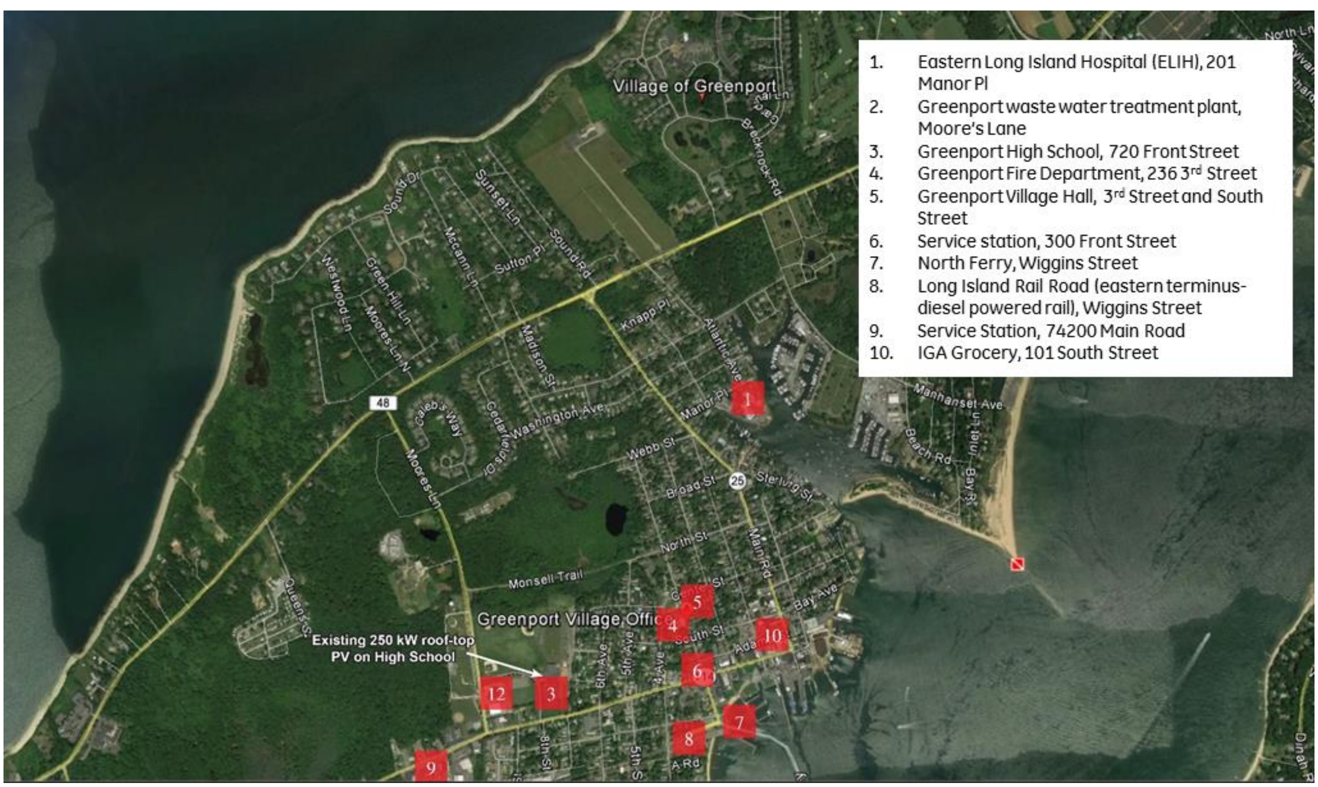
Although Greenport is somewhat isolated geographically, it has a number of facilities that provide critical services for Greenport as well as the entire east end of the North Fork, which stretches for over 30 miles from Riverhead to Orient Point. These facilities are vulnerable to storm impacts that have created power outages and prevented fuel deliveries due to flooding. These facilities and their electric and thermal loads are shown and listed below.

Summary of Microgrid Electrical, Heating, and Cooling Loads

Greenport	Electrical Load		Heating Load		Cooling Load	
Facility	**Energy (kWh)**	**Peak (kW)**	**Energy (kWh)**	**Peak (kW)**	**Energy (kWh)**	**Peak (kW)**
Eastern Long Island Hospital (ELIH)	2,688,0000	650	1,488,599	753	616,161	648
Greenport Waste Water Treatment Plant	552,000	97	•	•	•	•
Village of Greenport - Sewer Shed & Garage	24,379	19	•	•	•	•
Village of Greenport - WWTP Office	13,944	9	•	•	•	•
Suffolk County Water Authority	109,500	50	•	•	•	•
Greenport High School	357,783	105	•	•	•	•
Greenport Fire Department	95,400	59	•	•	•	•
Village of Greenport: Village Hall	17,120	6	•	•	•	•
Village of Greenport: Village Trailer	25,012	7	•	•	•	•
GMS Grocery/Service Station	152,960	39	•	•	•	•
Shelter Island Ferry (North Ferry)	7,577	1	•	•	•	•
Long Island Rail Road: Eastern Terminus	13,990	2	•	•	•	•
General Department - LIRR Bldg.	25,354	19	•	•	•	•
M&M Auto - Empire Service Station	15,156	7	•	•	•	•
IGA Grocery: Chasmur Supermarket	449,600	166	•	•	•	•
Extra Feeder Load[1]	28,273,500	5,332	•	•	•	•
Total	**32,821,275**	**6,569[2]**	**1,488,599**	**753**	**616,161**	**648**

1. "Extra Feeder" Load represents additional non-critical commercial and residential loads connected to the microgrid feeders.

2. Total Peak Load is the sum of non-coincident peak loads.



Map showing location of critical facilities in Greenport

The Eastern Long Island Hospital (ELIH) has 90 beds, and the nearest hospital is 25 miles to the west in Riverhead. As shown above, ELIH is the largest single load in Greenport, accounting for over eight percent of GMU's total energy usage. In addition, ELIH uses about 76,000 gallons of fuel oil per year for heating.

The Waste Water Treatment Plant (WWTP), which serves the Village as well as some other nearby areas, discharges to the LI Sound to the north. The Fire Department is responsible for fire, rescue and emergency services for the Village as well as the "East/West District," which extends from Southold to East Marion, a distance of about seven miles. The Suffolk County Water Authority (SCWA) storage facility on Moores Lane supplies drinking water for the Village and nearby areas.

The microgrid will also serve numerous non-critical commercial and residential establishments in and downtown Greenport and throughout the GMU service area. We estimate that the microgrid will serve approximately 500 small commercial establishments. These establishments include a pharmacy, gas station, grocery store, the Port of Greenport, and numerous restaurants, shops and stores. Hence, the Greenport microgrid will enable continued normal life and economic activity in Greenport during outages to the main grid.

Greenport is also a key transportation hub for eastern LI. The Greenport-Shelter Island Ferry provides one of two emergency evacuation routes from Shelter Island, which has a year-round population of approximately 2,400, which increases to over 8,000 in the summer. Also, Route 25 passes through Greenport to connect with the Cross Sound Ferry, about nine miles to the east, which is the only emergency evacuation route on the East End of the North Fork of Long Island.

Need for the Project

Greenport has experienced widespread and extended power outages as a result of extreme weather events and major bulk system outages such as the Northeastern Blackout in August 2003. Power supply to Greenport from the main grid was also disrupted following Hurricane Irene. Although the Village did not lose power from the main grid during Hurricane Sandy, there were significant distribution outages in the Village.

The Village receives service via a single distribution circuit from PSEG-LI. This configuration makes the Village susceptible to disruptions from the main grid during storm and non-storm events. In May 2015, the town lost power due to voltage problems on PSEG-LI's system caused by the loss of PSEG LI's Southold substation. Though power was restored within a few hours, PSEG-LI continued to experience system problems and requested that Greenport use their generator to provide PSEG-LI voltage support for approximately 20 hours following the initial outage event.

Greenport's vulnerability to extreme weather-related power outages and its location at the edge of the grid present unique vulnerabilities. It is critical to the region that Greenport is able to remain self-sufficient during power interruptions.

Task 2-Develop Preliminary Technical Design Costs and Configuration

Distributed Energy Resources

The project will include an optimized mix of DERs that will provide power for the microgrid and/or deliver power to the main grid, depending on operating conditions. The DERs are listed below. New or proposed DERs are listed in bold font.

Microgrid Planned and Existing DER

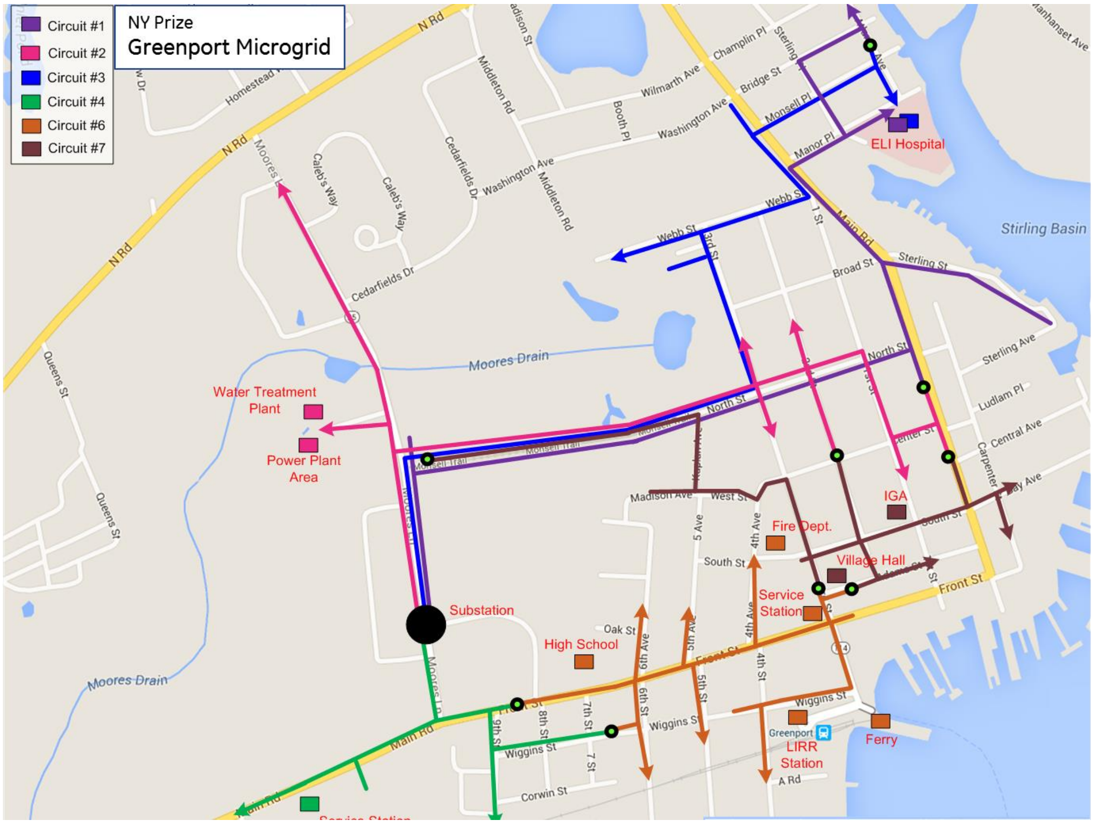
Distributed Energy Resource Name	Location/Facility Name	Energy Source	Capacity (kW)
Existing Backup Generator	Eastern Long Island Hospital	Diesel	500
Existing Solar PV	Greenport High School	Solar	250
New Solar PV	**Eastern Long Island Hospital or Moores Lane**	**Solar**	**250**
New CCHP	**Eastern Long Island Hospital**	**Natural Gas**	**375**
New Reciprocating Engine	**Moores Lane site near WWTP**	**LNG or pipeline gas (1)**	**7,400**
Battery Storage (125 kW - 500 kWh)	**Moores Lane site near WWTP**	**Electricity**	**125**
Absorption Chiller	**Eastern Long Island Hospital**	**CCHP Recovered Heat**	**100**
Load Curtailment	**Eastern Long Island Hospital: 65 kW Waste Water Treatment Plant: 10 kW IGC Grocery: 15 kW**	**Demand Response Resources**	**90**

Note 1: National Grid has indicated it may be able to supply pipeline gas on an interruptible basis; however, detailed engineering would need to be performed during Stage 2 to confirm this. This report assumes the project will use LNG, pending results of further studies by National Grid.

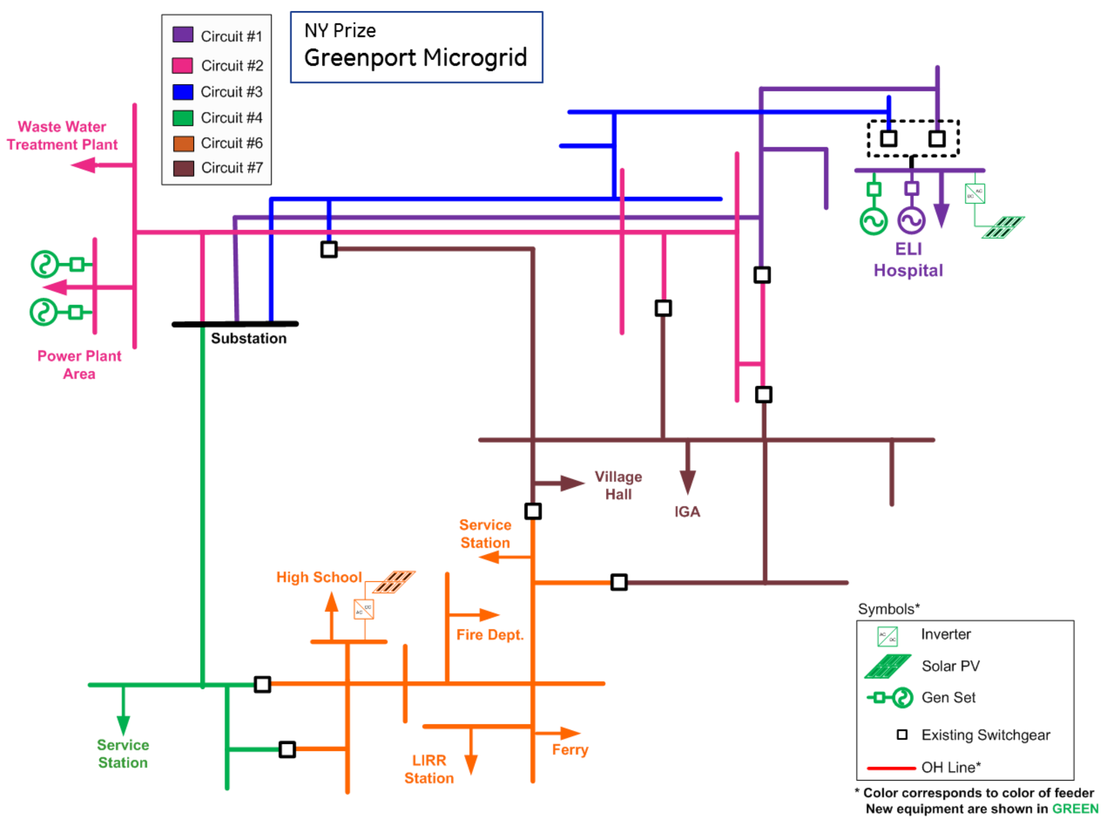
As shown, total new DERs, plus existing generation capacity, plus peak load reduction, will be 9,090kW. The CCHP facility will supply energy behind the meter, and the other DERs will utilize the existing GMU, and PSEG LI, distribution systems. The DERs, combined with energy efficiency and absorption chillers, will allow GMU to avoid most if not all purchases of market rate power, which will significantly reduce GMU's energy costs.

A circuit diagram and a one-line diagram for the microgrid are shown below. As shown in the figures, use of the existing GMU system will allow the DERs to connect with all the critical facilities and supply other customers served by GMU. The electric-only generation plant will utilize the PSEG-LI distribution system when selling to customers outside of Greenport.

The project will use the existing GMU above ground feeders, and install a number of switches that will enable the microgrid to operate in island mode during outages to the main grid. The existing feeders will be hardened in areas where there is significant exposure to vegetation.



Microgrid Circuit layout (above) and one-line diagram (below)



Fuel Supply

National Grid has indicated that it could complete pipeline reinforcements to supply up to 5MMBtu per hour of firm (i.e. non-interruptible) gas supply, which is more than adequate for the CCHP system. National Grid could complete these reinforcements by November 2016. National Grid indicated they likely could not provide gas supply for the approximately 62 MMBtu per hour needed to run the electric only plant on a firm basis. However, they indicated they may be able to supply adequate gas for this facility on an interruptible basis. National Grid would need to complete detailed engineering studies to confirm that interruptible service would be feasible.

Interruptible service would likely be adequate for the electric only facility, since peak heating demand occurs during cold weather, and peak electric demand occurs during the summer. If we plan on using interruptible service, we will evaluate the need for liquid fuel back up in the event of an interruption of gas supply. GC plans to request that National Grid perform detailed studies to confirm the feasibility of supplying pipeline gas for this facility.

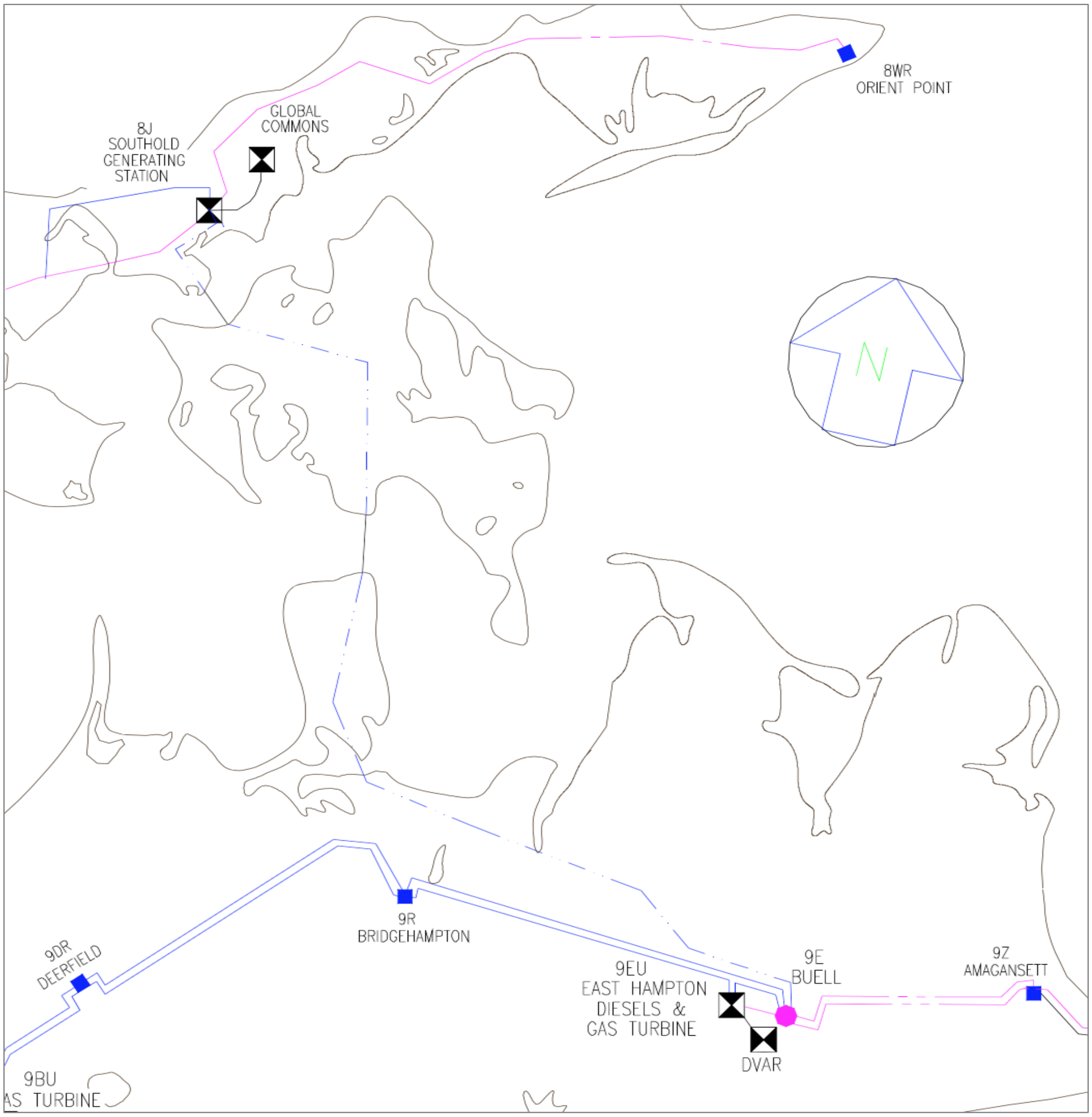
Since pipeline gas supply for the electric plant is currently uncertain, we have conservatively assumed that this plant will be fueled by liquefied natural gas (LNG) delivered by truck. The plant would have 70,000 gallons of LNG storage, which could provide fuel for seven days assuming average load conditions for GMU. Residents of Greenport have expressed support for using LNG for this facility.

The delivered cost of LNG would be about $9.00 to $10.00 per MMBtu, based on quotes received. The cost of pipeline gas would likely be less than $3.00 per MMBtu, assuming interruptible service and current gas prices. Therefore, pipeline gas supply, if available, would significantly improve the project economics, and reduce costs for customers.

South Fork Peak Power Supply Benefits

In addition to providing power for GMU, the electric generating plant would also supply peak power to PSEG-LI customers on the South Fork. PSEG-LI projects a 63 MW transmission deficit in the South Fork of Long Island by 2022, and estimates that the cost to upgrade the transmission system would be approximately $298 million. Residents on the south fork are strongly opposed to new above ground transmission lines that would be needed to supply power from western LI. In addition, there is not an adequate supply of pipeline gas on the South Fork (i.e. near East Hampton) to operate an adequate new gas fired power plant, and residents are strongly opposed to new diesel fired power plants.

As shown on the Figure below, the electric only plant in Greenport would be connected directly to a dedicated 69kV cable that runs under Shelter Island and connects to the Buell substation in East Hampton. This would reduce the need for new peaking plants on the South Fork, and reduce energy costs and emissions by reducing dispatch of existing inefficient diesel and kerosene-fueled plants in Greenport and East Hampton.



PSEG-LI East End Load Area

Energy Dispatch Analysis

We utilized the DER-CAM model to evaluate and project the performance of the DERs. Results are presented below. The DER-CAM model assumes the electric plant would use LNG. If pipeline gas proves to be available for this facility, the number of hours of dispatch would increase significantly.

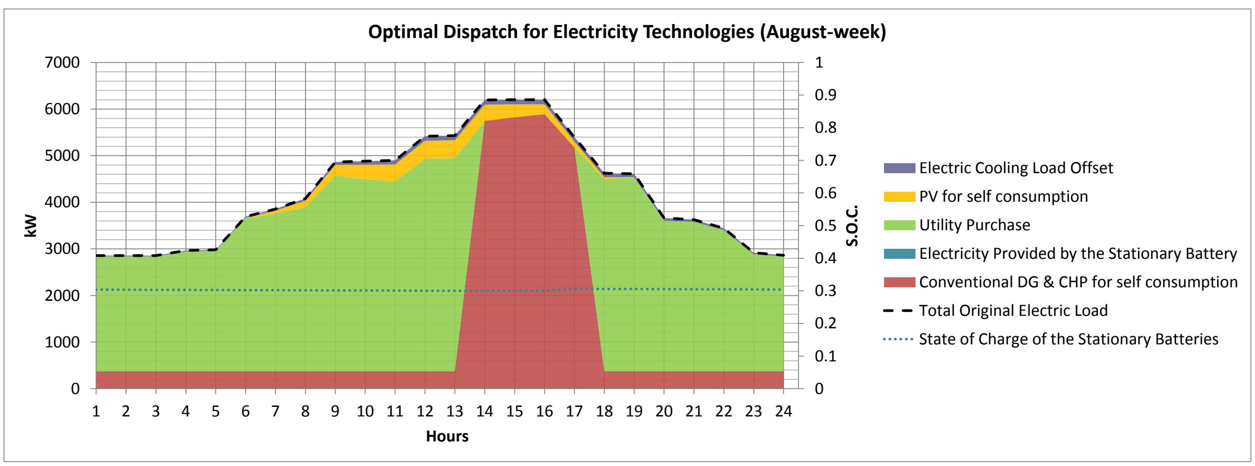
Electric Power Dispatch

The figure below shows the theoretical load and supply balance over a weekday of operation on a normal day in August. The DER-CAM model dispatches the generation resources based on the comparative economics of on-site generation versus purchase from the utility.

As can be seen, under the assumed prices, the DERs can produce all the needed energy onsite to meet the microgrid customers' load. The black dashed line is the microgrid electrical load. The burgundy colored area is the energy produced by the CCHP and the reciprocating engine. The green colored area is purchase from the grid. The State of Charge (SOC) of the battery storage is shown by the light blue dotted line and its value is indicated on the right-hand side Y-axis. The battery will help reduce peak loads due to pumping at the water and WWTP. This will reduce GMU's demand for market priced peaking power, increase GMU's load factor, which may allow GMU to increase its hydro allocation.

When the main grid is out of service, the battery will help stabilize the microgrid by assuring a balance between supply and demand. However, since the current version of the DER-CAM model only considers the "aggregate" load, it does not link the WWTP load to the battery storage, and hence it does not dispatch the battery storage due to the large size of the microgrid generation. Hence, dispatch of the battery storage is not properly handled by DER-CAM. In practice, it is expected that the storage battery will recharge at night when energy charges are low, and discharge during the day when energy and demand charges are high. The battery will have discharge duration of four hours. The yellow colored area is the energy produced by the solar PV systems. The dark blue area on the top is the electric cooling load offset due to the operation of the absorption chiller. The times where the colored areas go above the blue dotted line correspond to the times when the battery system gets charged.

Under the current assumptions on the delivered prices of electricity and gas, it appears that the CCHP generators will operate during normal days. In practice, the CCHP system would have a capacity factor of 95%, and the electric only generators would dispatch when the NYISO LBMP prices exceed the strike price. During normal operating conditions, the electric only generation system would sell to customers outside of GMU, and would not sell to any Greenport customers, because the energy costs in Greenport are less than the strike price of these units.

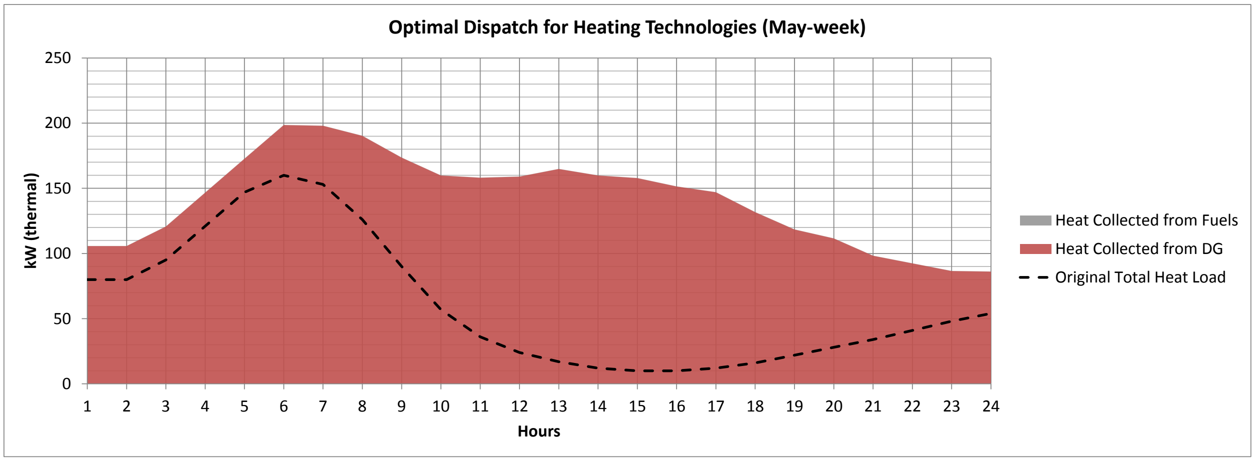


Microgrid Generation Stack to Meet Electrical Load – August Normal Weekday

As shown, the CCHP systems would provide baseload power for ELIH, substantially reducing the amount of power that ELIH would otherwise purchase from the grid throughout the day. The CCHP system will produce approximately 3.1 million kWh per year. The solar, load curtailment and absorption chillers would significantly reduce power purchased by Greenport during peak periods. We estimate that these systems and measures would reduce the coincident peak demand by approximately 725 kW.

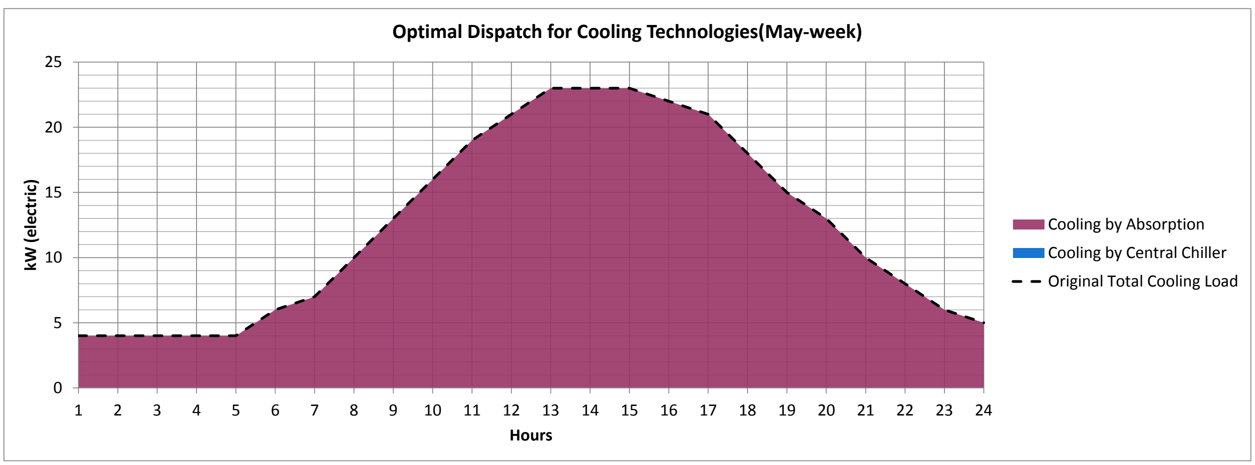
Thermal Dispatch

The figure below shows thermal dispatch for heating load during a normal weekday in August. The black dashed line is the hospital's heating load. The additional thermal generation going above and beyond the dashed line (heating load) is actually the portion of the thermal energy of the CCHP unit that is utilized to run the absorption chiller in the hospital to meet the hospital's cooling load (shown in the following figure.) In the following figure there are no additional heat collected from fuels (i.e., from the conventional boilers), and therefore, no "gray" areas are shown in the figure.



Microgrid Thermal Dispatch to Meet Heating Load – May Normal Weekday

The figure below shows thermal dispatch for cooling load during a normal weekday in May. The black dashed line is the hospital's cooling load. Note that in DER-CAM, the cooling load size is not based on the final cooling energy output. It is actually based on the equivalent electric input of central dispatch that will provide that amount of thermal energy, and hence reflects the assumed Coefficient of Performance (COP).We have assumed a COP of 4.5, which is the default value provided by DER-CAM and is also in the range of COPs for Water-Cooled Scroll or Screw Chillers 150 tons or smaller[1]. In the figure below, all cooling is provided by the absorption chiller, and hence there is no need for cooling by the central chiller, and therefore, it is not shown in the figure (i.e., no blue-shaded area).



Microgrid Thermal Dispatch to Meet Cooling Load – May Normal Weekday

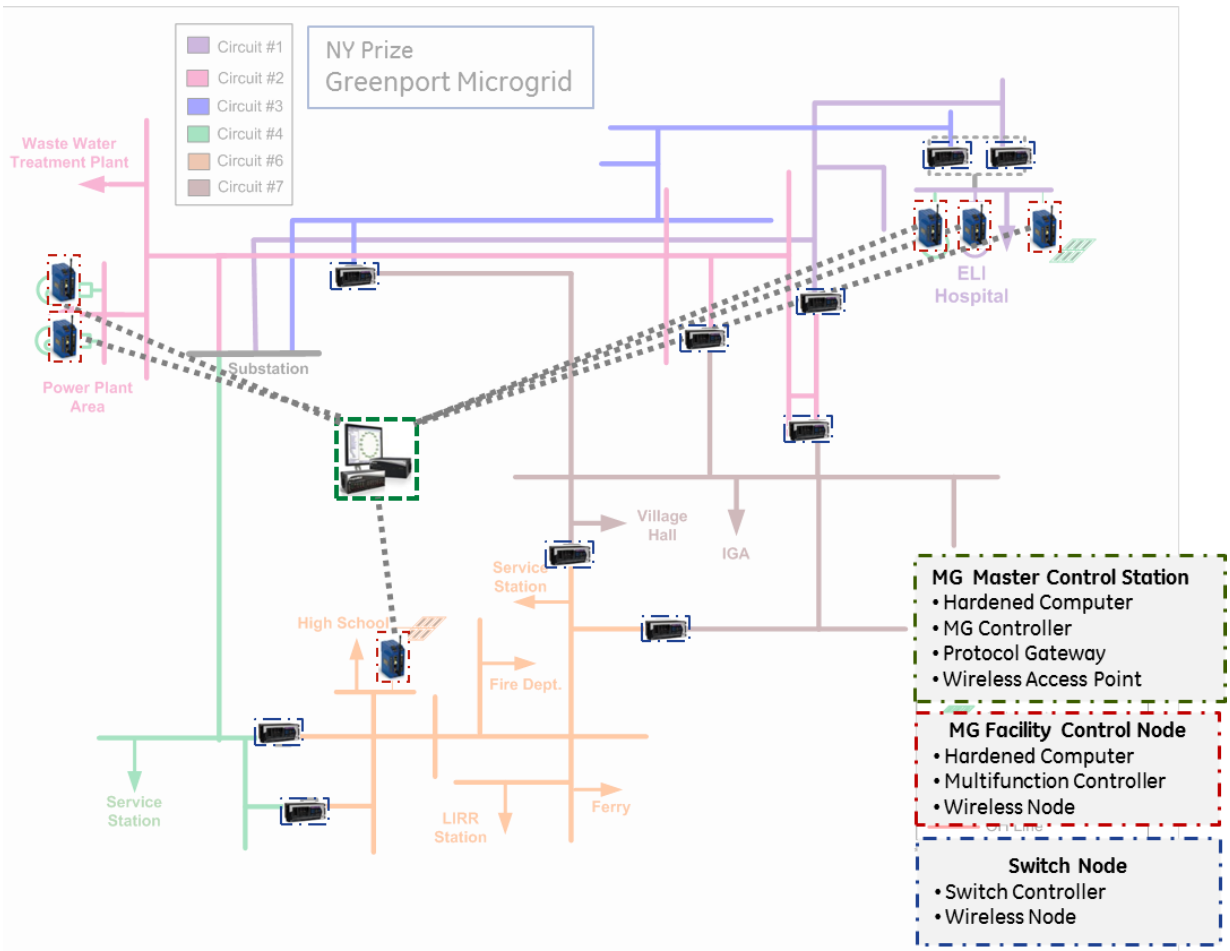
[1] https://www.progress-energy.com/assets/www/docs/business/bbnchvacck2007.pdf

Microgrid Controls

The proposed microgrid control architecture consists of four control device types:

- Microgrid Energy Management System (MG EMS) (1 per microgrid)
- Microgrid Master Control Station (1 per microgrid)
- Microgrid Facility Control Node (1 per facility)
- Microgrid Edge Control Node (1 per facility)

The figure below shows control devices for the proposed Greenport microgrid as an overlay on the electrical one-line diagram.



Task 3- Assessment of Microgrid's Commercial and Financial Feasibility

Business Model and Contractual Relationships

The project will involve a public/private partnership between GMU and the project developer. The project developer will be a Microgrid Energy Services Company (MESCO), which is a type of ESCO that supplies energy to microgrids during normal conditions and grid outages.

GMU will own the CCHP and battery systems, and the MESCO will own the 7.4 MW electric only generation plant and the solar PV units (in order to benefit from solar tax credits). GMU and the MESCO will each provide their share of funding that is not provided by NYSERDA grants. The MESCO will have a ground lease with the Village of Greenport for its DERs located on Greenport property. The lease may contain provisions that give GMU the option to purchase the DERs after the MESCO has received a pre-agreed return on its investment.

Business relationships between GMU, the MESCO and their customers for different DERs are explained below.

Blue Sky Scenarios

- GMU will sell the electric and thermal energy from the CCHP system to ELIH.
- GMU will dispatch energy from the battery to shave peak loads at the SCWA and WWTP facilities.
- The MESCO will sell solar PV located in the park area on Moores Lane to GMU, which in turn will sell it to its customers.
- The MESCO will sell energy and capacity from the 7.4 MW electric plant contractually to customers outside of the GMU service area, and sell any excess energy, capacity and ancillary services to the NYISO or GMU. This plant would sell energy or capacity to GMU if excess energy or capacity is available, and market conditions justify such sales. It would not sell energy to replace GMU's low cost hydro energy. Alternatively, the MESCO will explore obtaining a PPA with PSEG-LI.
- The GMU will continue to own and operate its own distribution system, and its diesel generators on Moores Lane, if needed. The project will use existing feeders owned by GMU, or use PSEG-LI feeders to connect the electric only facility to the Southold substation in order to sell energy to customers outside the GMU service area during normal conditions.

Grid Outages

- The MESCO will sell power produced by the electric plant to GMU, which will then deliver energy to its customers using its existing but hardened distribution system.
- Other DERs will also contribute energy to GMU to help power the microgrid.

Project Benefits

A summary of project benefits for various stakeholders is presented below.

Summary of Project Benefits for Various Stakeholders

Stakeholder	Value Proposition
GMU	• DERs will reduce energy costs by reducing the need for non-hydro energy from NYPA, and from revenue it receives from the CCHP system • The DERs will increase GMU's load factor, enabling GMU to increase its hydro allocation • The DERs and distribution hardening measures will improve system reliability and resiliency • GMU will have the option to purchase the 7.4 MW electric generating facility to replace its aging diesel generators, and purchase the solar PV system
Eastern Long Island Hospital (ELIH)	• Reduce cost for electric energy and heating • Reduce or eliminate use of fuel oil for heating • Provide more reliable energy supply • No capital investment
Other GMU customers	• Reduce electric energy charges • Continued power supply during outages to the main grid will assure the commercial establishments can maintain services for customers and the community • Commercial establishments will continue to earn revenue from their business operations during power outages to the main grid
National Grid	• CCHP system will provide a significant new customer (i.e. ELIH) for National Grid, with a high load factor demand profile • Pipeline reinforcements may facilitate sales to other customers
PSEG-LI	• The project will reduce load on existing transmission lines needed to deliver energy to the North Fork • The project will reduce the need for new transmission or generation needed to meet peak demand on the South Fork
Residents of the North Fork	• Residents will continue to benefit from services of ELIH and other critical and commercial facilities in Greenport during outages to the main grid
Environment	• Project will reduce air emissions by using more efficient CCHP technology to supply both electric and thermal energy • Use of LNG at the new electric only power plant, and the new gas fired CCHP plant, will reduce dispatch of diesel and kerosene fueled peaking plants in Greenport, Southold, East Hampton, and Shoreham, thus reducing emissions from these facilities, and reducing energy costs for PSEG-LI customers.
NY State	• Project would represent an innovative and financially viable microgrid and business model that could be replicated in other areas
Project investors, developers and lenders	• Will receive positive returns on investment, commensurate with project risk • Private investors and lenders will gain experience with an advanced microgrid that could enable similar future investments
Vendors and contractors	• Will generate new business by providing equipment and services • Will gain valuable experience in cutting edge project that could be applied to future microgrid projects

Project Financing Evaluation

The project will reduce energy costs for GMU's customers by providing an efficient CCHP system, reducing GMU's use of non-hydro energy and increasing GMU's hydro allocation. The project will also produce positive cash flow for the MESCO through sale of energy and capacity from the electric generating facility. The example income statements below are for illustrative purposes only, as more detailed analyses would need to be performed, and contract terms finalized, in order to complete a definitive income statement.

As shown in the capital structure below, GMU, the MESCO and NYSERDA may provide funding for the project. In addition, the project would benefit from ITCs for the solar PV system.

Sources and Uses of Funds with NY Prize Funding

Uses of Funds		Sources of Funds	
CCHP	$1,500,000	MESCO funding	$6,069,538
Electric generation	$11,360,000	GMU funding	$1,266,247
Solar	$666,750	NY Prize Grant	$7,000,000
Battery	$300,000	ITC	$200,025
Distribution and controls	$709,060		
Total	**$14,535,810**		**$14,535,810**

Sources and Uses of Funds without NY Prize Funding

Uses of Funds		Sources of Funds	
CCHP	$1,500,000	MESCO funding	$11,861,252
Electric generation	$11,360,000	GMU funding	$2,474,533
Solar	$666,750	NY Prize Grant	$0
Battery	$300,000	ITC	$200,025
Distribution and controls	$709,060		
Total	**$14,535,810**		**$14,535,810**

A comparison of financial performance with and without NY Prize funding is shown below. Detailed financial projections are shown in Section 3.5. The financial results shown below assume that ELIH would continue to pay its current electric rates to GMU, and pay GMU 50% of its current fuel oil cost for waste heat from the CCHP unit. The electric only income statements below assumes that the facility would use LNG and sell energy and capacity to customers outside the GMU service area using a contract for differences structure. The MESCO analysis assumes that the MESCO would offer customers a 10% discount in their electric rates, and an LNG price of $10 per MMBtu.

As shown, GMU would have an adequate debt coverage ration assuming it receives NY Prize funding, but would not be able to pay its share of project debt if it does not receive NY Prize funding. It is unlikely that the project returns would be adequate for the MESCO to attract equity funding if it does not also receive NY Prize funding, due to the risk of the offtake agreements, which are likely to be relatively short-term, and may not cover the full output of the electric generating facility.

Financial Performance with and without NY Prize Funding

	GMU		MESCO	
	With NY Prize Funding	***Without NY Prize Funding***	***With NY Prize Funding***	***Without NY Prize Funding***
EBITDA	$161,514	$161,514	$2,237,392	$2,237,392
Debt service	$104,377	$201,333	$0	$0
DSCR	1.55	-0.80	NA	NA
Unlevered pre-tax IRR	NA	NA	37.0%	17.9%

Task 4 BCA Results

IEc performed the BCA analyses for two scenarios: Scenario 1A uses IEc's standard approach to valuing transmission capacity benefits. Scenario 1B considers benefits from avoidance of transmission capacity upgrades that would be necessary in the absence of the project. As shown, the project would provide substantial benefits for both scenarios.

National Grid has indicated that it would be necessary to pay a fee for engineering studies to confirm the availability of pipeline gas. The team intends to pay for this study during Stage 2. In the meantime, we have assumed that the plant would use LNG.

A preliminary review of the BCA analysis indicates that use of pipeline gas rather than LNG would increase the net benefits by approximately $10 million. Therefore, we believe it is likely that the current BCA analysis significantly understates the potential benefits of this project.

The BCA calculates the emissions impacts from the microgrid. However, it does not account for the reduction of emissions from reducing dispatch of other liquid fired peaking plants on eastern LI.

Summary of BCA Results

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES		
	SCENARIO 1A: 0 DAYS/YEAR	SCENARIO 1B: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$13,600,000	$53,300,000	Not Evaluated
Benefit-Cost Ratio	1.2	2.0	Not Evaluated
Internal Rate of Return	16.5%	57.1%	Not Evaluated

The benefits in scenario 1B are substantially greater than Scenario 1A because 1B includes transmission avoidance benefits the project would provide for the South Fork of LI.

Conclusions and Recommendations

This section discusses obstacles encountered and lessons learned, as well as findings, conclusions and recommendations for the Greenport project and other microgrid projects.

Conclusions

1. A Greenport microgrid is technically feasible and would provide significant economic, environmental and societal benefits. A microgrid project in Greenport would provide significant financial, environmental and societal benefits for the Village of Greenport, Eastern Long Island Hospital (ELIH), and Long Island's North Fork in general. The project would also help reduce the need for new peaking generation and/or transmission on the South Fork of LI.
2. The lack a mechanism to assign a monetary value for reliability and resiliency limits microgrid development. Although the project would provide substantial benefits during grid outages, the value of these benefits is not reflected in the actual price of energy, capacity or other attributes. This limits the potential opportunities for developing microgrid projects in the absence of some type of subsidies.
3. Zonal capacity prices sometimes do not reflect the need for local peaking power. The proposed electric generation facility would reduce the need for new transmission or peak generating capacity on the South Fork. However, the value of these benefits is not reflected in zonal capacity prices. As a result, the project would not be economically viable without a subsidy, or a power purchase agreement (PPA) with PSEG-LI with a fixed capacity payment that is more than the zonal capacity price.
4. The Greenport community microgrid will require government subsidies and/or other incentives to attract private funding. Incentives could include NYSERDA grants, favorable gas supply tariffs, and/or credits for DER generation or capacity. Some type of subsidy is generally needed for community microgrids on LI, since the zonal prices for energy and capacity alone are not sufficient to justify investment in DERs.
5. The NY Prize program provides highly valuable funding for early stage design. However, early stage funding is also needed for other microgrid projects in order to expand deployment of microgrids. The costs to obtain, compile and analyze data from multiple facilities, and design the DERs and controls, and develop a microgrid project, are high in relation to the project size and risk. Government funding is critical for providing early stage capital to perform these tasks, and develop projects to the point where they can attract permanent private project financing.
6. **Energy storage and efficiency provides stability for microgrids and reduces peak demand charges.** A battery storage system can provide stability for the microgrid when operating in island mode, and can help reduce peak demand charges for facilities with "spikey" loads during blue-sky days, such as the water and wastewater treatment facilities in Greenport.
7. **The Greenport project is a model public/private partnership.** GMU would own the CCHP and battery systems, and a Microgrid Energy Services Company (MESCO) would own the electric generating plant and solar PV system. The electric plant would supply energy to GMU during grid outages, and sell to customers outside of GMU during other times. If energy is available, the MESCO may also sell energy to GMU during normal times to reduce or eliminate use of market

rate power by GMU. GMU will have an option to purchase the electric generating and solar PV facilities from the MESCO after the investors receive an appropriate return.

8. **The Greenport microgrid will benefit utility partners.** The project will benefit PSEG-LI by reducing the need for peaking power or new transmission on the South Fork of LI. The project will also benefit GMU by reducing energy costs and improving energy reliability and resiliency. The project will also provide a new customer (i.e. the CCHP system at ELIH) for National Grid for gas supply, and the new pipeline infrastructure needed to serve the CCHP system may stimulate new demand from other customers.
9. Some gas utility policies create barriers to microgrids.
   a. The National Grid gas tariff for electric generation includes a Value Added Charge (VAC) that could result in prohibitive delivery charges for gas for the electric only generating plant. In addition, the VAC charge can impose a year-end True Up charge for generators that cannot be predicted or passed on to customers. These policies could policies could effectively preclude use of pipeline gas for the electric only generating plant, even if pipeline gas proves to be available on an interruptible basis.

Recommendations

1. The Greenport project should proceed with design, development and financing, subject to support from NYSERDA.
2. NYSERDA should continue to provide financial subsidies for microgrids in order to help recognize the value of greater reliability and resiliency. NYSERDA should continue to provide financial incentives and technical support for development of microgrids. Incentives should include funding for feasibility studies, design and development, and construction funding.
3. **NYSERDA or local utilities should consider microgrid energy or capacity credits**. NYSERDA or local utilities should consider providing microgrid energy credits and/or capacity payments ("MECs" or "MCAPs"), similar to RECs for renewable energy sources, to provide financial incentives for DERs that support microgrids and are not eligible for RECs under the RPS. The MECs or MCAPs would be justified in light of the financial, societal and environmental benefits provided by microgrids.
4. Utilities should do more to help facilitate development of microgrids.
   a. Gas utilities should evaluate new incentives for microgrids to reflect their financial, societal and environmental benefits.
   b. Gas utilities should offer favorable microgrid gas supply tariffs, and prioritize infrastructure improvements needed to serve microgrids.
   c. National Grid should eliminate the VAC that is currently charged to electric generating customers.
5. Continue development of analytical tools**.** Government entities should continue development of analytical tools for analyzing microgrids, such as DER-CAM.

Selected Photographs of Critical Facilities and Downtown Greenport

Greenport Location Map

Eastern Long Island Hospital

Greenport High School

Fire Department

Village Hall

Greenport-Shelter Island Ferry

Tall Ships Festival

Downtown Greenport 1

Downtown Greenport 2

Greenport Harbor

1. DESCRIPTION OF MICROGRID CAPABILITIES

1.1. Minimum Required Capabilities

1.1.1. Critical Facilities

Background

The Village of Greenport is located on the east end of the north fork of Long Island, about 100 miles east of Manhattan, and about nine miles west of Orient Point, which is the eastern most point on the north fork of Long Island (LI). The 2010 Census population was 2,197. However, the population increases to over 3,000 in the summer due to tourism. Greenport has a number of facilities that are critical to both the Village and the eastern north fork in general, and these facilities are vulnerable to storm impacts that have created power outages and prevented fuel deliveries due to flooding, as discussed further below.

Greenport is a municipal electric utility (GMU) that serves about 2,000 customers, about 1,000 of which are within the Village. The peak demand in the village is approximately 6.6 MW. The Village has its own 6.8 MW power plant that uses Number 2 fuel oil. The plant has three diesel generating units that were installed in 1957, 1965 and 1971. Because of the age of these units, they are only used for back-up power, and their long-term reliability is questionable.

A 54 MW kerosene-fired gas turbine peaking plant is also located in Greenport that sells energy and capacity to PSEG-LI under a long-term power purchase agreement. This plant is owned by an independent power producer (IPP). All of the power plants in Greenport run on liquid fuel because there is not currently an adequate supply of pipeline gas; however, limited pipeline gas supply is available for some residential and commercial establishments, and possibly for additional generating facilities.

The Village has a full requirements contract with the New York Power Authority (NYPA), and gets about 70% of its power from a hydro allocation from the Mohawk/Niagara facility, at a cost of less than $0.01/kWh. NYPA purchases the remainder of power on the open market and passes the cost on to GMU's customers. The cost of this incremental energy is substantially greater than the cost of the hydro allocation, and varies on a monthly, daily and hourly basis. GMU could reduce its energy costs if it could reduce the cost of this incremental electricity that is not supplied by the hydro allocation and/or increase its hydro allocation. GMU could potentially increase its hydro energy allocation by increasing its load factor. Modifications to Greenport's full requirements contract may be required if Greenport produces some of its own power at lower rates.

Microgrid Scope and Critical Facilities

The microgrid will include the entire GMU service area, which includes 10 critical facilities shown in Figure 2-1, and listed in Table 1-1. The critical facilities are important to both the Village of Greenport and surrounding communities on the North Fork.

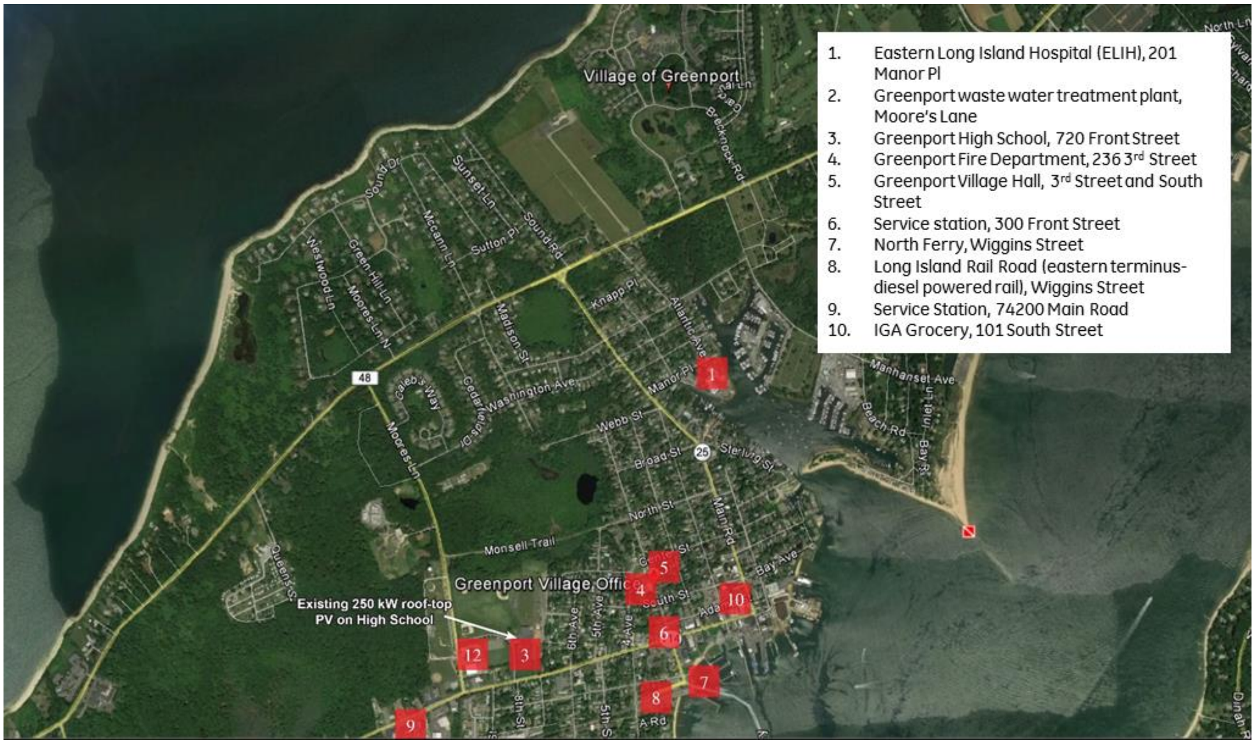


Figure 1-1: Map Showing Critical Facilities in Greenport

Table 1-1 List and Addresses of Critical Facilities

1. Eastern Long Island Hospital (ELIH), 201 Manor Pl
2. Greenport waste water treatment plant, Moore's Lane
3. Greenport High School, 720 Front Street
4. Greenport Fire Department, 236 3rd Street
5. Greenport Village Hall, 3rd Street and South Street
6. Service station, 300 Front Street
7. North Ferry, Wiggins Street
8. Long Island Rail Road (eastern terminus-diesel powered rail), Wiggins Street
9. Service Station, 74200 Main Road
10. IGA Grocery, 101 South Street

A summary of the electric and thermal loads of these critical facilities is shown on Table 1-2. As shown, the total non-coincident peak electric load is 6,569 kW. ELIH has the largest electric load, with a peak demand of 650 kW, which includes demand from a 123 kW chiller. ELIH also uses about 76,000 gallons per year of fuel oil for heating. In addition, the high school uses about 120,000 gallons per year of fuel oil.

Table 1-2: Summary of Microgrid Electrical, Heating, and Cooling Loads

Greenport	Electrical Load		Heating Load		Cooling Load	
Facility	**Energy (kWh)**	**Peak (kW)**	**Energy (kWh)**	**Peak (kW)**	**Energy (kWh)**	**Peak (kW)**
Eastern Long Island Hospital (ELIH)	2,688,0000	650	1,488,599	753	616,161	648
Greenport Waste Water Treatment Plant	552,000	97				
Village of Greenport - Sewer Shed & Garage	24,379	19				
Village of Greenport - WWTP Office	13,944	9				
Suffolk County Water Authority (SCWA)	109,500	50				
Greenport High School	357,783	105				
Greenport Fire Department	95,400	59				
Village of Greenport: Village Hall	17,120	6				
Village of Greenport: Village Trailer	25,012	7				
GMS Grocery/Service Station	152,960	39				
Shelter Island Ferry (North Ferry)	7,577	1				
Long Island Rail Road: Eastern Terminus	13,990	2				
General Department - LIRR Bldg.	25,354	19				
M&M Auto - Empire Service Station	15,156	7				
IGA Grocery: Chasmur Supermarket	449,600	166				
Other commercial/residential loads	28,273,500	5,332				
Total	**32,821,275**	**6,569***	**1,488,599**	**753**	**616,161**	**648**

*Total peak shown is the sum of non-coincident Peaks.

1.1.2. Primary Generation Source

National Grid has indicated that it is willing to make two system reinforcements needed to supply about 5.0 MMBtu per hour of natural gas for a CCHP for ELIH. The reinforcements could be implemented as early as November 2016.

Pipeline natural gas is less costly and more reliable than diesel. Based on discussions with National Grid, the delivery charge for natural gas to the hospital would be approximately $2.23 per MMBtu, plus the gas commodity charge, which is currently less than $2/MMBtu. By contrast, the delivered cost of fuel oil is currently over $10 per MMBtu. In addition, pipeline supply of natural gas is highly reliable, even during severe weather events or outages to the electric grid, while delivery of fuel oil is subject to disruption during storm events and flooding. Newer natural gas engines can meet the 10-second startup requirements for backup systems, and hence, diesel engines no longer have an inherent startup/ramp-up capability advantage over the gas engines.

The ability to utilize pipeline gas to supply the CCHP system at ELIH would provide a substantial benefit for the hospital and the eastern North Fork in general, since storms have potential to completely flood roads needed to deliver liquid fuels. Moreover, the hospital only has about five days of fuel storage, and there is not adequate space for additional storage. Both County Road 48 and Route 25 (the only to access roads to Greenport) were impassable following Hurricane Sandy due to flooding around Hashomomack Pond (about two miles west of Greenport Village), preventing deliveries of liquid fuels to Greenport. If the grid were also disrupted during such flooding events, it would not be possible to provide electric power east of Hashomomack Pond after the emergency liquid fuel storage is consumed. Thus, the ability to provide pipeline gas-fired generation to critical facilities is critical.

The project will also include a 7.4 MW reciprocating engine. National Grid has indicated it may be possible to supply pipeline gas on an interruptible basis; however, a detailed engineering study would need to be performed to confirm this. Therefore, we have conservatively assumed that this plant will be fueled by liquefied natural gas (LNG) delivered by truck. Assuming fuel is supplied by LNG, this plant would have about seven days of LNG supply at average load conditions. A detailed study of the pipeline improvements that would be required will be conducted during Stage 2. Supply of this plant on an interruptible basis would likely provide adequate gas supply, since peak heating demand occurs during cold weather, and peak electric demand occurs during the summer. If pipeline gas is feasible, we will evaluate the need for liquid fuel back up in the event of an interruption of gas supply.

The gas-fired DER will be supplemented with solar PV and battery systems. The solar PV will be built on top of part of the skating rink on the west side of Moore’s Lane, and/or at ELIH. The batteries will be located adjacent to the water and wastewater treatment facilities on Moores Lane, and will supply power during peak periods (when pumps are on), thus increasing GMU’s load factor. As stated previously, a higher load factor could potentially have the added benefit of allowing Greenport to increase its hydro energy allocation.

The microgrid may also include existing diesel power reciprocating engines that would provide backup energy in the event of an outage to the main grid and microgrid. The current generation portfolio in Greenport includes the following backup generators at the hospital:

- 675 kW Main Backup
- 350 kW Lab Backup
- 60 kW Food Service Backup

Local existing DER also include the existing 6.8 MW diesel plant owned by Greenport (which is nearly 60 years old), and a 250 kW solar PV array at the high school. Additional fossil-fueled generation and PV generation will be considered during the load and supply analysis subtask.

One of the factors against selection of diesel engines has been the unavailability of adequate fuel storage to ensure uninterrupted operation of the microgrid for a period of at least one week. In most cases, the existing diesel storage systems are sized to enable diesel engine operations for a day or two during short-term grid outages. In the NYSERDA 5-Site study that preceded NY Prize, the New York State Division of Homeland Security and Emergency Services (NYS DHSES) representative stated that during long-term emergences diesel fuel would be regularly trucked to the microgrid sites.

However, in the absence of a formal emergency fuel delivery structure, for the purposes of this study (with the objective of replicability and scalability in mind), the Team will not assume continued and extended availability diesel fuel supply.

If the analysis shows that new natural gas generation is the least-cost option, then any existing back-up diesel generators can still be used as a standalone backup generation (as in their pre-microgrid role) as a last resort in the event of both larger grid and microgrid contingencies.

1.1.3. Operation in Grid Connected and Islanded Mode

As discussed previously, in Task 2 the Team evaluated the use of CCHP at ELIH, as well as solar and storage technologies. The new generation systems would supplement the existing 250 kW solar PV system at the high school.

The Village also owns a 6.8 MW diesel-fired generating plant, which is located on Moore's Lane. However, because the plant is nearly 60 years old, and its reliability is questionable, additional new DER will be needed to create a reliable and resilient microgrid for the village. The team has proposed a new 7.4 MW electric only gas engine at Moore's Lane to replace the old diesel plant.

In islanded mode, the generation sources are expected to be available to support the microgrid load. The new electric-only gas unit is expected to provide a strong voltage reference that would allow inverter-based generation to function in islanded mode. To avoid a collapse of the island, some generators would switch from baseload to frequency control and excess (curtailable) load may be shed to maintain balance. This is further discussed in Section 2.3.6

The Team considered both grid-connected and islanded mode in the microgrid design, including several possible solutions for the Microgrid Control System. Along with the advanced microgrid controller being developed in a DOE project by GE, NREL and others, a set of commercial platforms are also available as candidate solutions. The available commercial microgrid control platforms vary in functionality. A complete control solution will typically be comprised of an integrated suite of both hardware and software components. Depending on the microgrid site use cases, the control solution will often require some level of custom code development or configuration scripting to support integration with electric distribution equipment, the building energy management systems (BEMS), controllable loads, and generation assets within the microgrid, the ISO control center, as well as the utility enterprise systems which include energy management systems (EMS), distribution management system (DMS), and outage management systems (OMS). More detail on the control and communications design for Greenport is provided in Section 2.5.

1.1.4. Intentional Islanding

Islanding is the situation where distributed generation or a microgrid continues energizing a feeder, or a portion of a feeder, when the normal utility source is disconnected. For a microgrid to sustain an islanded subsystem for any extended duration, the real and reactive power output of the generation must match the demand of that subsystem, at the time that the event occurs. Exact real and reactive power equilibrium on a subsystem is improbable without some means of control. If there is a mismatch, the subsystem voltage and frequency will go outside of the normal range, and cause the DG to be tripped on over- or under-frequency or voltage protection. The amount of time required for voltage or frequency excursion to trip the DG is a function of the mismatch, parameters of the circuit, as well as the trip points used. Without active voltage and frequency regulation controls providing stabilization, an island is very unlikely to remain in continuous operation for long. The Team will consider switching technologies (described in the response above) that would allow the microgrid to seamlessly and quickly transition to islanded mode, and also incorporate the appropriate communications and controls technologies (also discussed above) that would allow the microgrid to remain electrically viable and persist for the duration of the emergency (subject to fuel availability).

The current concept includes several feeders out of one substation in the municipal utility grid that are interconnected at various locations in the Village via normally-open. When the substation is disconnected from the bulk power supply, an intentional island would be formed. To sustain the island, the microgrid logic controller would shed load (if necessary), and actively monitor and control voltage and frequency in the area. Some machines will operate as baseload generation, and others (perhaps some of the existing diesel engines at the hospital) will operate in load-following mode to maintain load-generation balance in "real time."

1.1.5. Automatic Separation from Grid

The design will include power and communication equipment necessary to separate from the grid in the microgrid design. Furthermore, strategies for re-connecting and the equipment necessary to accomplish these strategies are also considered. As discussed, the Greenport microgrid will be connected to the bulk power supply at the substation and several feeders are interconnected via normally-open switches. When the bulk power source is lost, the controller monitoring voltage at the POI would initiate the transition process from grid-connected to islanded mode. The specific nature of the transition is discussed later in Section 2.1 along with include power and communication equipment necessary to facilitate the transition. Furthermore, strategies for re-connecting and the equipment necessary to accomplish these strategies are also considered.

1.1.6. Requirements or Scheduled Maintenance

The system will be designed to accommodate all manufacturers' maintenance requirements and intermittent renewable generation dynamics.

The solar PV systems will be installed in the park area on Moores Lane, and/or at ELIH. The amount of PV will be about 7.1% peak demand (including existing and new solar PV) and an even less percentage of the energy. However, in Stage 2 steps will be taken to ensure that the microgrid generation has the range and flexibility to mitigate the expected variability of the PV generation. The project will also include 125 kW of energy storage. The Team has also considered other options such as controllable loads.

Because the microgrid includes variable renewable resources, the project also includes sufficient baseload or dispatchable resources to ensure that the system can provide reliable energy on a 24/7 basis.

Most routine maintenance can be accomplished during off peak periods, eliminating the possibility of incurring peak demand penalties from system down-time. Lengthier maintenance can be scheduled for off peak hours.

The maintenance plan will adhere to and comply with manufacturer's requirements for scheduled maintenance intervals for all generation. In Stage 2, the Team will consider reliability-centered maintenance (RCM) strategies that focus more attention on critical pieces of equipment that could affect the microgrid operation (such as rotating machines, transfer switches, breakers) but will recommend periods during the day, week, and year when routine maintenance would be less likely to coincide with an outage event. This is a data driven task that is likely to become more effective given a longer operating history.

1.1.7. Load Following

In connected mode (parallel to the grid), microgrid generation resources would typically not be required to regulate frequency or voltage or follow load. These services are provided by generators under governor control. However, in islanded mode, microgrid resources must switch from baseload power control to frequency control and the bus voltage must be controlled either by a generator's voltage regulator or by some supervisory control (such as a microgrid controller). To avoid a collapse of the island, some generators would switch from baseload to frequency control; some voltage regulators would switch from power factor control to bus voltage regulation; and excess loads should be shed to maintain balance. With multiple DERs of various types, and controllable loads in an area, a microgrid control system may be preferable for successful islanded operation. The team explored these operational issues in Task 2.

The microgrid's functional design considered both the sufficiency and control & communication capability for generation to maintain voltage and frequency while in islanded mode. The study also explored the economics of energy storage both as resource for capturing variable renewable energy, if any, to ensure reliability of meeting load during emergency, or to engage in energy arbitrage with the grid, and to provide ancillary services to the grid.

When considering the load/generation mix, several classifications of load may be considered. Generally, these classifications fall into critical, discretionary, and deferrable. At a minimum, the generation and storage mix must be sufficient to meet critical load at all times, i.e. the microgrid will be sized to meet the critical load (constituting the baseload) at all times during normal and emergency periods. The microgrid will attempt to meet the discretionary load during the emergency period, provided there is sufficient supply from internal generation. However, in a variety of likely circumstances, available generation might exceed critical load. In such cases, additional load may be served, but sufficient controllability must be incorporated in the design to shed load if the need arises. In a contingency, the microgrid will incrementally shed discretionary loads until load and supply balance is achieved. Curtailable load is the load that will be immediately dropped at the onset of the interruption of power delivery from the larger grid. Additionally, some load has flexibility to be scheduled which adds an additional layer of control to the load/generation mix. If storage is feasible for the design, the load/generation mix will also consider charge/discharge needs for the storage system.

While the islanded operation of the microgrid was the primary driver for determining the generation and load mix, size and operating modes and import/export in grid-connected mode were also evaluated. The import/export of power to and from the microgrid was determined from the Load & Supply Analysis in Task 2 and comparison of variable costs of microgrid generation with the applicable hourly prices to buy from or sell to the larger grid.

Dispatch of internal generation was based on both economic (i.e., efficiency) and reliability considerations, with the least expensive generation resource running as baseload and incrementally more expensive resources running in cycling or peaking mode, and stacked on top of the baseload generation (i.e., microgrid's merit order curve).

1.1.8. Two-Way Communication and Control

The Team considered design options for this task. Important information was requested from the utilities and facilities, which provided information on in-place networks and protocols that possibly could be leveraged in support of this requirement (e.g. leverage for cost saving and interoperability purposes).

The first step was to determine if the microgrid solution would leverage existing networks or if there was a need to design and deploy new communications systems. Once the network platform was identified the Team selected platform and protocol compatible monitoring services as well as security services to satisfy the cyber security protection functions.

The Team evaluated the use of existing communications systems in two important areas.

Cost Savings and Interoperability:

Reuse of existing communications systems can provide cost savings as the microgrid developer will not be required to deploy an entirely new communications fabric. Individual network segments or complete reuse of the communications system can be applied and significant cost savings can be achieved. Additionally, where reuse is leveraged, protocols and data models can be selected to achieve maximum interoperability and performance.

Security and Resilience:

There is a trade-off between cost savings acquired via reuse of existing communications systems and the reduced security and resilience attributes in older communications technology and design approaches. This will be analyzed, and cost and security considerations will be balanced to accommodate the site-specific functional requirements.

Maximum weather resilience and performance is achieved when underground fiber optic networks are deployed. Additional surety can be obtained by creating redundant fiber rings and including two-way communications. The use of fiber, redundant networks, and underground deployment makes this the most reliable and resilient method, but it is also the most costly option. The generation portfolio for the microgrid and potential use cases during connected and islanded modes would go a long way in determining the performance requirements for the communications infrastructure.

Cyber security addresses protection against hacking and malicious intent. The team will consider options such as: modern hardware platforms and network nodes that incorporate device level authentication and authorization; adding security services to the microgrid control nodes and control center to address encryption of data at rest and data in motion; and adding a security architecture that applies defense in depth design principles which includes segmenting of data and system components across different levels of security zones to offer a hierarchy of authorization constraints and system access barriers. Note that cyber security services can be added as a security layer on top of existing communications when reusing networks but cannot change the existing physical security, resilience or performance limitations of the existing networks or device nodes.

1.1.9. Power to Diverse Group of Customers

The proposed microgrid will serve the facilities identified in Table 1-1 as well as numerous residential and small commercial establishments throughout the GMU service area. The critical facilities include the

Eastern Long Island Hospital, which is the only hospital on the North Fork of LI, emergency responders (fire, police, and ambulance), Greenport Village Hall, Greenport High School, and the water and waste water treatment facilities. This presents a diversity of critical facilities and customers and thus the possible benefit of complimentary loads for maximum utilization and capacity factor.

The microgrid will benefit populations served by the critical facilities to be powered by the microgrid, which extends far beyond the resident population of the Village. Although Greenport is somewhat isolated geographically, it has a number of facilities that provide critical services for the entire east end of the North Fork. These facilities include the Eastern Long Island Hospital (ELIH), the Greenport wastewater treatment plant, and the Greenport Fire Department, among several others. The ELIH has 90 beds, and serves the entire east end of the north fork. The nearest hospital is 25 miles to the west in Riverhead. The Greenport wastewater treatment plant treats wastewater from the Village, as well as some other nearby areas, including the Peconic Landing assisted living home and the San Simeon Nursing Home. The Fire Department is responsible for fire, rescue and emergency services for the Village as well as a rather large surrounding area called the “East/West District.”

Traffic control devices on roads within the microgrid service area, including roads leading to the hospital, will be powered, reducing strain on emergency responders and increasing public safety.

The microgrid service area is a major employment center. The microgrid will reduce or eliminate the need to shut down facilities during regional power outages, eliminating the costs associated with lost productivity.

The Fire Department was organized in 1845 and now has over 180 members and serves an area of over 8 square miles with over 12,000 residents. The Department responds to over 800 calls for assistance annually, about 75%-80% of which are ambulance calls.

Information on the microgrid feasibility assessment as well as progress and outputs of Stage 2 and Stage 3 activities will be made available for public informational purposes. This public outreach aspect will raise awareness around the interrelated topics of resiliency planning, energy efficiency and renewable energy.

1.1.10. Uninterruptable Fuel Supply

National Grid has indicated that it is willing to make two system reinforcements needed to supply about 5.0 MMBtu per hour of natural gas for the CCHP facility for ELIH. In the event of an outage, the hospital could utilize its emergency backup generators (although these backup generators do not have one week of liquid fuel supply). National Grid has indicated that the reinforcements could be implemented as early as November 2016.

The project will also include a 7.4 MW LNG-fueled reciprocating engine generator that can supply the entire GMU service area during outages to the main grid. The LNG will be transported in 10,000-gallon tanker trucks and store on site in a 70,000 LNG storage tank, consistent with New York State Department of Environmental Conservation (NYSDEC) regulations. This quantity would provide approximately seven days of fuel supply at average load conditions. If needed, since the engines will have dual fuel capabilities, the project could include diesel storage to provide additional fuel supply. However, as noted previously, it may be possible to supply this plant with pipeline gas on an interruptible basis, subject to further studies by National Grid.

The Team may also designate some loads as "super critical" (e.g. ELIH) and use the backup diesel engines to supply only those supercritical loads during the low probability, high impact event where both electricity and natural gas supply fail.

1.1.11. Resiliency to Forces of Nature

The Village of Greenport is geographically remote and isolated compared to other Long Island communities. Located at the eastern end of Long Island's north fork, it is at the end of the PSEG-LI power transmission line. Any damage to the substation in Southold (2 miles to the west) will knock out power for the entire Village area.

Power supply to Greenport from the main grid was disrupted following Hurricane Irene. Although the Village did not lose power from the main grid during Hurricane Sandy, there were significant distribution outages in the Village that impacted many homes and other facilities.

In addition, the natural hazard event history for the Village demonstrates that Severe Snowstorms, Nor'easters, Severe Storms, Hurricanes and Severe Winter Storms are high risk hazards, all of which have the potential to cause short or long term power outages due to wind, water and snow related impacts on transmission lines.

The Village also experiences disruptions from the main grid during non-storm events. In May 2015, the town lost power due to voltage problems on PSEG-LI's system caused by the loss of PSEG-LI's Southold substation. Though power was restored within a few hours, PSEG-LI continued to experience system problems and requested that Greenport use their generator to provide PSEG-LI voltage support for approximately 20 hours following the initial outage event. Greenport's vulnerability to extreme weather-related power outages and its location at the edge of the grid present unique vulnerabilities. It is critical to the region that Greenport is able to remain self-sufficient during power interruptions.

The microgrid will mitigate the impact of the power outage hazard by providing a redundant, resilient generation and distribution system. The system will also mitigate potential seasonal brownouts related to high utilization of air conditioning during peak hours in hot summer months.

The Team will develop a resilient design that incorporates hardening strategies commonly practiced by systems engineers in areas exposed to storms and outage events. One method to reduce outage frequency is to replace older style un-insulated open wire primary conductors with spacer cable. These conductors have the advantage of a compact design reducing exposure to tree related damage and are supported by a messenger wire further reducing the likelihood of conductor damage

Where appropriate, we may also utilize flood avoidance and flood control measures applied to generators, transformers, and switchgear, fault-tolerant and self-healing network designs, redundant supply or reconfigurable supply where it makes sense, remote monitoring and diagnostic equipment, robust construction, undergrounding where possible, and a host of other time-tested measures.

Flood avoidance and flood control measures include the use of submersible equipment, flood walls, pumping equipment, watertight enclosures, and elevated construction.

As stated previously, the electric generation system will have seven days of fuel storage on-site, or use pipeline gas, and the CCHP system will use pipeline gas, and the backup generators provide additional redundancy and have five days of fuel storage.

1.1.12. Black-Start Capability

The on-site power systems will have the ability to start and operate using battery power and UPS devices and controls to start from a state of zero power to a state of sustained power production as matched to the microgrid load. Based on criticality and necessity, certain critical loads will be given a priority during black-start operation.

The hospital has the following backup generators:

- 675 kW Main Backup
- 350 kW Lab Backup
- 60 kW Food Service Backup

The microgrid would likely include backup generators with capacities greater than 200 kW. The smaller generators would remain as stand-alone backups, since the benefit of connecting the small generators would not be worth the cost for system integration and automatic control interface needed to enable command based dispatch.

The 7.4 MW-generator will also have black start capability.

1.2. Preferable Microgrid Capabilities

1.2.1. Operational Capabilities

In Task 2, the Team explored the application of advanced automation and control technologies to enable enhanced visualization, monitoring, control and interaction. The ultimate goal of “advanced, innovative technologies” is to enable safe, reliable, economic operation of the microgrid, in both connected and islanded mode. Technologies considered during the analysis included: distributed energy resources, including demand response, energy efficiency measures and energy storage; smart grid and distribution automation technologies, such as transfer switches, and automatic fault location isolation and service restoration (FLISR) schemes to ensure reliability; smart relays, adaptive protection, special protection schemes.

Strategic placement of field devices can enhance the flexibility and innate reliability of the microgrid area, whether it is in connected or islanded mode. Reclosers, sectionalizers, and fuses are the mainstays of conventional utility overcurrent protection schemes. Digital sensors and measurement devices, such as transformer monitors, remote fault sensors, and AMI Smart Meters all help to provide additional situational awareness to the both the utility operations center and the microgrid control system. During storm operations and post-storm recovery, increased situational awareness provides faster detection of fault conditions to allow operators to respond more rapidly – both through automation and dispatch of field crews. D-SCADA and Integrated OMS/DMS are emerging technologies that provide the operator interface for monitoring remote sensors, as well as the control fabric for communication with switching devices on the distribution system. When the microgrid is in islanded mode, it is possible for a mature microgrid controllers to take on features of a DMS/OMS, monitoring the system for fault events and automatically isolating faulted areas and reconfiguring the system so that as little of the load is affected as possible. In the Stage 2 design, the Team will assess the existing SG-DA investment and plans by the utility and determine, conceptually, how they impact the microgrid operations, and what additions may be feasible.

1.2.2. Active Network Control System

The Team is evaluating the current set of available commercial microgrid controllers. A best of breed selection will be made to obtain alignment with the microgrid site's requirements. From our recent microgrid studies we are aware that available commercial microgrid controllers primarily support various levels of the most fundamental operating functions such as; load shedding, optimal dispatch, integration of renewables or energy storage, forecast and scheduling, and basic situational awareness. Advanced functions like deep control integration with external SCADA or DMS systems or deep monitoring integration with AMI and other data collection and analysis systems is typically a custom developed adapter built to support a specific microgrid use case and system configuration. Section 2.5 provides a fuller characterization of the microgrid active network control system.

1.2.3. Clean Power Supply Sources

The Team has considered all opportunities to incorporate renewable resources into the generation mix for the microgrid. The feasibility analysis evaluated a 375 kW CCHP plant at ELIH to supply the hospital's thermal loads and a portion of the electrical load with clean natural gas.

The microgrid design also incorporates existing and new renewable resources, including a 250 kW solar system that currently exists at the high school. Although land is limited and very expensive, the project will include an additional 250 kW of solar at ELIH and/or in the park area on Moores Lane and a 125 kW, 500 kWh Battery Energy Storage System.

The project also incorporates 90 kW of demand response/load curtailment at ELIH, the WWTP and IGA Grocery.

1.2.4. Energy Efficiency and Other Demand Response

The Village is in the process of installing LED lighting with financing support from Suffolk County. Also, ELIH is in the process of converting all of its lighting to LEDs.

The microgrid includes other cost-effective energy efficiency measures that have not already been taken to minimize new generation requirements. For example, we evaluated the potential use of an absorptive chiller for the hospital to replace the existing 123 kW chiller. The energy efficiency of the system will be based on the choice of new equipment and devices that will be included in the microgrid. The designed microgrid will include demand response functionalities for scheduling and control of the demand response resources included in the microgrid facilities.

This study considered the demand response options by working together with the facility owners/managers to identify potential demand response resources (curtailable and discretionary loads) and their size and location, and take them into consideration in the functional design of the control and communications infrastructure.

The microgrid has the ability to provide generation/load reduction to support the grid during critical periods as an alternative to distribution-system reinforcement and potentially receive; payments for islanding as a demand response ("DR") service, payments for exporting power as a generation service, and payments for maintaining critical loads during a larger system outage. A contract could call for immediate response in local crises, not just to reduce peak system demand. Short-term markets for local service could be local voltage/VAR support, short-term substation relief, and emergency services (e.g., agreements to make agreed-upon energy exports or to assume prescribed load shapes). Through distribution support services, the microgrid could provide grid restoration services that are more flexible than typical black-start capabilities and ultimately, ensure local reliability, circuit by circuit, across the larger grid. All of these different market constructs need to be discussed with PSEG, and an appropriate mix of services agreed to in order to support both PSEG and microgrid participant requirements.

This study will consider demand response options, both within the utility programs and also in NYISO markets, by working together with the facility owners/managers to identify potential demand response resources (curtailable and discretionary loads) and their size and location, and take them into consideration in the functional design of the control and communications infrastructure.

The GE Team met with NYISO representatives to discuss the potential for NYISO market participation by microgrids and behind the meter DG. NYISO is still working on the applicable market rules. The GE Team will maintain the relationship with NYISO and monitor on-going developments. Based on the latest information, as the project moves on, the team will explore ways for the proposed microgrid to actively participate in the NYISO's energy, capacity, and ancillary services markets.

1.2.5. Installation, Operations and Maintenance and Communications

The Team is coordinating with the Town and Village to determine how to incorporate any new distribution infrastructure into the existing grid. In any case, above ground distribution lines will be hardened to assure reliability and resiliency of the microgrid. Given the options available for modern microgrid design, the existing infrastructure will often be the differentiating factor in design decisions. Considerations such as the interconnecting network construction and topology will govern many of the design decisions. When feasible, ease of maintenance and installation as well as operational synergy will be factored into design decisions. However, it should be noted that primary microgrid design criteria such as stability and resiliency will generally have priority over operations/maintenance concerns.

The Team worked with the municipal utility to develop an understanding of the relevant features of the electric distribution system and identify the current distribution network challenges in terms of parsing out a microgrid out of the current grid and ensuring that the larger grid will not be adversely impacted.

The type and the configuration of the underlying electric network of the microgrid is highly dependent on the current distribution network, locations and distances of the microgrid facilities on the feeders, and the technical requirements that need to be considered in the functional design of the microgrid electrical infrastructure. A very important consideration is the overall cost of various grid type options. Initially, the Team developed a design that that interconnected sections of various feeders and isolated other sections so that primarily critical facilities could be served by the microgrid generation. However, it was later determined that increasing the size of the generation and simplifying the infrastructure design by picking up entire feeders was more beneficial to the Village.

1.2.6. Coordination with REV

The Greenport project has the advantage of being located within a municipal utility service area, with an experienced and pragmatic management team. Mr. Paul Pallas, P.E. is the Village Administrator and manager of the municipal utility. He previously managed the municipal utility for Rockville Centre, NY, and is President of the New York Association of Public Power (NYAPP). In addition, the Village trustees have long supported energy projects in Greenport, and will help assure community support for viable microgrid opportunities. This local support and expertise will help identify innovative microgrid strategies, and minimize potential obstacles faced by some other microgrids.

The village and the microgrid developer have worked closely together on this project, and expect to establish a formal public/private partnership to own and operate the DERs and distribution system. The specific roles and responsibilities or the parties are discussed in later sections of this report.

The Team is following ongoing activities involving REV that would have relevance to the development and operation of the microgrid. In particular, GE has a dedicated team that regularly monitors the latest REV filings and developments, and is in contact with various policy makers and stakeholders.

The Team will take into account the latest REV developments in considering various business models and operational modes of the microgrid within the REV framework. In particular, the Team will describe the options for microgrid's operation during the blue sky days across the possible distribution system platform (DSP) and trading in the animated market, that most likely may involve dynamic trading (including buy and sell of power and demand resources) both at retail/distribution system level and also at NYISO/transmission system level. We understand that details of REV framework will keep evolving, which we will take into account in our development of the microgrid functionalities.

1.2.7. Comprehensive Cost/Benefit Analysis

In Task 4, the Team provided input needed for the NYSERDA cost/benefit analysis tool to evaluate both the net societal benefits and also the costs and benefits from the perspectives of the various stakeholders.

On the cost side, the Team identified (a) various costs elements, covering the design, development, and deployment of the microgrid, capital costs of various components, fuel, variable operations and maintenance (VOM), and fixed operations and maintenance (FOM) cost of generation and demand side resources, (b) costs of the electrical network infrastructure, (c) costs of the control and communications infrastructure.

On the benefit side, the Team identified various potential revenue sources such as utility demand side programs, and those from participating as a virtual plant in the NYISO wholesale market. Additional benefits include estimation of avoided costs of power interruptions for different facilities within the microgrid. See Chapter 4 for more detail on the cost/benefit analysis.

1.2.8. Leverage Private Capital

The Team designed the project and structured the financing to produce returns on investment and debt coverage that will attract private financing needed to complete the project. The team also evaluated different ownership models that will help attract third party funding. The full financial analysis will determine the amount of private funding needed to supplement any NYSERDA funding, and produce acceptable returns and risk for the private investors. It is also expected that GMU will provide its share of funding for DERs and hardening of the distribution system. However, NYSERDA funding will also be a key part of the capital structure.

The Benefit/Cost Analysis (BCA) includes potential benefits and costs from various perspectives, including the microgrid as a single entity, and also from the viewpoint of the facility owners and the utility.

In addition, the BCA includes the societal net benefits/costs. The Team's contributions reflect lessons from the original NYSERDA 5-Site study which included consideration of various financial benefit and cost streams, and was supplanted by accounting for other non-tangible benefits and costs, including environmental benefits and avoided interruption costs. The latter, which is more difficult to quantify, were estimated based on available benchmarks depending on the classification of the facility type, critical loads impacted, number of persons impacted, and the duration of emergency period.

1.2.9. Tangible Community Benefits

The Project will benefit the community both by providing added reliability and resiliency for microgrid participants, and potentially reducing energy costs for the village. It is expected that the microgrid will serve up to ten critical facilities, including the hospital, village hall, the High School, water and waste water treatment facilities, and other facilities, as well as the entire GMU service area which includes numerous residential and small commercial establishments in the Village. Providing reliable energy for these facilities during outages to the main grid will also benefit the Village and surrounding communities by ensuring that the Village can continue to provide critical services, including effective emergency response and recovery, during outages to the main grid. The system will also mitigate seasonal brownouts related to high utilization of air conditioning during peak hours in hot summer months, which in the past has caused businesses to close.

1.2.10. Innovation That Strengthens the Power Grid

The Team will consider the options for interaction of the microgrid with the surrounding power grid, including both the distribution utility and the NYISO. The interaction with the surrounding grid across a Distribution System Platform (DSP) through market animation is a major aspect of the New York Reforming of Energy Vision (REV).

For instance, one possible innovation that may be considered within the REV framework is optimal economic operation of the resilient microgrid during blue sky days (i.e., during normal, non-emergency periods), by participation in the utility demand response programs and also NYISO's energy, ancillary services, and capacity markets.

An active and dynamic scheduling of microgrid operations that would maximize the economic efficiency and technical reliability of the microgrid and the surrounding system will require both technical innovations and also reform of regulatory and policy regime that would enable market participation. The Team will elaborate on needed innovations and requirements that would enable such market participation. These may include complementary hardware that would provide more flexibility, such as integrated energy storage, and the smart scheduling software.

The Team will describe the actionable information that would need to be made available to customers for economically efficient and technically reliable operation and scheduling of the microgrid generation. These include real-time load and supply status of the microgrid and the underlying variable costs of operations and the applicable seller and buyer prices on the DSP and/or NYISO. It should also be noted that such actionable information, although accessible to customers when requested or queried, would function and used mostly in the background in automated microgrid systems.

2. DEVELOP PRELIMINARY TECHNICAL DESIGN COSTS AND CONFIGURATION

2.1. Proposed Microgrid Infrastructure and Operations

2.1.1. Simplified Equipment Layout Diagram and One-Line

Figure 2-1 below is a simplified layout of the Greenport microgrid showing the electrical service to the microgrid facilities. The existing overhead lines are shown in different colors to identify the individual feeders. Six circuits, #1, #2, #3, #4, #6 and #7 out of the Greenport substation will be used to provide power to the critical facilities as well as other Greenport loads.

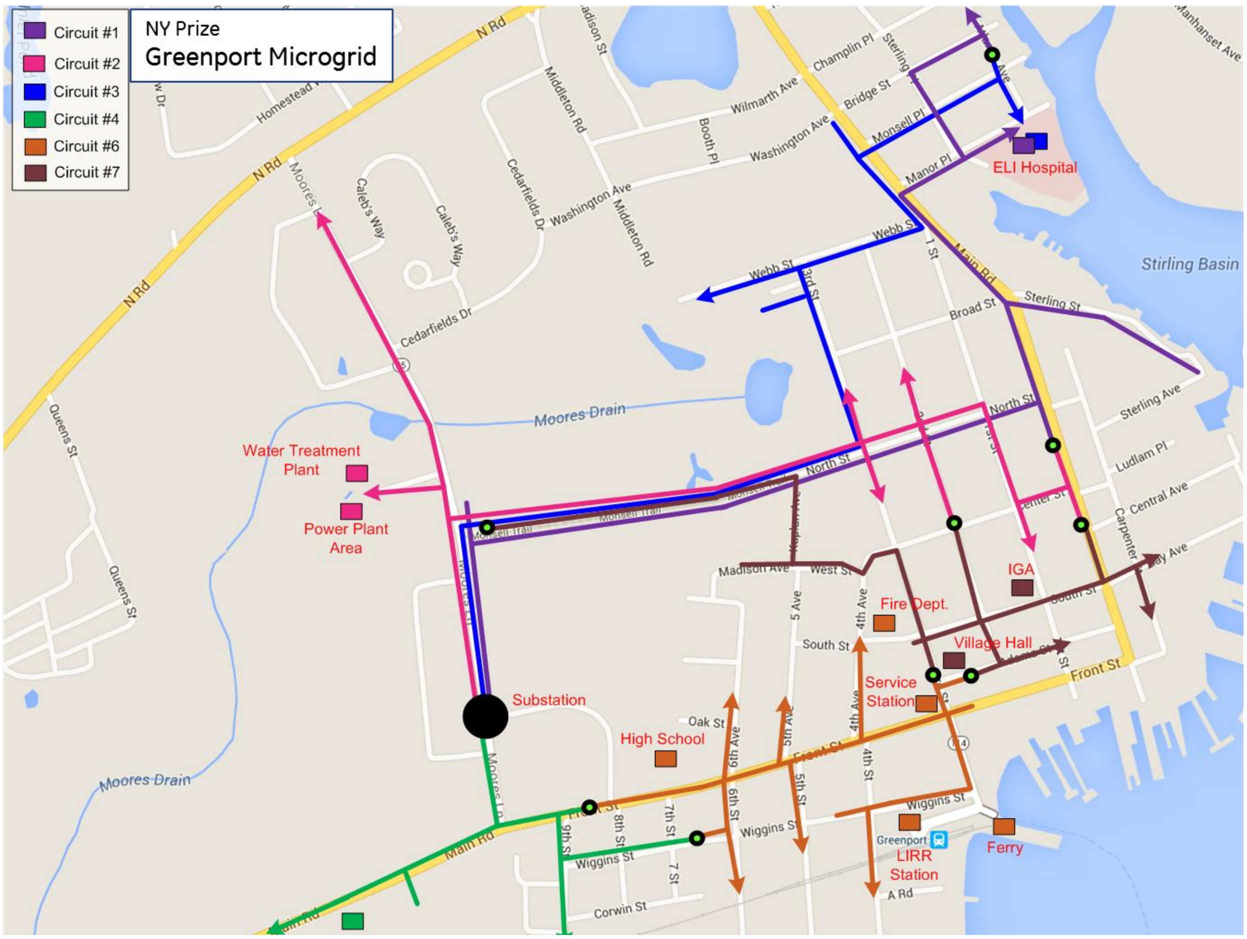


Figure 2-1: Simplified Layout of Greenport Microgrid Showing Facilities and Routing of Electrical Connections

This configuration will allow the microgrid to serve the entire GMU service area. The critical facilities identified in the figure include a hospital, water and waste water treatment facilities, a high school, a fire department, a ferry dock, Long Island Rail Road terminus, the Village Hall, a grocery store, and two service stations. In addition, there are a large number of residential commercial establishments served by sections of existing feeders that the microgrid will utilize. These customers will continue to receive service from the microgrid in islanded mode because 1) it is too complicated and expensive to isolate them individually, and 2) they are vital to functioning of the village.

Figure 2-2 below shows a simplified one-line diagram with the location of the distributed energy resources (DERs) and the utility interconnection points. Due to the distances between facilities, the microgrid design makes heavy use of the existing overhead utility infrastructure.

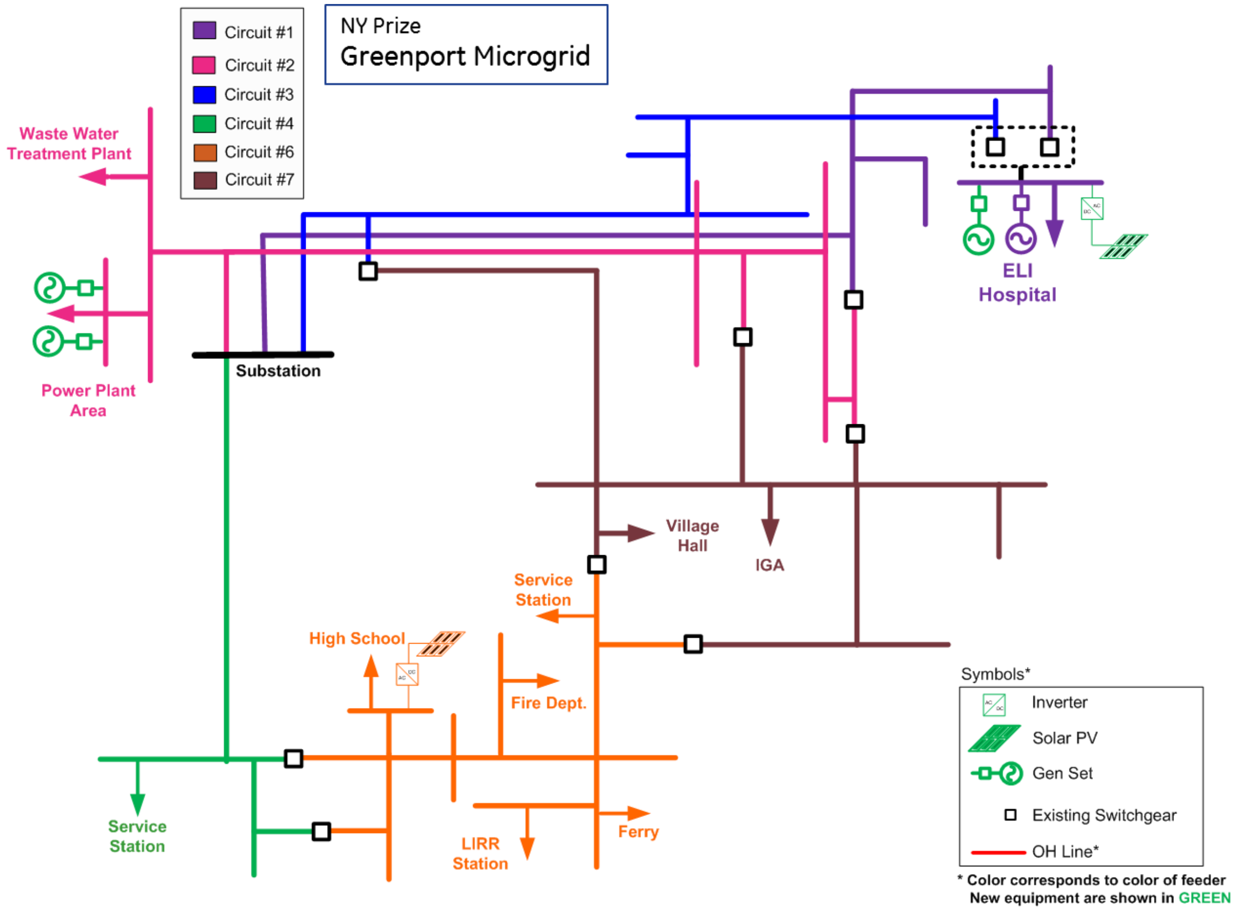


Figure 2-2: Greenport Microgrid One-Line Diagram Showing Generation Sources and Major Equipment

To facilitate isolation of the microgrid system from the larger utility grid supply, new switchgear will be installed and some existing switches will be upgraded to remote operating capability. Other additions include a CCHP unit at ELIH, a new natural gas reciprocating engine in the area of the existing power plant, and solar PV at hospital (or on Moores Lane), and an electric batter storage at Moores Lane site near WWTP.

2.1.2. Operation under Normal and Emergency Conditions

Normal Conditions

Under normal condition the microgrid facilities will be served by six circuits out of one substation on the Village of Greenport's municipal distribution system. The CCHP will operate as baseload at ELIH throughout the year, providing electrical and thermal energy (heating and cooling) to the hospital. The new installed electric only generation on Moores Lane will continue to operate during normal conditions, primarily dispatching during warm weather for sale of power to customers outside the GMU service area. The electric plant may also supply GMU during peak demand periods to reduce the need for market priced (i.e., non-hydro) energy. In addition, the 125 kW – 500 kWh electric battery storage will help provide grid stability and also would be able to provide capacity, energy, and frequency response to the NYISO. In an event of an outage newly installed and upgraded switchgear may also be used to reduce the impact and speed up the restoration effort.

Emergency Conditions

When power is lost to all of the facilities due to, for example, a catastrophic event on the bulk power system or the Greenport substation, loads in all facilities will be unserved by the PSEG-LI grid. The microgrid controller which is monitoring the points of facility interconnection (POIs) with the main grid and the switches that form the boundary of microgrid (see Figure 2-2) will sense loss of voltage and frequency, and the CCHP generation at ELIH, natural gas engine at Moores Ln, and PV will go off-line (in accordance with anti-islanding protection procedures). Normally closed switchgear at the boundary of microgrid will open to disconnect the village system from the main grid (bulk power supply). The diesel-fueled generator at the hospital will start up to supply critical facility loads within 10 seconds, by code.

Once all the facilities are isolated from the bulk power supply, the CCHP generator at the hospital will restart and synchronize with the online backup generation (5-10 minutes). The natural gas engine near the power plant will also start up in islanded mode (self-synchronized) and pick up some load in the area, including the WWTP. When the CCHP generation and natural gas engine are stable, the normally open feeder tie between the circuits is closed in, the generation sources are synchronized, and an islanded microgrid is formed. Subsequently, more tie switches in the area can be closed, and additional microgrid load can be sequentially transferred to the CCHP and the natural gas engine. Simultaneously, the backup generation at the hospital may be ramped down if no longer needed. Once the island is stable and active, PV would reconnect and begin generating. During islanded operation, the microgrid controller would actively monitor voltage and frequency in the island. Some loads designated as curtailable may be shed, and backup diesel generation might remain online or be brought online to maintain stable operation.

In cases when the grid is stressed but there is no forced outage, "seamless" transition (in a few cycles) to islanded microgrid mode is possible with advanced controller functions. In this scenario the natural gas generators would remain online during the transition, and the microgrid controller would shed load if necessary. The project will also include a 125 kW battery that would aid the seamless transition, and help stabilize the microgrid during emergencies.

2.2. Load Characterization

2.2.1. Description of Electrical and Thermal Loads

The Greenport microgrid project is a public-private partnership that will jointly own and operate the DERs. A list of the DERs and ownership is shown below.

DER	Owner/Operator
375 kW CCHP	GMU
7,400 kW Electric generating plant	MESCO
125 kW Batteries	GMU
500 kW solar PV	MESCO

In grid connected mode the 375 kW CCHP at ELIH will operate at maximum capacity, providing electrical power in addition to thermal energy for heating and cooling needs of the hospital. Power will be imported from the grid to make up any shortfall over the load cycle. Other facilities in the microgrid will also continue to purchase power from GMU under existing energy supply arrangments.

The electric only generator will sell energy to customers contractually to customers outside of Greenport, and will not replace any of GMU's hydro allocation, because the cost of energy from the electric plant will be much greater than the cost of energy from the hydro allocation. The energy will be sold to these customers using a contract for differences structure, and the generating facility would be dispatched when the LBMP exceeds the strike price of the facility. However, if excess energy that is not contractually obligated is available from the electric generating plant, energy from may also replace some of GMU's market rate power, subject to requirements of the NYPA contract.

The 7,400 kW electric-only reciprocating engine will participate in electricity markets by selling power to PSEG-LI and/or NYISO based on economic considerations. To fulfill its obligations to its customers outside of Greenport, the MESCO will purchase power from the market when it is not running its own generation.

The DERs will also include a 125 kW-500 kWh battery system, which will be owned and operated by GMU, located at the wastewater treatment plant and water supply area. The battery will reduce peak loads due to pumping at the WWTP and the SCWA water storage facility during blue-sky days, and help stabilize the microgrid during grid outages.

In islanded mode during emergencies and larger grid outage periods, the CCHP and the electric-only engine will provide electric energy to the entire microgrid load. Other available resources include a total of 500 kW solar PV (to be owned and operated by the MESCO in order to utilize ITC tax credits), one 125 kW – 500 kWh battery storage, and 90 kW of load curtailment. The CCHP unit will also provide thermal energy for the heating and cooling of the hospital. ELIH also has a 500 kW diesel backup unit which is not expected to run for any significant amount of time, except during transition periods, and in extreme emergencies when the microgrid generation units are not available.

The table below summarizes the monthly peak demand and energy consumption of microgrid electrical and thermal loads over a year of operation. Note that the electrical Peak load of 6,210 kW is the sum of the "coincident" peak load of the microgrid across all facilities. As shown in other load tables in this report, the total "non-coincident" peak load (i.e., sum of peak loads of individual facilities) is 6,569 kW. Winter peaks are likely due to electric heating loads.

Table 2-1: Monthly Microgrid Electrical, Heating, and Cooling Load

	Electrical Load		Heating Load		Cooling Load	
	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)
JAN	2,747,123	5,463	314,111	753	0	0
FEB	2,790,942	6,161	268,303	711	0	0
MAR	2,927,718	5,861	222,184	533	1,556	5
APR	2,478,467	5,100	122,154	474	6,224	17
MAY	2,339,973	4,667	42,380	160	35,787	97
JUN	2,710,534	5,588	4,986	19	113,585	318
JUL	2,913,324	5,821	312	1	238,062	648
AUG	3,039,697	6,097	312	1	168,044	458
SEP	3,023,777	6,210	12,465	48	49,791	139
OCT	2,392,226	4,783	77,593	186	3,112	9
NOV	2,368,870	4,868	163,288	402	0	0
DEC	3,088,623	6,151	260,513	625	0	0
YEAR	**32,821,275**	**6,210**	**1,488,599**	**753**	**616,161**	**648**

Note: Electrical peak load (6,210 kW) is the coincident peak

2.2.2. Hourly Load Profile of Loads

The main sources of electrical load data for critical facilities and other commercial and residential customers were provided by the GMU in the form of monthly bills, and loads on individual feeders. To keep the costs down and spread the social benefits of the microgrid to a wider population, in addition to the selected critical facilities, the project team included in the microgrid numerous other commercial establishments in downtown Greenport that happen to be on the same feeder(s) as the critical loads. The information provided by the Village was used to estimate the annual peak load of the microgrid and to determine the annual energy demand on the microgrid. Consequently, a 12 x 24 (month x hour) load shape for the aggregate microgrid including extra feeder loads was developed, resulting in an annual coincident peak load of about of 6.2 MW and a load factor of 60%. Extra Feeder Load represents additional non-critical commercial and residential loads connected to the microgrid feeders.

The main source of thermal data is information on the annual fuel oil purchases by the hospital. The annual heating and cooling loads of the hospital were projected based on the monthly Heating Degree Days and Cooling Degree Days data (at LaGuardia Airport), downloaded from the NYSERDA website.[2] The monthly loads were then projected onto a 12x24 profile based on seasonal load shapes developed by EPRI for each region of the USA by customer class for different end uses.[3] The microgrid's 12x24 electrical and thermal load profiles in tabular and graphical forms are provided in the tables and charts below.

[2] http://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Weather-Data/Monthly-Cooling-and-Heating-Degree-Day-Data

[3] http://loadshape.epri.com/enduse

Table 2-2: Microgrid 12x24 Electrical Load (kW)

Day-type	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
weekday	JAN	2611	2603	2612	2604	2674	3152	3267	3453	4263	4272	4273	4749	4748	5462	5463	5463	4750	4232	4107	3401	3305	3230	2647	2602
weekday	FEB	2911	2904	2912	2905	3009	3536	3698	3936	4852	4860	4860	5380	5380	6161	6161	6161	5382	4811	4626	3852	3708	3628	2951	2901
weekday	MAR	2764	2768	2765	2800	2820	3411	3545	3726	4565	4568	4568	5084	5085	5861	5861	5861	5051	4435	4391	3556	3465	3371	2801	2765
weekday	APR	2412	2418	2413	2481	2484	3044	3182	3319	3989	3990	3990	4433	4434	5099	5099	5100	4399	3829	3830	3072	3012	2905	2448	2415
weekday	MAY	2189	2191	2190	2275	2282	2814	2961	3099	3688	3689	3690	4080	4081	4665	4666	4667	4052	3503	3503	2807	2758	2625	2226	2190
weekday	JUN	2625	2625	2625	2712	2720	3352	3510	3662	4384	4386	4388	4865	4868	5582	5586	5588	4842	4184	4183	3349	3295	3151	2666	2625
weekday	JUL	2738	2738	2738	2830	2840	3502	3634	3817	4565	4568	4570	5065	5069	5811	5816	5821	5048	4347	4346	3459	3436	3282	2778	2738
weekday	AUG	2838	2838	2838	2945	2960	3665	3821	4036	4804	4807	4812	5320	5326	6086	6092	6097	5299	4540	4539	3605	3579	3403	2886	2838
weekday	SEP	2949	2950	2949	3037	3043	3737	3897	4037	4852	4854	4856	5397	5399	6208	6210	6210	5370	4660	4659	3735	3672	3535	2985	2949
weekday	OCT	2235	2241	2237	2319	2323	2865	3036	3171	3777	3778	3779	4180	4182	4782	4783	4782	4151	3602	3602	2895	2805	2680	2267	2237
weekday	NOV	2304	2298	2306	2298	2374	2791	2920	3113	3823	3831	3832	4246	4247	4867	4868	4868	4245	3795	3668	3049	2949	2868	2345	2297
weekday	DEC	2923	2914	2924	2914	3006	3537	3682	3908	4817	4826	4827	5356	5356	6151	6151	6151	5358	4785	4627	3839	3717	3627	2964	2911
weekend	JAN	2605	2595	2607	2596	2629	3096	3133	3189	3939	3949	3957	4429	4433	5143	5119	5106	4394	3899	3876	3158	3145	3138	2639	2595
weekend	FEB	2901	2892	2902	2894	2935	3450	3499	3572	4403	4423	4428	4947	4948	5727	5687	5669	4888	4346	4306	3528	3495	3494	2936	2894
weekend	MAR	2761	2759	2761	2770	2777	3312	3334	3406	4210	4218	4221	4738	4738	5492	5467	5461	4675	4135	4126	3343	3336	3322	2793	2761
weekend	APR	2406	2410	2406	2431	2428	2908	2930	3005	3680	3685	3685	4129	4129	4766	4755	4754	4075	3604	3602	2920	2918	2892	2442	2412
weekend	MAY	2182	2183	2183	2212	2212	2647	2677	2756	3354	3361	3361	3751	3751	4306	4290	4290	3690	3266	3262	2653	2650	2610	2218	2181
weekend	JUN	2617	2617	2618	2645	2646	3172	3202	3286	4015	4023	4023	4500	4500	5183	5167	5167	4437	3925	3921	3183	3179	3135	2658	2617
weekend	JUL	2729	2729	2729	2760	2760	3310	3343	3434	4191	4199	4200	4695	4695	5400	5380	5381	4622	4091	4084	3319	3313	3264	2770	2729
weekend	AUG	2827	2827	2827	2862	2862	3428	3468	3570	4349	4357	4357	4864	4864	5583	5560	5560	4781	4232	4228	3439	3434	3382	2877	2827
weekend	SEP	2942	2943	2943	2972	2972	3563	3596	3678	4504	4512	4512	5053	5053	5829	5810	5810	4984	4407	4403	3565	3563	3520	2979	2942
weekend	OCT	2227	2229	2227	2257	2254	2699	2724	2795	3408	3414	3415	3816	3818	4390	4378	4377	3762	3326	3324	2703	2702	2665	2261	2232
weekend	NOV	2298	2293	2299	2301	2323	2743	2778	2847	3497	3510	3514	3927	3928	4541	4517	4507	3882	3447	3424	2797	2781	2770	2334	2293
weekend	DEC	2914	2903	2916	2904	2944	3463	3512	3578	4418	4434	4442	4969	4972	5763	5731	5715	4921	4371	4339	3542	3518	3514	2953	2904

Table 2-3: Microgrid 12x24 Heating Load (kW)

Day-type	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
weekday	JAN	385	385	381	408	476	577	685	753	745	666	561	473	416	383	368	368	375	381	382	380	377	376	376	376
weekday	FEB	364	364	359	386	450	545	647	711	704	629	529	447	393	362	348	348	354	360	360	358	356	355	355	355
weekday	MAR	273	273	269	289	337	408	484	533	527	471	397	335	294	271	260	260	265	270	270	268	267	266	266	266
weekday	APR	237	237	281	359	435	474	454	374	265	169	106	70	49	36	29	29	35	48	64	82	101	121	142	159
weekday	MAY	80	80	95	121	147	160	153	126	90	57	36	24	17	12	10	10	12	16	22	28	34	41	48	54
weekday	JUN	10	10	11	15	18	19	19	15	11	7	4	3	2	1	1	1	1	2	3	3	4	5	6	7
weekday	JUL	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekday	AUG	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekday	SEP	24	24	29	37	44	48	46	38	27	17	11	7	5	4	3	3	4	5	7	8	10	12	14	16
weekday	OCT	95	95	94	101	118	143	169	186	184	164	138	117	103	95	91	91	93	94	94	94	93	93	93	93
weekday	NOV	206	206	203	218	254	308	365	402	397	355	299	252	222	204	196	196	200	203	204	202	201	201	200	200
weekday	DEC	320	320	316	339	395	479	568	625	618	552	465	392	345	317	305	305	311	316	317	315	313	312	311	312
weekend	JAN	274	274	275	275	285	314	364	422	461	459	423	375	335	307	289	281	283	292	303	311	317	321	323	317
weekend	FEB	259	259	260	260	269	296	344	398	435	434	399	355	317	290	273	265	267	276	286	293	299	303	305	300
weekend	MAR	194	194	195	195	201	222	257	298	326	325	299	266	237	217	204	198	200	207	214	220	224	227	228	225
weekend	APR	132	132	144	162	181	200	212	213	199	176	152	131	115	103	93	86	84	85	89	98	110	123	135	142
weekend	MAY	44	44	49	55	61	67	72	72	67	60	51	44	39	35	31	29	28	29	30	33	37	41	45	48
weekend	JUN	5	5	6	7	7	8	9	9	8	7	6	5	5	4	4	4	3	3	4	4	4	5	5	6
weekend	JUL	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekend	AUG	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekend	SEP	13	13	15	16	18	20	22	22	20	18	15	13	12	10	9	9	9	9	9	10	11	13	14	15
weekend	OCT	68	68	68	68	70	77	90	104	114	113	104	93	83	76	71	69	70	72	75	77	78	79	80	78
weekend	NOV	146	146	147	147	152	167	194	225	246	245	225	200	179	164	154	150	151	156	161	166	169	171	172	169
weekend	DEC	228	228	228	228	236	260	302	350	382	381	351	311	278	255	239	233	235	243	251	258	263	267	268	263

Table 2-4: Microgrid 12x24 Cooling Load (kW)

Day-type	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
weekday	JAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekday	FEB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekday	MAR	1	1	1	1	1	1	1	2	2	2	3	4	4	4	5	4	4	4	3	2	2	2	1	1
weekday	APR	3	3	3	3	3	4	5	7	10	12	14	15	17	17	17	17	15	13	11	9	8	6	5	4
weekday	MAY	17	17	16	17	19	23	31	41	54	66	77	87	94	97	97	93	85	74	63	52	42	34	27	22
weekday	JUN	54	54	53	54	61	76	100	135	175	216	252	283	305	318	317	304	277	243	205	170	138	110	88	72
weekday	JUL	111	111	108	110	124	154	205	275	357	440	515	577	623	648	648	620	566	495	419	347	282	225	179	146
weekday	AUG	78	78	76	78	87	109	145	194	252	311	364	407	440	458	457	438	399	350	296	245	199	159	127	103
weekday	SEP	24	24	23	24	27	33	44	59	77	94	111	124	134	139	139	133	122	106	90	75	60	48	38	31
weekday	OCT	2	2	2	2	2	2	3	3	4	5	6	7	8	9	9	9	8	7	6	5	4	3	3	2
weekday	NOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekday	DEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekend	JAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekend	FEB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekend	MAR	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	1	1	1
weekend	APR	3	3	3	3	3	4	4	5	7	8	10	11	11	12	12	11	11	10	9	8	7	5	5	4
weekend	MAY	18	18	17	17	18	20	24	31	39	47	54	59	63	65	65	63	59	54	48	43	37	31	25	21
weekend	JUN	58	58	56	56	58	65	79	100	126	152	175	192	204	210	210	204	192	176	158	139	119	100	83	68
weekend	JUL	117	117	115	113	118	132	161	204	257	311	356	392	416	429	430	417	392	359	322	283	243	204	168	140
weekend	AUG	83	83	81	80	83	93	113	144	181	219	252	277	294	303	303	294	277	254	228	200	172	144	119	98
weekend	SEP	25	25	25	24	25	28	34	44	55	67	77	84	89	92	92	89	84	77	69	61	52	44	36	30
weekend	OCT	2	2	2	2	2	2	2	2	2	3	3	4	4	5	5	5	4	4	4	4	3	3	2	2
weekend	NOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weekend	DEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

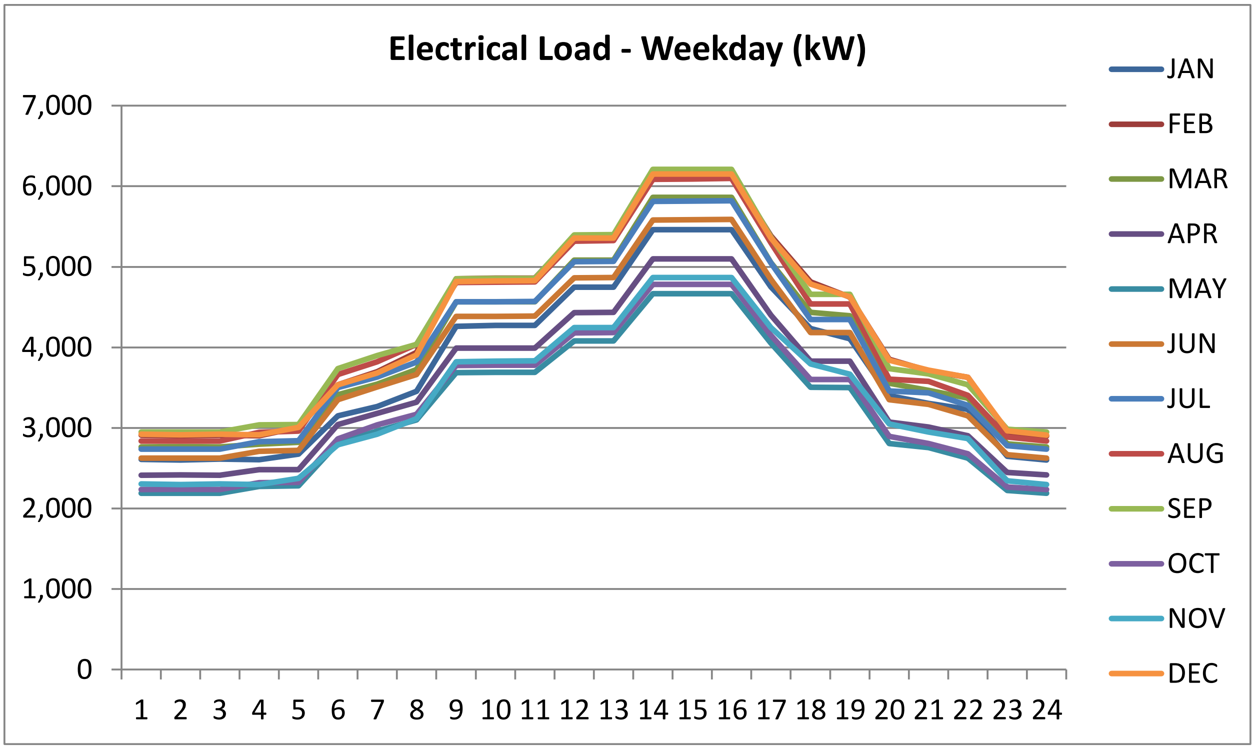


Figure 2-3: Microgrid Weekday Electrical Load Profile (kW)

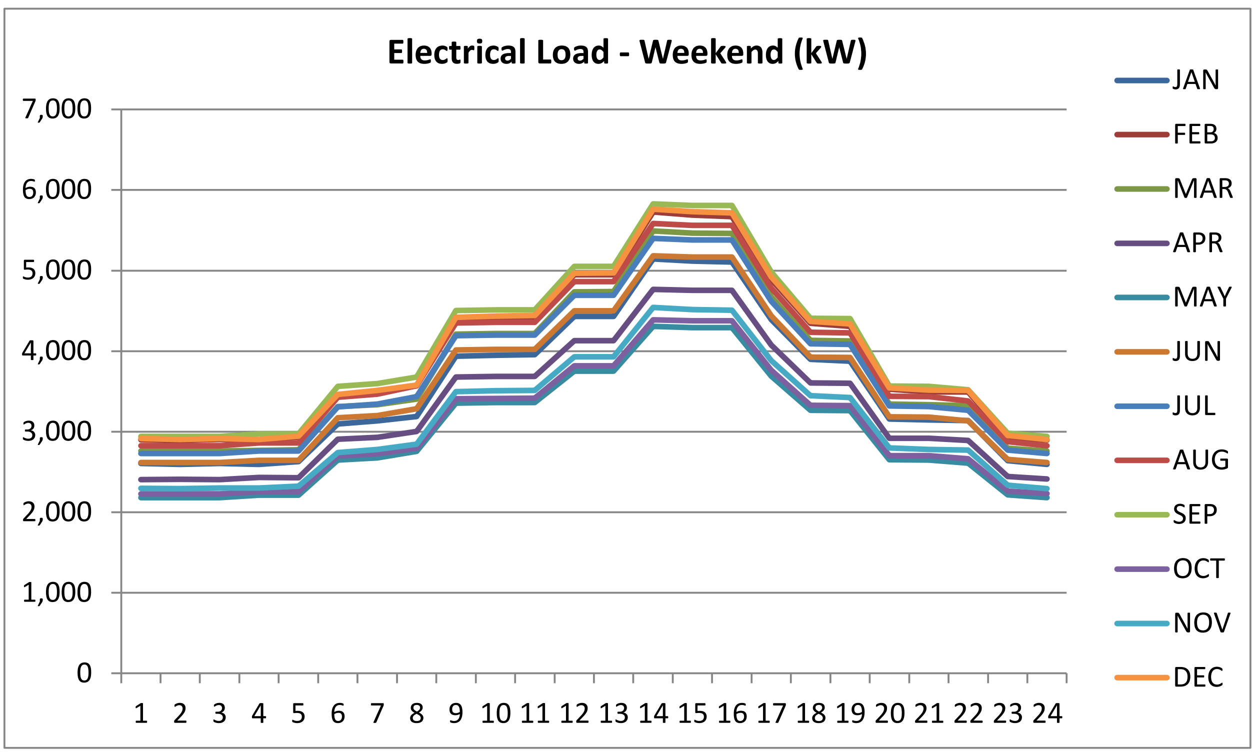


Figure 2-4: Microgrid Weekend Electrical Load Profile (kW)

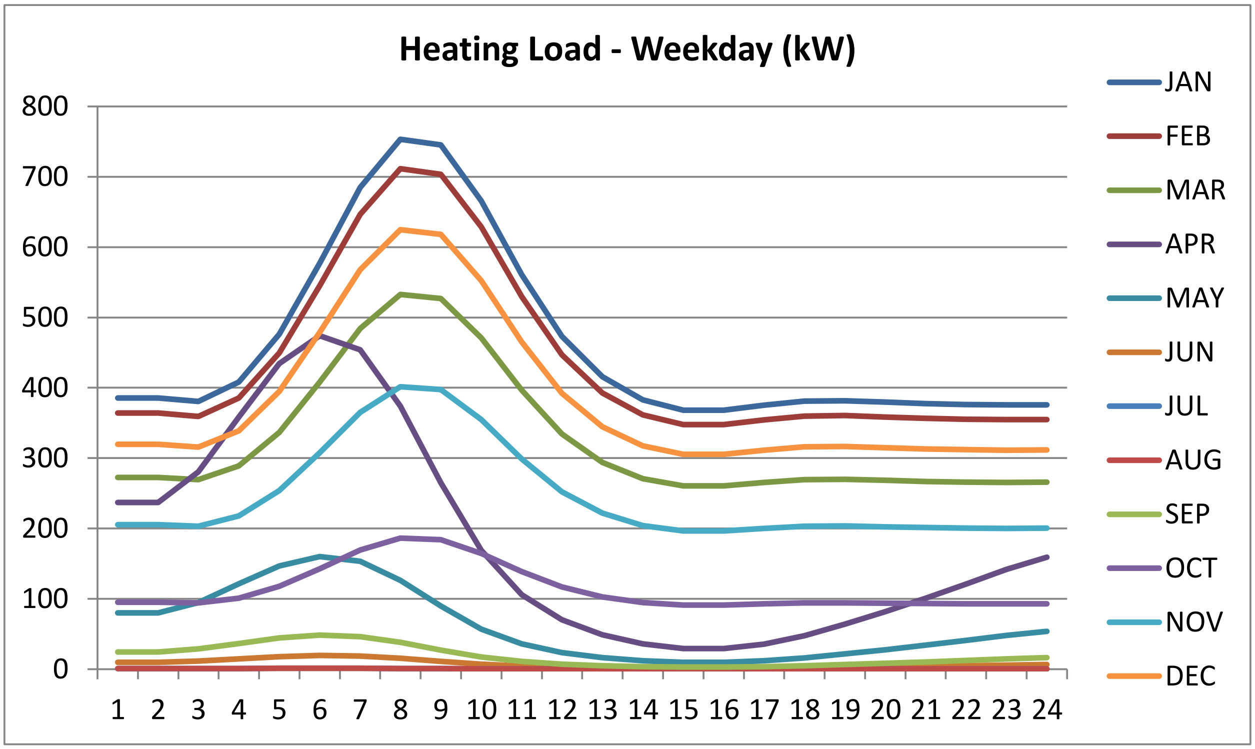


Figure 2-5: Microgrid Weekday Heating Load Profile (kW)

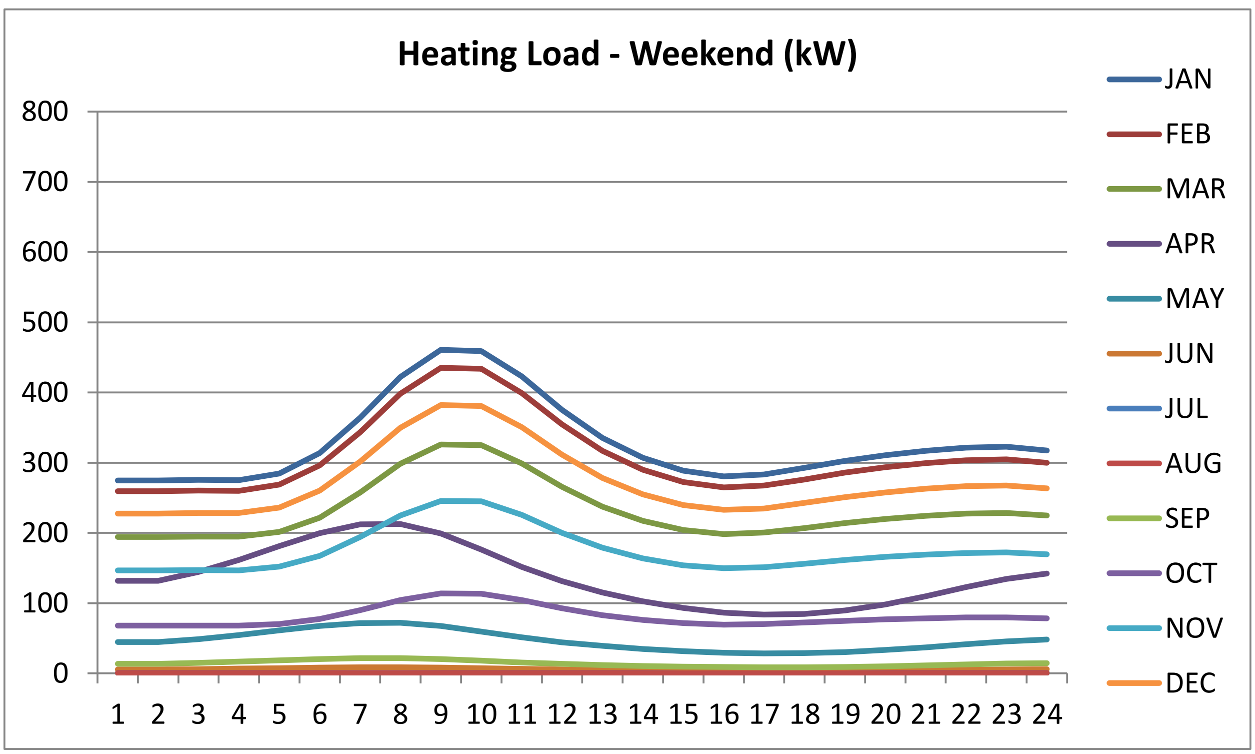


Figure 2-6: Microgrid Weekend Heating Load Profile (kW)

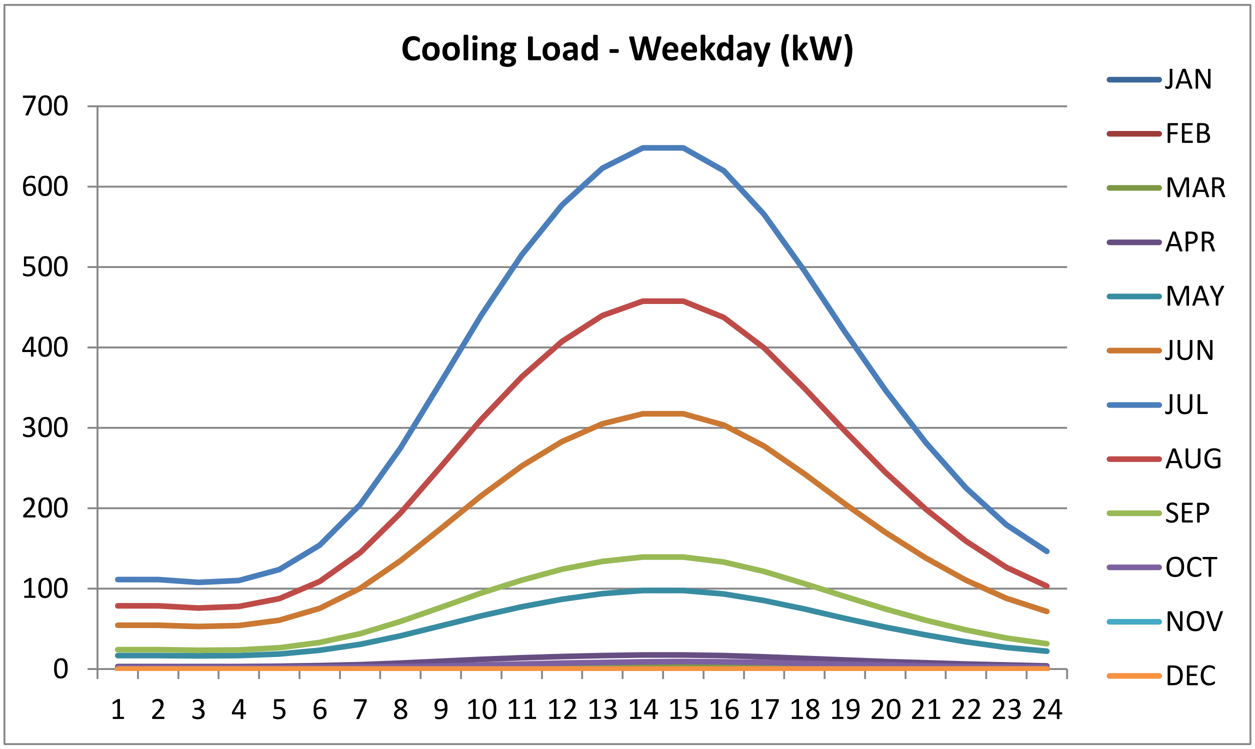


Figure 2-7: Microgrid Weekday Cooling Load Profile (kW)

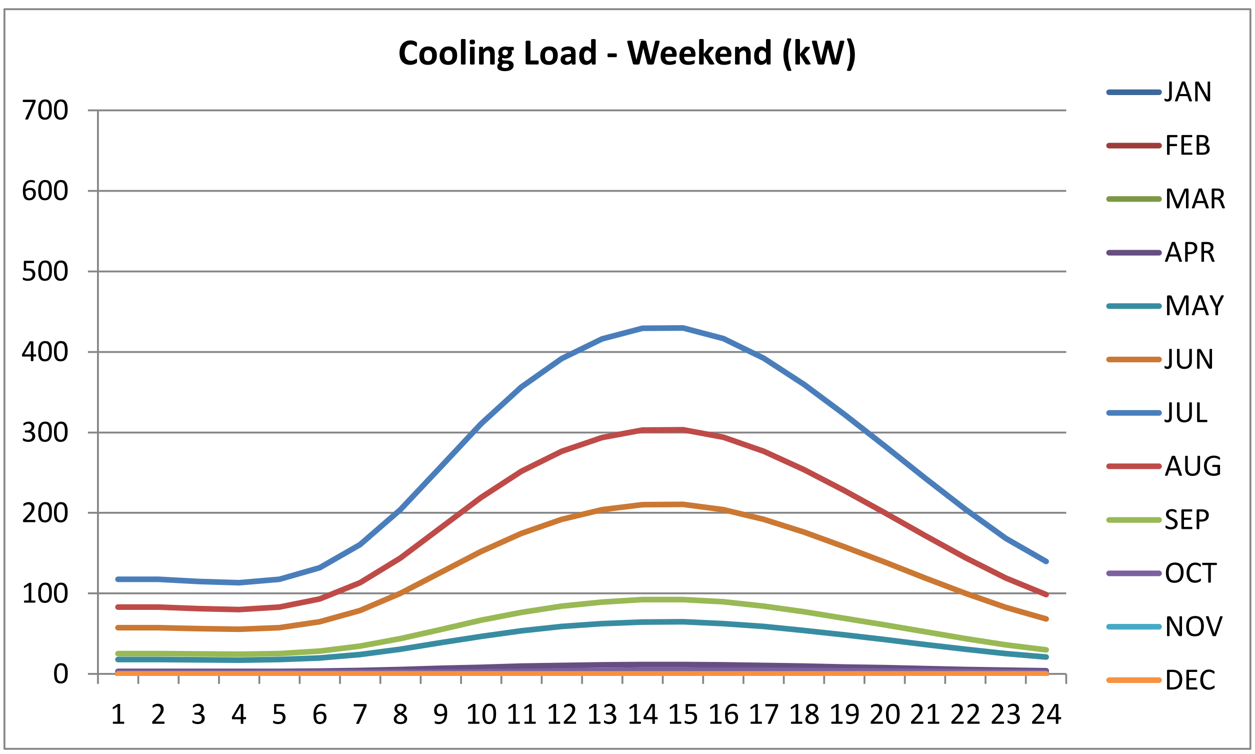


Figure 2-8: Microgrid Weekend Cooling Load Profile (kW)

2.2.3. Description Sizing of Loads

The microgrid total electrical load is based on the sum of all the loads of individual critical facilities to be served by the microgrid, plus the additional non-critical loads connected to the microgrid feeders (i.e., extra feeder load), as listed in Table 2-5 below. Extra Feeder Load represents additional non-critical commercial and residential loads connected to the microgrid feeders.

The sum of the non-coincident peak loads in is 6,569 kW, which is significantly higher than the estimated coincident peak load of 6,210 kW (which occurs in August as shown earlier in Table 2-1). The coincident peak load is used for planning the microgrid generation.

The thermal loads serviced by the microgrid are limited to the thermal heating and cooling loads of the ELIH, which are mostly met by the new CCHP unit located in the hospital.

Table 2-5: Summary of Microgrid Electrical, Heating, and Cooling Load

Greenport	Electrical Load		Heating Load		Cooling Load	
Facility	**Energy (kWh)**	**Peak (kW)**	**Energy (kWh)**	**Peak (kW)**	**Energy (kWh)**	**Peak (kW)**
Eastern Long Island Hospital (ELIH)	2,688,0000	650	1,488,599	753	616,161	648
Greenport Waste Water Treatment Plant	552,000	97				
Village of Greenport - Sewer Shed & Garage	24,379	19				
Village of Greenport - WWTP Office	13,944	9				
Suffolk County Water Authority (SCWA)	109,500	50				
Greenport High School	357,783	105				
Greenport Fire Department	95,400	59				
Village of Greenport: Village Hall	17,120	6				
Village of Greenport: Village Trailer	25,012	7				
GMS Grocery/Service Station	152,960	39				
Shelter Island Ferry (North Ferry)	7,577	1				
Long Island Rail Road: Eastern Terminus	13,990	2				
General Department - LIRR Bldg.	25,354	19				
M&M Auto - Empire Service Station	15,156	7				
IGA Grocery: Chasmur Supermarket	449,600	166				
Other commercial/residential loads	28,273,500	5,332				
Total	**32,821,275**	**6,569***	**1,488,599**	**753**	**616,161**	**648**

* Sum of non-coincident peak loads

2.3. Distributed Energy Resources Characterization

2.3.1. DER and Thermal Generation Resources

The following table lists the existing and proposed (in bold font) DER resources in the microgrid.

Table 2-6 Microgrid Generation Resources

Distributed Energy Resource Name	Location/Facility Name	Energy Source	Capacity (kW)
Existing Backup Generator	Eastern Long Island Hospital	Diesel	500
Existing Solar PV	Greenport High School	Solar	250
New Solar PV	**Eastern Long Island Hospital or Moores Lane**	**Solar**	**250**
New CCHP	**Eastern Long Island Hospital**	**Natural Gas**	**375**
New Reciprocating Engine	**Moores Lane site near WWTP**	**LNG or pipeline gas (1)**	**7,400**
Battery Storage (125 kW - 500 kWh)	**Moores Lane site near WWTP**	**Electricity**	**125**
Absorption Chiller	**Eastern Long Island Hospital**	**CCHP Recovered Heat**	**100**
Load Curtailment	**Eastern Long Island Hospital: 65 kW Waste Water Treatment Plant: 10 kW IGC Grocery: 15 kW**	**Demand Response Resources**	**90**

Note 1: National Grid has indicated it may be able to supply pipeline gas on an interruptible basis; however, detailed engineering would need to be performed during Stage 2 to confirm this. This report assumes the project will use LNG, pending results of further studies by National Grid.

2.3.2. New DER or Thermal Generation

New generation resources and their locations is listed bold font in Table 2-6. The new CCHP unit will be located at ELIH. This CCHP unit will provide thermal energy to the hospital to meet its heating load, and also the cooling load with the addition of an absorption chiller. A new 250 kW solar PV system will be located at ELIH and/or Moores Lane. The location of the PV system will be determined during Stage 2. ELIH will also provide at least 65 kW of load curtailment during emergency periods and demand response during normal days. A 125 kW - 500 kWh battery storage system will be installed on Moores Lane adjacent to the wastewater treatment plant for peak load shaving both during emergency periods and normal days. ELIH also has a 500 kW backup diesel engine, which is not expected to be used for any significant amount of time, except during transitions and in extreme emergency conditions when the other microgrid resources are unavailable.

The new 7,400 kW electric only reciprocating natural gas unit will be installed on Moores Lane, near the 54 MW peaking plant on Moores Lane. This power plant location would enable the new generation resource to participate in the available energy markets.

Additional load curtailment/demand response will be provided by the Greenport wastewater treatment plant (about 10 kW), and the IGA Grocery store (about 15 kW). The DERs, combined with energy efficiency and absorption chillers, will allow GMU to avoid most if not all purchases of market rate power.

The CCHP unit, the natural gas engine, and the PV installations are shown on each facility's load bus on the one-line diagram in Figure 2-2. The details of the in-facility wiring are omitted at this point.

2.3.3. Adequacy of DERs and Thermal Generation Resources

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

The solar energy (based on the solar irradiance profile in West Hampton Airport, NY) is available during on-peak hours.

Figure 2-9 provides a view of the "theoretical" load and supply balance over a weekday of operation on a normal day in the month of August. The DER-CAM model dispatches all the generation resources based on the comparative economics of on-site generation versus purchase from the utility. As can be seen, under the assumed prices, the MESCO can produce all the needed energy onsite to meet the microgrid customers' load.

Although not shown in the chart, the MESCO can operate the onsite generation at higher loads to meet obligations of other customers that may be located outside the designed microgrid. The black dashed line is the microgrid electrical load. The burgundy colored area is the energy produced by the CCHP and the reciprocating engine. The green colored area is purchase from the grid. The State of Charge (SOC) of the battery storage is shown by the light blue dotted line and its value is indicated on the right-hand side Y-axis. The battery will help reduce peak loads due to pumping at the water and WWTP. This will reduce GMU's demand for market priced peaking power, increase GMU's load factor, which may allow GMU to increase its hydro allocation. When the larger grid is out of service, the battery will help stabilize the microgrid by assuring a balance between supply and demand. However, since the current version of the DER-CAM model only considers the "aggregate" load, it does not link the WWTP load to the battery storage, and hence it does not dispatch the battery storage due to the large size of the microgrid generation. Hence, dispatch of the battery storage is not properly handled by DER-CAM. In practice, it is expected that the storage battery will recharge at night when energy charges are low, and discharge during the day when energy and demand charges are high. The battery will have discharge duration of four hours. The yellow colored area is the energy produced by the solar PV systems. The dark blue area on the top is the electric cooling load offset due to the operation of the absorption chiller. The times where the colored areas go above the blue dotted line correspond to the times when the battery system gets charged.

Under the current assumptions on the delivered prices of electricity and gas, it appears that the onsite microgrid generators will operate during normal days. In any case, the microgrid generators will be owned and operated by the MESCO, and the decision to operate them or purchase power from the grid will depend on market electricity and fuel prices.

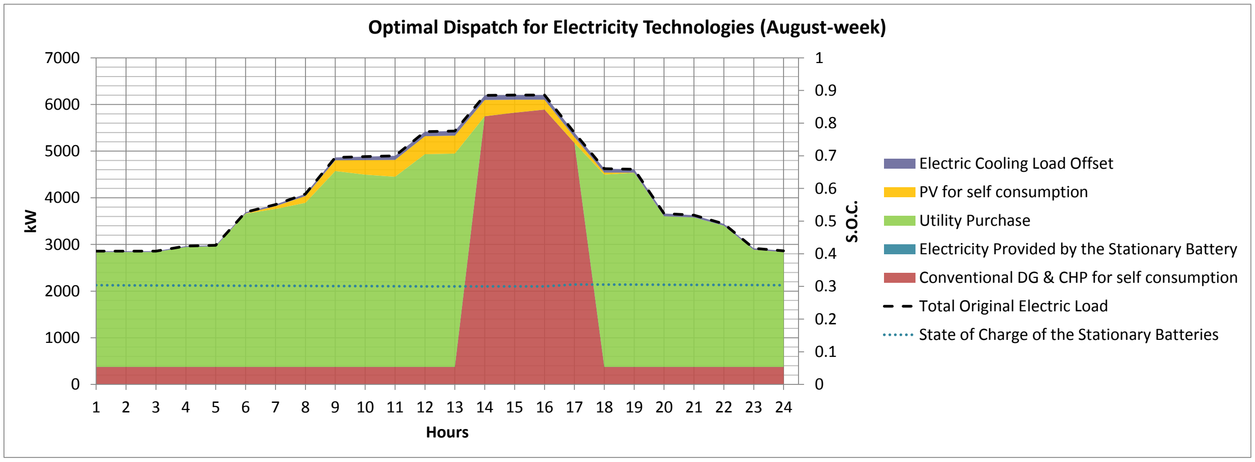


Figure 2-9: Microgrid Generation Stack to Meet Electrical Load – August Normal Weekday

Figure 2-10 shows the microgrid operation during an emergency weekday in August (the month with the highest microgrid load based on the assumed load shape). As can be observed, again the microgrid's entire load is met by on-site generation, including solar PV. The blank space below the black dashed line represents load curtailment applied during the emergency periods. Load curtailment level is set at 5% of the peak load of the three largest facilities in the microgrid. It is believed that higher levels of load curtailment are achievable, but since the largest facility is a hospital, a conservative 10% level was selected.

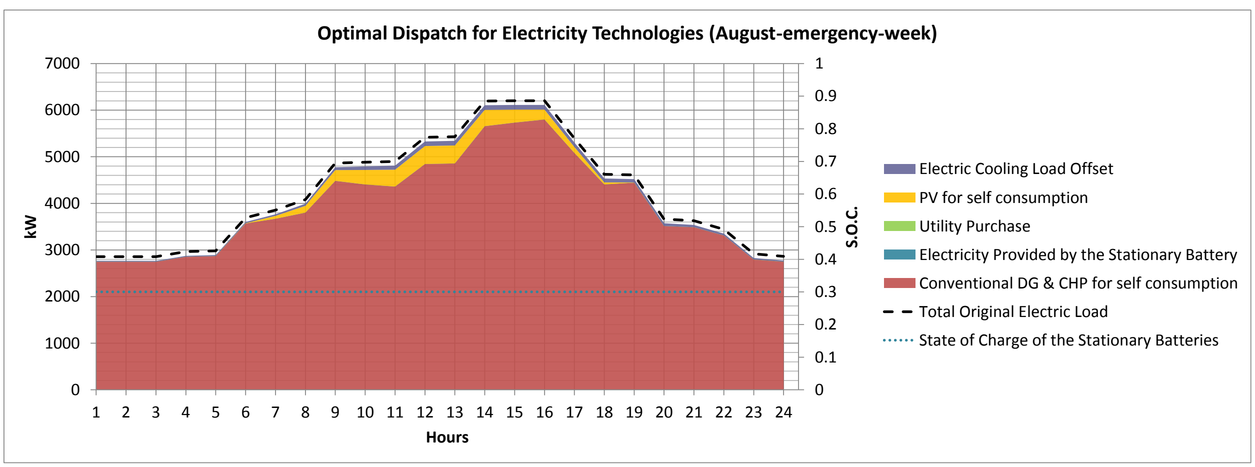


Figure 2-10: Microgrid Generation Stack to Meet Electrical Load – August Emergency Weekday

Figure 2-11 shows thermal dispatch for heating load during a normal weekday in August. The black dashed line is the hospital's heating load. The additional thermal generation going above and beyond the dashed line (heating load) is actually the portion of the thermal energy of the CCHP unit that is utilized to run the absorption chiller in the hospital to meet the hospital's cooling load (shown in the following figure. In the following figure there are no additional heat collected from fuels (i.e., from the conventional boilers), and therefore, no "gray" areas are shown in the figure.

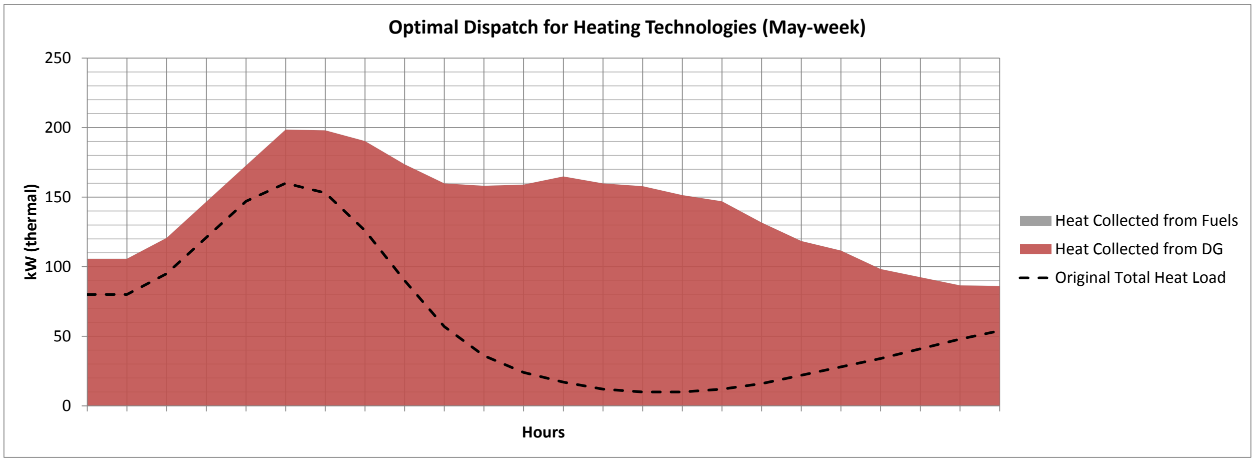


Figure 2-11: Microgrid Thermal Dispatch to Meet Heating Load – May Normal Weekday

Figure 2-12 shows thermal dispatch for cooling load during a normal weekday in May. The black dashed line is the hospital's cooling load. Note that in DER-CAM, the cooling load size is not based on the final cooling energy output. It is actually based on the equivalent electric input of central dispatch that will provide that amount of thermal energy, and hence reflects the assumed Coefficient of Performance (COP). We have assumed a COP of 4.5, which is the default value provided by DER-CAM and is also in the range of COPs for Water-Cooled Scroll or Screw Chillers 150 tons or smaller[4]. In the figure below, all cooling is provided by the absorption chiller, and hence there is no need for cooling by the central chiller, and therefore, it is not shown in the figure (i.e., no blue-shaded area).

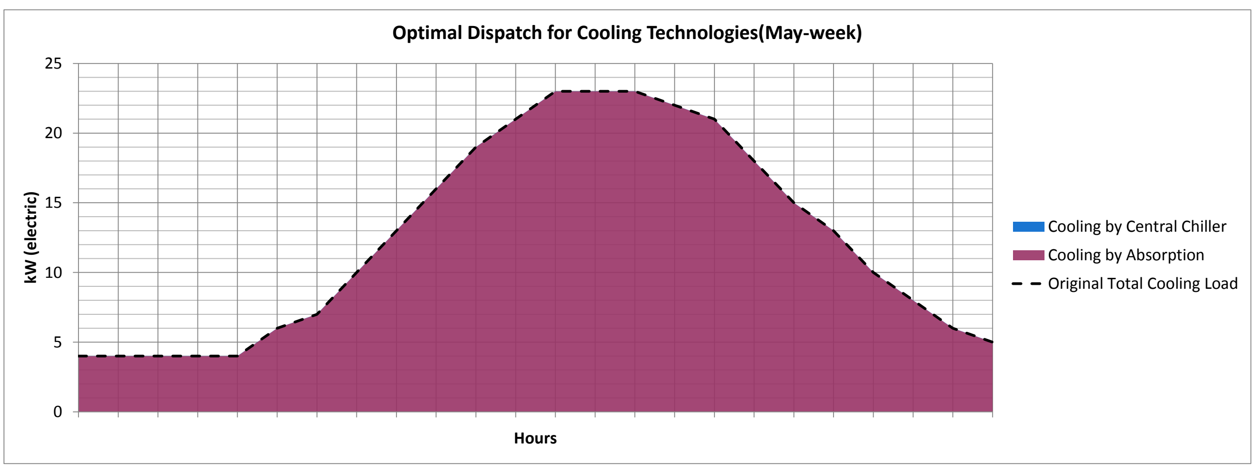


Figure 2-12: Microgrid Thermal Dispatch to Meet Cooling Load – May Normal Weekday

[4] https://www.progress-energy.com/assets/www/docs/business/bbnchvacck2007.pdf

Similar profiles for July are provided in the following figures. In the first figure there are no additional heat collected from fuels (i.e., from the conventional boilers), and therefore, no "gray" areas are shown in the figure.

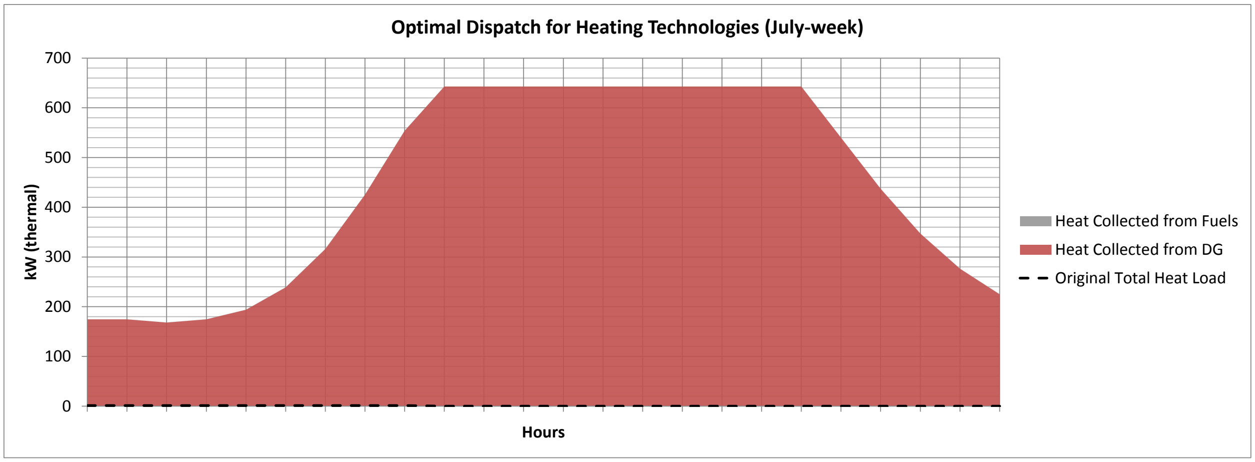


Figure 2-13: Microgrid Thermal Dispatch to Meet Heating Load – July Normal Weekday

As shown in Figure 2-13, the heating load in July is almost zero, as shown by the dashed line touching the X-axis. Therefore, the amount of recovered heat above the dashed line (i.e., the solid area), is not being used to meet heating load, but instead, is used to power the absorption chiller, as shown in Figure 2-14.

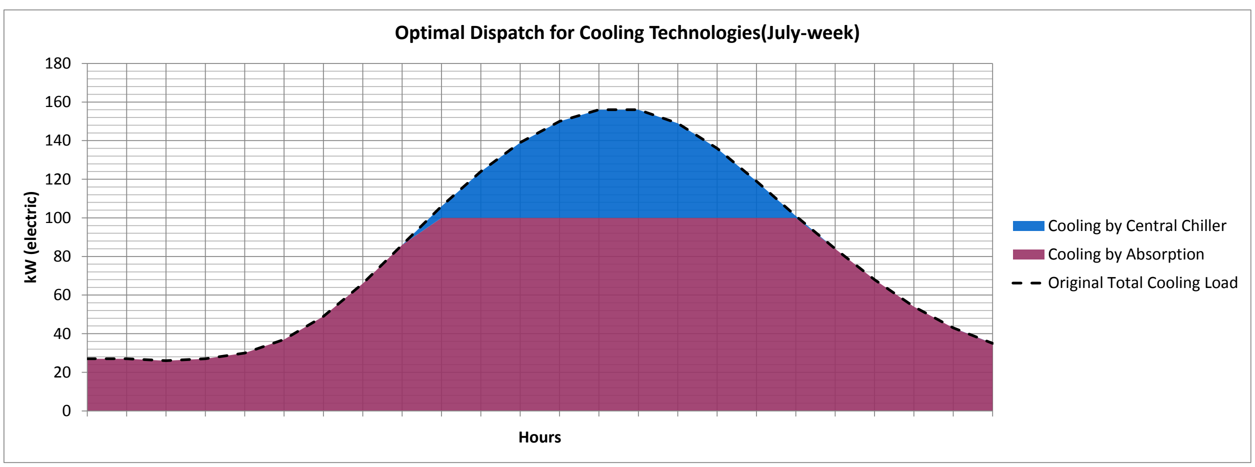


Figure 2-14: Microgrid Thermal Dispatch to Meet Cooling Load – July Normal Weekday

2.3.4. Resiliency of DERs and Thermal Generation Resources

The design will include appropriate protection against possible flooding that could damage the CCHP system at ELIH. The new reciprocating engine on Moores Lane will be installed above the flood plain, and is therefore protected from most severe weather incidents, and flooding. Natural gas reciprocating engines have a high availability. According to the EPA Catalog of CHP technologies,[5] natural gas engine has an availability of about 96% for units sized 100-800 kW, a forced outage rate of about 2%, and a scheduled outage rate of about 2.5%. For larger units, the availability is even higher, around 98%, and the forced outage rate is less than 1%. These units result in a collective power system with very high reliability that is insulated from the forces of nature. The expected forced-outage rate of the entire power plant will be analyzed in Stage 2.

According to Village of Greenport, the natural gas supply has proven to be extremely resilient during past major events. In addition, National Grid has indicated it can supply gas for ELIH on a firm basis by November 2016. Therefore, supply to the CCHP is not expected to be interrupted (barring seismic activity or sabotage). The diesel engines could be used to black start the CCHP system.

We have assumed the electric plant will use LNG; however, National Grid has indicated it may be able to supply gas for this plant on an interruptible basis, subject to further studies that will be performed during Stage 2.

The roof-top PV panels are at some risk of being partially or completely covered with snow cover during 4-5 months of the year. However, the actual contribution of these panels to the overall power profile is not substantial enough to warrant additional action besides an occasional cleaning during these months. In any case, the new microgrid resources were sized so as not to depend on the availability of solar power during emergency.

2.3.5. Description of Fuel Sources for DER

The primary source of energy for the Greenport microgrid is the roughly 7,800 kW of natural gas generation located at ELIH and the Moores Lane area. National Grid has confirmed that it can supply natural gas needed to operate the CCHP system by November 2016. National Grid indicated that it will need to perform additional study, and that a fee deposit is required, to confirm adequate pipeline gas supply for the electric only generation plant on Moores Lane. However, it is assumed that with the development of the microgrid and the prospects for providing normal economic activity to a significant portion of the town during emergencies and the larger grid outage, regulators and policy makers will act to ensure natural gas delivery needed to keep critical facilities in operation during emergencies.

In the event it is determined that delivery of pipeline natural gas is not economical, the project will utilize LNG delivered by truck for use by the reciprocating engine on Moores Lane.

2.3.6. Description Operational Capabilities of DERs

In connected mode (parallel to the grid), microgrid generation resources would not be required to regulate frequency, and would likely have a small role if any in voltage regulation. These services are provided by the bulk power system and the surrounding distribution system. However, in islanded mode, microgrid resources will need to provide for power balance/frequency control and reactive power balance/voltage control.

New York State and utility interconnection requirements with respect to voltage and frequency response will apply to the microgrid generation when it is in grid-connected mode. Whenever voltage or

[5] http://www.epa.gov/sites/production/files/2015-07/documents/catalog_of_chp_technologies.pdf

frequency at the POI are outside the allowable bands, the microgrid controller should initiate a disconnect sequence. However, the microgrid generation and control system have the ability to ride-through grid events and regulate voltage and frequency at the POI to help in fault recovery. This action can be coordinated with the utility operations center if needed.

The diesel standby generator at ELIH is capable of operating without the presence of the distribution system. That ability makes it an ideal candidate for blackstart application. These types of generators will have the ability to maintain real and reactive power balance and can maintain frequency and voltage. Most have the capacity for partial load operation within a range (minimum/maximum capacity ratings). The diesel generators would be available to supply ELIH, but would not be connected to the microgrid. The 125 kW battery energy storage system at ELIH can be used to blackstart the microgrid generation resources.

Some types of generators are more capable of providing frequency control than others. For the Greenport microgrid, the CCHP unit and the reciprocating engine will provide baseload power while other assets would switch to frequency control mode. This means that the majority of fast frequency regulation must come from the battery storage system and possibly from the diesel unit at ELIH. However, the reciprocating engine is also capable of providing frequency regulation when not operated at full capacity. To augment this fast frequency regulation, selected load curtailment resources may need to be controlled. Additionally, it may be necessary for solar production to be curtailed. The specific demands for power matching/frequency regulation will be determined through study, and the microgrid controller will manage assets in response to changing conditions.

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

While the PV will likely have some advanced functionality such as Volt/VAR control, the dispatchable generation and storage will likely be used to perform the majority of frequency/voltage control. Further study will indicate if the PV will need to be curtailed to maintain stability in islanded operation.

2.4. Electrical and Thermal Infrastructure Characterization

2.4.1. High-Level Description of Electrical Infrastructure

The electrical infrastructure supporting the microgrid is shown in Figure 2-2. The microgrid design relies extensively on the existing overhead lines. Sections of circuits #1, #2, #6 and #7 will be disconnected from rest of the system by new and existing switches and used to form the microgrid. To facilitate isolation of the microgrid system from the larger utility grid, ten new switches will be installed and another four existing switches will be upgraded to remote operating capability.

Please refer to Figure 2-1 for geographic layout showing the location of the microgrid facilities, sections of existing feeders and routes. As shown in the layout, the proposed microgrid will isolate from the grid in ten locations labeled using new and existing switches.

To detect abnormal conditions, and to detect when the grid has returned to normal, CTs/PTs will be installed at the isolations points. To achieve the appropriate selectivity/sensitivity, it is likely that some combination of direct instrumentation of isolation points and transfer trip will be used. The appropriate configuration will be determined through further study.

Since the CCHP unit at the hospital will serve the heating and cooling requirements at the hospital only, relying on the current thermal networks and conduits, there is no need for additional development of thermal network in Greenport microgrid.

2.4.2. Resiliency of Electrical and Thermal Infrastructure

The proposed microgrid loads are currently served by overhead distribution lines. The largest risks to the electrical infrastructure are: 1) a widespread transmission outage, such as the 2003 Northeast blackout, 2) failure of the Greenport substation, such as during a catastrophic weather event or transformer failure, 3) storm surge and flooding leading to shut down. The team has heard anecdotally that during past hurricane events, overhead lines in many Long island communities that were free of vegetation were not severely unaffected, but some substations were compromised. Due to the lack of vegetation (trees), the OH system near the coastline can actually be more resilient during flooding events than UG systems.

While the proposed microgrid infrastructure is relatively free of trees or other obstructions that typically cause distribution line outages, some susceptible portions of the circuit may need to be hardened to ensure reliability, particularly along Monsell Trail, between Moores Lane and 3rd Street. This could include measures such as aggressive tree-trimming, removal of danger and hazard trees, use of upgraded poles and cross-arms, use of tree wire, compact construction, or selective use of space cable. Any efforts on behalf of the microgrid will have to be coordinated with ongoing hardening efforts by the Greenport Municipal Utility.

During a widespread emergency (such as a blackout, substation transformer failure, or system collapse), the microgrid infrastructure would likely not be affected and would be able to form an island. The gas supply line is also highly resilient, and will assure fuel supply at all times. The major risk to the microgrid infrastructure is a catastrophic weather event that might damage the sections of existing electric distribution system that microgrid intends to utilize. However, this risk will be limited because large trees in downtown Greenport are limited, and because the project will include measures to harden the existing distribution lines.

2.4.3. Microgrid Interconnection to the Grid

Figure 2-2 shows the many points of interconnection with the existing feeders connecting the microgrid facilities. Because the facilities are spread around geographically as well as on four different feeders, the microgrid will pick up several non-microgrid customers during the islanded mode. Since the microgrid uses existing overhead lines, several new switches need to be added and several others upgraded for interconnection between feeders. Refer to Figure 2-1 and Figure 2-2 for location of new and existing switchgears that need to be upgraded.

Although the microgrid sources are primarily rotating machines, traditional protection schemes based on high fault currents will likely not be applicable when in islanded mode because the sources are located at multiple sites. The complexity of protection in islanded mode will require relays capable of being remotely switched between multiple modes or set-points. The protection scheme will be finalized during Stage 2, subject to technical requirements and based on input from GMU.

In addition to Instantaneous/Timed Overcurrent protection (Functions 50P/50G/51P/51G), the microgrid protection scheme will employ some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

2.5. Microgrid and Building Controls Characterization

2.5.1. System Control Architecture Description

The proposed microgrid control architecture consists of four control device types:

- Microgrid Energy Management System (MG EMS) (1 per microgrid)

  The MG EMS orchestrates all control actions as well as provides the utility interface. It serves as a main microgrid configuration and dashboard station. For instance, a station operator is able to provide scheduling policies through its web interface. The data historian and possibly other data bases are stored at MG EMS which also provides analytics applications.
- Microgrid Master Control Station (1 per microgrid)

  Master Control Station is a hardened computer that hosts critical real-time monitoring and control services. It performs forecasting, optimization and dispatch functions.

- Microgrid Facility Control Node (1 per facility)

  Facility Control Node coordinates control across multiple buildings composing a specific facility. This controller abstraction is utilized also for any building in the microgrid with local control functions, i.e. a building that hosts a generation unit or building management system (BEMS). Most facility control nodes would also be hardened industrial computers.

- Microgrid Edge Control Node (1 per facility)

Edge Control Node is an automation controller or a feeder management relay with a direct switching interface to loads in a building. This is typically a multifunction controller/IED providing automation and physical interface to switchgear and sensors.

Figure 2-15 shows control devices for the proposed Greenport microgrid as an overlay on the electrical one-line diagram.

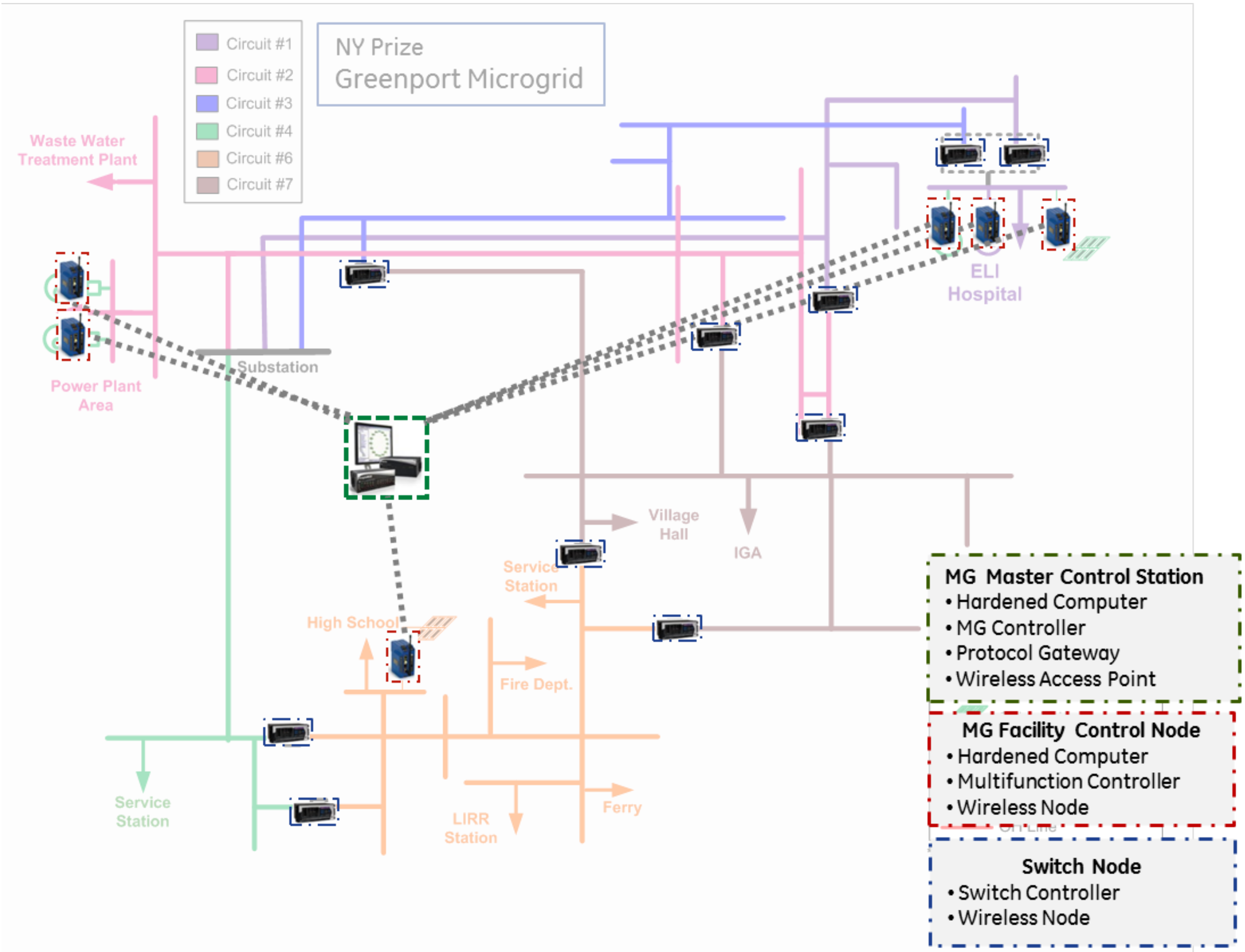


Figure 2-15 Greenport Microgrid Electrical One-Line Diagram with Control and Communications Overlay

The microgrid master control station performs economic optimization, i.e. it periodically determines a combination of generation units to bring on or keep on such that the total cost of operation is minimal. This includes the CCHP unit and the reciprocating engine, the solar PV systems, the battery storage, and even the ELIH backup generation, which will be tied into the control system with Edge Control Nodes. The start/stop commands as well as optimal setpoints for real power, and sometimes even for reactive power, are sent to each generation unit. In addition to regulating the generation units a primary task of the Microgrid Master Control Station is to coordinate the switching devices at the boundary of the microgrid. To simplify Figure 2-15 these communication links are not shown.

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

The local controller devices can interface with the hierarchical control system via Modbus communications. This interface would be used to communicate necessary information between a microgrid facility control node and the local controller of the generation unit located in that facility. The facility control node would act as Modbus master, and the local controller would act as the Modbus slave, sometimes called a remote transmitter unit. The master device initiates all communication, sending commands or requests for information. The local controller would relay all of the AC power related information back to the facility control node including the voltage, current, frequency, and power factor. Thus, this interface will allow the microgrid control system to individually start, stop, and change the setpoint of any microgrid generation unit, as well as read all of its inputs and outputs.

The microgrid master controller will likely include load management for the economic optimization of microgrid assets. In such cases, it will communicate with building energy management systems to determine and set load set points. At this point it is not clear which facilities have energy management systems and which will be included in microgrid optimization. For load curtailment and demand response, primary candidates are ELIH, waste water treatment plant, and the IGA Supermarket. We recommend that the microgrid control architecture be built on one of the open software control platforms such as Tridium JACE (Java Application Control Engine). Such a platform can be used to control a variety of BEMS systems, HVAC and DDC devices. This platform supports most of the open protocols for building automation systems sector such as LonWorks, BACnet, and Modbus.

2.5.2. Services That Could Be Provided by the Microgrid

Automatically connecting to and disconnecting from the grid

At all times in grid connected mode, the microgrid control scheme must maintain enough generation, to supply the critical microgrid loads. When an event occurs, the microgrid control system would initiate a sequence of operations to transition from grid-connected to islanded mode. This was described earlier in Section 2.1.2. Seamless transition during an unplanned event is not foreseen due to current interconnection rules governing DER operation. However, it is conceivable that a planned seamless transition can be achieved.

The formation of a microgrid generally proceeds as follows:

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

Note: some steps may be performed in parallel.

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

Automatic disconnection: The Greenport microgrid is interconnected to the external distribution system at ten locations (see Figure 2-2). At the points of interconnection, the microgrid will sense abnormal grid conditions such as loss of voltage (on all feeds) and automatically isolate from the grid. The microgrid will then form in the manner described above.

Automatic connection: The microgrid will also be capable of automatically reconnecting to the grid if desired. However, since the microgrid will be reconnecting into a network, the microgrid may be required to power down before reconnection. If automatic reconnection is desired, when the microgrid senses that the utility feed has returned to normal (generally for a period of time), the microgrid will sense the phase and magnitude of the voltage at the utility interconnection point. Using either active or passive synchronization, the microgrid controller may close the breaker that ties the microgrid to the utility system.

At the time of reconnection, the net load to the system from the microgrid will be minimal. The microgrid can coordinate the return of the additional microgrid loads to normal status with the utility to avoid undue stress on the recovering grid. Depending on the final design of the microgrid, this return to normal may be a combination of automatic and manual operations.

Load shedding schemes

Load management is also integral in islanded mode and in the transition to islanded mode. During microgrid formation, load will likely be shed to allow seamless transition for the uninterruptable loads on the microgrid. Once the microgrid is established, controllable loads may be used in much the same was spinning reserve generation. The three largest facilities in the microgrid are slated to provide about 5% of their peak load as load curtailment resource during emergencies. The amount of load curtailment could be set at higher level (i.e., 15% of peak load for instance), but a conservative 10% level was selected since the largest facility is a hospital and hence subject to stricter critical load requirements.

Black start and load addition

During an unplanned event, the microgrid must be capable of black-starting or energizing without an existing power system. Many grid-forming generators can be used for black-starting. Once the generator has been started and the core microgrid formed, the formation of the microgrid may proceed normally.

For the Greenport microgrid, the diesel generators can be used to blackstart. Once the standby generator is up, the CCHP unit and gas reciprocating engine may be added to the grid. Additionally, storage can be added to allow them to blackstart without the standby generator.

Generators designed for standby operation are capable of maintaining voltage, frequency, and real and reactive power balance when the larger grid is not present; however, protection may be currently in place to prevent feeding a larger grid. The protection and control schemes of the standby generators will be evaluated to make sure the selected standby generators are capable of supporting the blackstart scheme.

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

Performing economic dispatch and load following

The Greenport microgrid will provide load following during emergency periods utilizing the reciprocating engine to be installed at the Greenport power plant area.

The economic dispatch of the microgrid generation units during emergency periods will be performed by the microgrid controller and energy management system, based on the amount of generation needed to balance the time varying net load (i.e., load minus solar generation), and the microgrid generation unit efficiencies and constraints, fuel prices, and variable operations and maintenance (VOM) costs. The emergency period dispatch will also take account of the available solar power and battery storage and impact of the absorption chiller in reducing the required electrical load.

During normal/blue sky days, the CCHP unit is expected to run as baseload, providing both electrical and thermal energy to the hospital. The reciprocating engine will be dispatched based on the comparison of their marginal costs of operation and the price of electricity purchase from the larger grid. The CCHP units will be owned by GMU, and the electric only plant will be owned by the MESCO. The MESCO will make a decision based on economic considerations whether to dispatch the electric generating plant.

Other drivers include the structure of the electricity delivery charges (such as daily on-peak or monthly demand charges). It is plausible to assume that at some future point in time, a more complex decision process will determine the microgrid resource dispatch during normal days, more likely based on the relative economic costs of on-site generation versus purchase from the utility, or a future LMP+D pricing system being discussed by REV working groups, or even sales to the larger grid or NYISO, subject to applicable future REV framework. The trade-off between on-site generation and utility purchase is demonstrated in the DER-CAM modeling. Although simplified compared to actual operations, the DER-CAM model illustrates how utility purchases vary with time, and shows their dependency on relative energy costs of on-site generation versus utility purchases, and the influence of utility monthly and daily on-peak demand charges. Under the current electricity price assumptions applicable in the Greenport microgrid, it appears that generation resources proposed for the Greenport microgrid would be operating all the time, including during both the emergency and normal periods.

Demand response

The same load resources that are available for load curtailment are also available for demand response. The initial plan is to have at least 5% of the Greenport microgrid peak load be curtailable during a long-term emergency when the microgrid goes into islanded mode. However, the same load resources can be used as demand response during normal/blue sky days. The 5% of peak load of the combined facilities is about 90 kW, and should be available as demand response during normal days. The demand response resources can be utilized in various utility price-based or event-based demand response programs in the future, such as critical peak pricing (CPP) or critical peak rebates (CPR), or even as part of a portfolio of aggregated demand response resources under management of third party demand response providers who participate in the NYISO demand response and load management programs.

Storage Optimization

The proposed Greenport microgrid includes a 125 kW – 500 kWh battery storage located at Moores Lane site near WWTP. In grid connected mode the storage system will be scheduled based on applicable electricity rates and prices subject to its operational limitations. The main value of storage system will be to reduce the total cost of electricity consumption. This will be accomplished by storage charging during low price hours (usually during off-peak periods) and discharging during high price hours (usually during on-peak periods). Furthermore, more complex algorithms, such as those used in DER-CAM will be employed to schedule the discharge of the storage systems to minimize the applicable utility demand charges.

In fact, one of the earliest experiments in optimal scheduling of thermal heat and cool[6] and heat[7] storage was managed and performed (under funding by NYSERDA, EPRI, ESEERCo, NYSEG, and Con Edison) by one of the lead technical consultants on this project. The experiment involved remote control of heat and cool storage using a complex but fast algorithm that used projected need of commercial facilities in the experiment, and next day's hourly real time prices (RPT) and weather forecast, to set the thermal storage schedule on a 4 hour ahead basis.

In islanded mode, the storage will generally be optimized for fast frequency control and to support dispatch of other generation assets. Storage can minimize the variability due to PV, help conventional generation maintain minimum loading requirements, provide power while units are coming online, reduce the need for baseload generation such as the CCHP unit to respond to changes in load, and provide a variety of service that will greatly increase the flexibility of the microgrid assets.

Maintaining frequency and voltage

When in grid-connected mode, the primary focus of the microgrid control systems will be to maintain system voltage within the acceptable range. This range is generally specified in ANSI C84.1 but may also be coordinated with utility conservation voltage reduction schemes.

For the Greenport microgrid, a portion of the generation will be CCHP. This CCHP generation will act as base-load generation and reserve margin. The faster acting generators such as the national gas units located at the Greenport Power Plant area will be used to manage fluctuations in load as well as variation in power output caused by solar. If additional control is needed, curtailable load may be used

[6] "Automatic Control of Thermal Electric Storage (Cool) under Real-Time Pricing", NYERDA, 1994, Lead Author: Bahman Daryanian: https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB96195151.xhtml

[7] "Automatic Control of Thermal Electric Storage (Heat) under Real-Time Pricing", NYERDA, 1995, Lead Author: Bahman Daryanian: https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB96198023.xhtml

to help maintain the microgrid frequency, and PV generation may be curtailed or taken offline. The microgrid controller will assign the load-generation mix based on what is needed to satisfy the primary control objectives.

For reactive power / voltage control, reciprocating engine and the CCHP unit may be used. The microgrid controller will determine the appropriate control modes (voltage, pf control, VAR control, etc.) and set-points for the various microgrid assets.

PV observability and controllability; forecasting

Greenport PV production will be monitored by the microgrid controller and data will be communicated and stored so that it is available to microgrid operators and owners through a web interface. The controls and communications interface is shown in Figure 2-15. The total nameplate capacity of existing and new PV installations is 500 kW. Although the solar nameplate capacity is almost 25% of the peak load of the microgrid, other generation resources in the microgrid were sized so that the Greenport Microgrid would not be dependent on the solar power during emergency periods.

Given the size of PV relative to firm generation, some forecasting may be helpful for smooth operation of the microgrid. Alternatively, the proposed battery energy storage may be used to store the solar energy and provide levelized output in necessary. Hence, the load-generation balance and stable operation of the microgrid is planned without dependency on solar PV. The microgrid controller will monitor PV production and will 1) balance PV variability with fast-acting generation resources, 2) use load resources to offset variability, 3) if necessary, store PV production when it goes beyond a percentage of online load.

Coordination of protection settings

When the microgrid is in islanded mode, some key protection functions will be under the purview of the microgrid controller. Where fault current is insufficient to ensure that secure, safe, dependable, reliable operation of protection systems (such as fuses), the Team may consider another layer of protection that predicated on transfer trip signals from the controller.

Because the microgrid sources are primarily rotating machines, traditional protection schemes based on high fault currents will likely be appropriate when in islanded mode. While fuses are a low cost option for overcurrent protection, coordination the protection schemes between grid-connected and islanded mode may require relays capable of being switched between multiple modes or set-points.

In addition to Instantaneous / Timed Overcurrent protection (Functions 50P/50G/51P/51G), the microgrid protection scheme will employ some combination of the following:

- Over / Under Voltage (Functions 27/59)
- Over / Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

Selling energy and ancillary services

Subject to evolving NY REV framework, the NYISO market rules applicable to microgrids and distributed generation, and enabling technology (to allow back-feeding in the network), it is expected that the distributed generation within the Greenport microgrid can sell energy into the larger grid though the Distribution System Platform (DSPP) model being developed within REV, but also participate in the NYISO energy, ancillary services, and capacity markets.

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

The ancillary services, including regulation up and down and spinning and non-spinning reserve can also be provided by the on-site generation subject to future market rules.

And finally, subject to qualification, on-site generation can participate in NYISO capacity auctions, and if they clear the market, they can be paid the applicable NYISO capacity prices.

Data logging features

According to the control architecture presented above, data logging is both local (at microgrid facility control nodes) and global (at microgrid master control station). These controllers, typically industrial PCs, record system data at regular intervals of time. A Human Machine Interface client for accessing data through a web interface exists at least at the master control station.

The data is stored in a round robin database that overwrites oldest values. The standard storage solutions (e.g. 1 TB) are sufficient to store data for at least a full year. Depending on the devices that a facility control node regulates, such a node may be equipped with an event recorder that captures asynchronous events with high time resolution. This allows for fast, sub-second, data collecting and analysis.

2.5.3. Resiliency of Microgrid and Building Controls

The standard industrial-grade control and communication devices can withstand extreme operational temperature range of -40^{o} C to +70^{o} C. In addition, they are often enclosed in rugged aluminum chassis tested for shock and vibration according to military standards. Control boxes will also be elevated for flood avoidance

2.6. Information Technology (IT)/Telecommunications Infrastructure Characterization

2.6.1. Information Technology

Due to the lack of existing dedicated communication infrastructure, for the microgrid communications backbone we are proposing a wireless field network as shown in the Figure 2-15. The Microgrid Master Control Station is a hardened computer hosting monitoring, optimization and control services. It communicates to the utility wide area network through 3G/4G, WiMax, or 900 MHz communication links.

In addition, each microgrid facility is equipped with a Control Node, a hardened computer hosting local control applications. At least the control node at IGA Supermarket will integrate with the existing building management system. Communication with the master control station is achieved through 900

MHz or WiMax field network. The wireless communication links to the switchgear devices are not shown in the figure.

The communications network will provide at least 100 Mbit/s Ethernet which is expected to be sufficient for all monitoring and control applications and for the network of this size. The application-layer protocols will be selected among DNP3, Modbus TCP/IP, Modbus Serial, OPC or IEC61850 depending on MG deployed devices (e.g. IED's, PLC, switchgear, relay, sensors, meters, etc.).

2.6.2. Communications

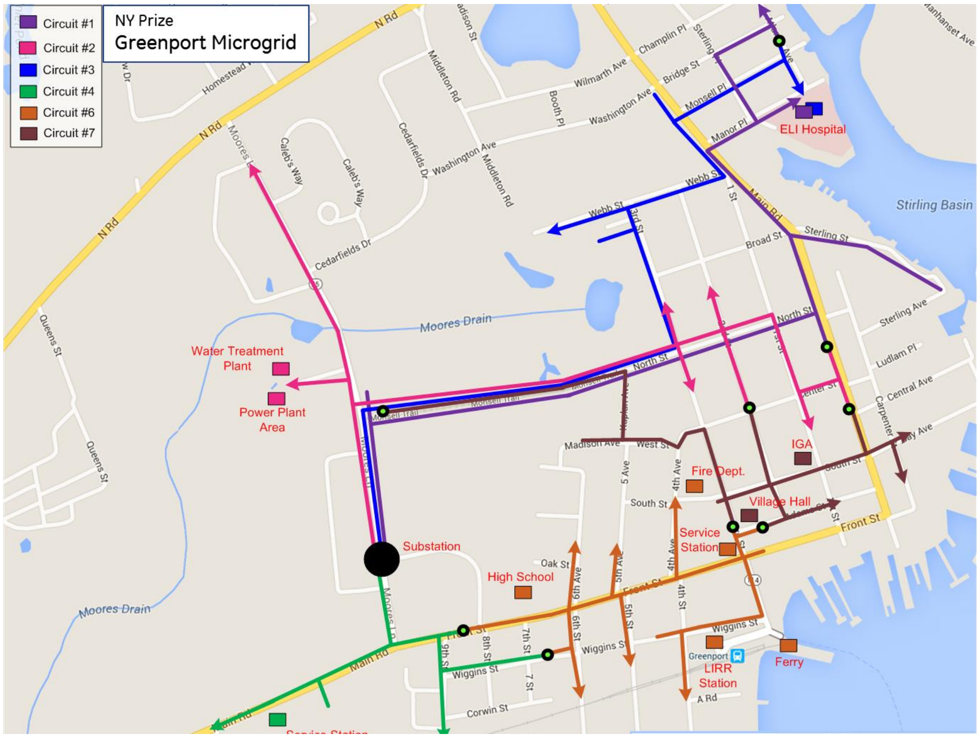
When the lack of communication signals from the utility is set as an abnormal condition, the microgrid can isolate from the utility and thus operate when there is a loss in communications with the utility. From that moment the local generation and load devices are under the control of the microgrid controller.

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

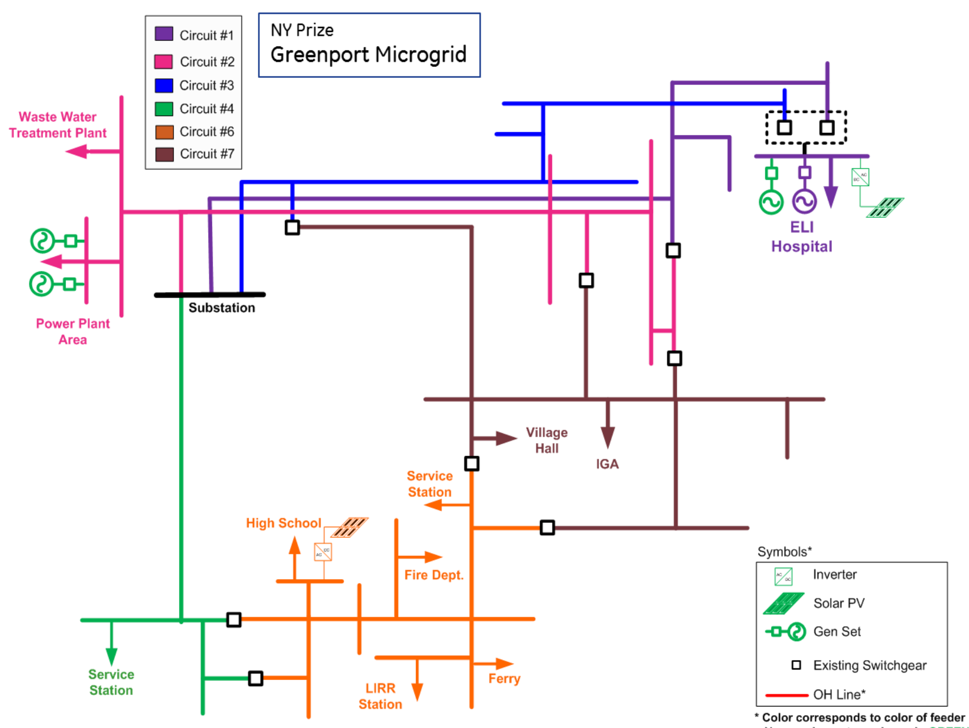
The suggested communication infrastructure design assumes industrial-grade, long range, point-to-multipoint wireless communication with MIMO (Multiple-In, Multiple-Out) antennas that provide robust communications.

3. ASSESSMENT OF MICROGRID'S COMMERCIAL AND FINANCIAL FEASIBILITY

A map showing the location of critical facilities relative to the microgrid circuits, and a one-line diagram are shown below. These were shown and described earlier in Section 2.1.



Microgrid Circuit layout (above) and one-line diagram (below)



As shown, the microgrid will include the entire Greenport Municipal Utility (GMU) service area, which includes a number of critical facilities, numerous commercial establishments in downtown Greenport, and residences in Greenport and adjoining areas. The non-coincident peak microgrid load based on 2014/2015 data is approximately 6.6 kW, which includes the critical facilities shown on the figure, and about 5,382 kW from small commercial establishments and residences. The project will use the existing above ground feeders to connect these facilities, and automate a number of existing switches that will enable the microgrid to operate in island mode during outages of the larger grid. The existing feeders will be hardened in areas where there is significant exposure to vegetation, particularly along Monsell Trail, between Moores Ln and 3rd St, and along Moores Lane north of Monsell Trail. Hardening measures could include expanded tree-trimming, removal of danger and hazard trees, use of upgraded poles and cross-arms, use of tree wire, compact construction, or selective use of space cable. Any efforts on behalf of the microgrid will have to be coordinated with ongoing hardening efforts by the Greenport Municipal Utility.

GMU is a municipal utility and has a full requirements contract with the New York Power Authority (NYPA). The village gets about 70% of its power from a hydro allocation from the Mohawk/Niagara facility, at a cost of less than $0.01/kWh. NYPA purchases the remainder of power on the open market and passes the cost on to GMU's customers. The cost of this incremental energy is substantially greater than the cost of the hydro allocation, and varies on a monthly, daily and hourly basis. Greenport could reduce its energy costs if it could reduce the cost of this incremental electricity that is not supplied by the hydro allocation and/or increase its hydro allocation. GMU could potentially increase its hydro energy allocation by increasing its load factor. Modifications to GMU's full requirements contract may be required if GMU produces some of its own power.

An optimized mix of DERs will provide energy for the microgrid and/or deliver power to the larger grid, depending on operating conditions. The DERs include CCHP, electric only generation, new and existing solar PV, batteries and existing back up diesel-powered generation.

The supply of pipeline gas in Greenport is limited. National Grid has indicated it can supply up to 5 MMBtu per hour for the CCHP system, and may be able to supply the new 7.4 MW electric generating plant on an interruptible basis. However, we have assumed that the proposed electric-only generation system will utilize liquefied natural gas (LNG) delivered by truck for this study. National Grid will perform a detailed engineering study during Stage 2 to confirm the potential to use pipeline gas for this plant.

Use of natural gas will reduce both emissions and costs in comparison to existing diesel and kerosene fueled facilities that serve the east end of LI. Moreover, the residents of Greenport are supportive of using pipeline gas or LNG rather than diesel for new generation. The proposed LNG facilities and operations are proven technologies, and will comply with recent NYSDEC requirements issued in 2015. Finally, this approach is replicable, as LNG could be used in other locations that do not have an adequate supply of pipeline gas.

Responses to specific questions contained in the SOW are presented below.

3.1. Commercial Viability – Customers

3.1.1. Individuals Affected by/Associated with Critical Loads

The Village of Greenport is located on the east end of the North Fork of Long Island, about 100 miles east of Manhattan, and about nine miles west of Orient Point, which is the eastern most point on the north fork of Long Island (LI). The 2010 Census population was 2,197. However, the population increases to over 3,000 in the summer due to tourism.

Greenport has a number of facilities that are critical to both the Village and the North Fork in general, and these facilities are vulnerable to storm impacts that have created power outages and prevented fuel deliveries due to flooding, as discussed further below. These facilities include Eastern Long Island Hospital (ELIH), which has 90 beds, and handles 9,300 ER cases and 3,200 inpatients each year.

The Greenport Municipal Utility (GMU) serves about 2,000 customers, about 1,000 of which are within the Village. The non-coincident peak demand for the entire municipal utility is approximately 6.6 MW. The Village has its own 6.8 MW power plant that uses Number 2 fuel oil. The plant has three diesel generating units that were installed in 1957, 1965 and 1971. Because of the age of these units, they are only used for back-up power, and their long-term reliability is questionable.

During normal operating conditions, the electric only generation plant will serve customers outside of the GMU service area. These customers will include (but not be limited to) residences and commercial establishments on the South Fork of LI, where PSEG-LI has projected there will be a 63 MW deficit of peak power supply by 2022. Greenport is connected to the South Fork of LI via a dedicated 69 kV underground/underwater cable that connects to the Buell substation in East Hampton, which is an area PSEG-LI, has identified having a deficit of peak power supply. During outages to the main grid, the electric only plant will supply power to the GMU service area.

3.1.2. Direct/Paid Services Generated by Microgrid

The electric generation plant will sell energy, capacity and ancillary services to commercial customers outside of the GMU service area, as well as to the NYISO. In addition, we plan to explore PSEG-LI's interest in a power purchase agreement (PPA) for sale of energy, capacity and ancillary services produced by this facility. Indirect benefits include reinforcement of local municipal distribution system, and reduced peak demand during peak summer vacation periods. The project will also improve the reliability and resiliency of the GMU system.

3.1.3. Customers Expected to Purchase Services

The microgrid will serve the following critical facilities in the GMU service area:

- Eastern Long Island Hospital (ELIH)
- Greenport Waste Water Treatment Plant (WWTP)
- Suffolk County Water Authority (SCWA) water supply pumping and storage facility
- Greenport High School
- Greenport Fire Department
- Greenport Village Hall
- Shelter Island Ferry

- Long Island Rail Road
- M&M Auto
- IGA Grocery

In addition, the project will serve all residential and other commercial establishments in the Greenport municipal utility service area during outages to the PSEG-LI grid. As stated previously, the electric only plant will serve customers outside of Greenport during normal operating conditions.

3.1.4. Other Microgrid Stakeholders

Many thousands of year-round residents and local businesses, as well as thousands of visitors and travelers each year that pass through Greenport to use the ferry and Long Island Railroad, will benefit by increased power reliability and resilience in the event of a protracted grid failure.

In addition, the project will supply energy during peak demand periods to the South Fork of LI, via a dedicated underground 69 kV cable that runs from the Southold substation (about one miles west of Greenport) across Shelter Island, and connects to the Buell substation in East Hampton. This power will reduce or defer the need for new transmission lines or distributed generation that would otherwise be needed to meet increases in demand that PSEG LI projects for the South Fork. The project will also reduce the need to dispatch existing less efficient diesel and kerosene fueled plants in East Hampton, Southold, Shoreham and Greenport that are currently used to meet peak demand on the east end, thus reducing both emissions and operating costs.

We do not anticipate that there will be any customers will experience any negative impacts as a result of the project.

3.1.5. Relationship between Microgrid Owner and Customers

The project will involve a public/private partnership between GMU and the project developer. The project developer is called a Microgrid Energy Services Company (MESCO).

GMU will own the CCHP and battery systems, and the MESCO will own the 7.4 MW electric only generation plant and the solar PV units (in order to benefit from solar tax credits). GMU and the MESCO will each provide their share of funding that is not provided by NYSERDA grants, which will be allocated to the DERs and distribution system on a pro-rata basis. The MESCO will have a ground lease with the Village of Greenport for its DERs located on Greenport property. The lease may contain provisions that give GMU the option to purchase the DERs after the MESCO has received a pre-agreed return on its investment.

Business relationships between GMU, the MESCO and their customers for different DERs are explained below.

Blue Sky Scenarios

- GMU will sell the electric and thermal energy from the CCHP system to ELIH.
- GMU will dispatch energy from the battery to shave peak loads at the SCWA and WWTP facilities.
- The MESCO will sell solar PV located in the park area on Moores Lane to GMU, which in turn will sell it to its customers.

- The MESCO will sell energy and capacity from the 7.4 MW electric plant contractually to customers outside of the GMU service area, and sell excess energy, capacity and ancillary services to the NYISO or GMU. This plant would only sell energy or capacity to GMU if excess energy or capacity is available, and market conditions justify such sales. It would not sell energy to replace GMU's low cost hydro energy. Alternatively, the MESCO will explore obtaining a PPA with PSEG-LI.

Grid Outages

- The MESCO will sell power produced by the electric plant to GMU, which will then deliver energy its customers.
- Other DERs will also contribute energy to GMU to help power the microgrid.

The GMU will continue to own and operate its own distribution system, and its diesel generators on Moores Lane. The project will use existing feeders owned by GMU or PSEG-LI to connect the electric only facility to the Southold substation in order to sell energy to customers outside the GMU service area during normal conditions.

3.1.6. Customers during Normal Operation vs. Island Operation

Please see response to question 3.1.5 regarding which party will purchase energy during normal operation. The electric only system will supply energy contractually to customers outside of Greenport during normal conditions, because the cost of power from GMU's hydro allocation is less than the cost of production. The price of energy in Greenport is low because Greenport gets about 70% of its energy from a hydro allocation from the Mohawk/Niagara facility, at a price of less than $0.01/kWh. The behind the meter CCHP system, which will be owned and operated by GMU, would supply electrical and thermal energy to ELIH. The CCHP plant will reduce total energy costs for ELIH because it will reduce both energy and delivery charges, and reduce or eliminate the need for fuel oil.

However, when the larger grid is out of service, the DERs, including the electric only plant, will supply all of the GMU customers.

3.1.7. Planned or Executed Contractual Agreements

Please see response to question 3.1.5. The following contracts or agreements are expected:

- It is anticipated that GMU will have a long-term agreement with ELIH to sell electric and thermal energy from the CCHP system.
- The MESCO will have a Microgrid Energy Services Agreement (MESA) with GMU to supply solar PV to GMU.
- The MESCO will have a MESA with GMU to supply power to GMU during outages to the main grid.
- The MESCO will sell power from the electric only plant to customers outside of the GMU service area using an Internal Bilateral Transaction structure. The MESCO will sell any excess energy, capacity or ancillary services to the NYISO.
- Alternatively, the MESCO will explore establishing a PPA with PSEG-LI. PSEG-LI may have an interest in procuring energy and capacity from this plant to help meet its needs for peaking

power on the South Fork. The PPA would contain provisions that would allow the plant to serve GMU microgrid in the event of an outage to the main grid.

3.1.8. Plan to Solicit and Register Customers

GMU will engage in direct negotiations with ELIH to develop mutually agreeable terms for sale of electric and thermal energy. The MESCO will have direct bi-lateral negotiations with GMU to establish terms under which the MESCO will supply energy to GMU in the event of an outage to the main grid.

The MESCO plans to directly approach large commercial customers outside the GMU service area that may have an interest in purchasing energy. We believe these customers may be interested in purchasing energy from the electric plant, because MESCO could reduce their energy costs. Alternatively, we may partner with an established ESCO to assist in marketing energy, or partner with an energy company, such as Con Ed Energy Services, that would help market energy from this facility.

As explained in Question 3.1.7, the MESCO will also approach PSEG-LI regarding the possibility of a long-term PPA for energy and capacity from the electric only plant. However, completion of the electric only generation is not dependent on securing a PPA with PSEG-LI, since this plant could generate adequate revenue from sale to the commercial customers if a PPA cannot be obtained with PSEG-LI.

Global Common has had an ongoing dialogue with Greenport officials concerning development of the microgrid. The Village Board has approved a lease option agreement with Global Common to lease land on Moores Lane for use as an LNG fired power plant. The Board has indicated that Greenport would strongly prefer use of LNG rather than diesel fuel. Global Common would assign its lease rights to the MESCO.

3.1.9. Other Energy Commodities

Microgrid energy commodities will be predominantly electric but the CCHP system will also provide thermal energy to ELIH.

3.2. Commercial Viability - Value Proposition

3.2.1. Benefits and Costs Realized By Community

Improved Reliability and Resiliency

Critical and Non-Critical Facilities

The project will improve the reliability and resiliency of power supply for critical facilities connected to the microgrid, as well as other commercial establishments and residences in the entire GMU service area. A list of the critical facilities appears in Section 3.1.3. In addition to these facilities, the project will assure energy for all GMU customers during outages to the main grid. This will benefit not only GMU customers, but also thousands of visitors and nearby communities rely on the critical facilities and commercial establishments in Greenport.

The proposed DERs will assure that all of these facilities, establishments and residents will have full power to meet coincident peak demand to operate at full capability during outages to the main grid.

Eastern Long Island Hospital (ELIH)

ELIH has 90 beds. Although the hospital has a 500 kW of diesel powered back up generation, fuel storage is limited to five days. The project will provide new pipeline gas supply for the CCHP system to assure that full power can be maintained in the event of an outage, and help reduce energy costs during normal operating conditions. National Grid has indicated that it can supply up to 5 MMBtu per hour, which is more than adequate to operate the proposed 375 kW CCHP system. National Grid indicated that it could complete system reinforcements need to supply this gas by November 2016.

Reduced Energy Costs

We estimate that the project could also significantly reduce the total energy costs for ELIH.

The exact terms of energy supply would need to be negotiated between GMU and ELIH. However, we expect that ELIH would continue to pay its current rate for electric energy. The CCHP system would provide nearly all of the thermal energy ELIH requires, which will allow ELIH to significantly reduce or eliminate nearly 76,000 gallons per year of heating oil (nearly all of its fuel use). Therefore, it is expected that ELIH would benefit from a significant reduction in fuel costs.

The 125 kW – 500 kWh battery facility located at Moores Lane site near the WWTP and the SCWA water storage tank would reduce peak demand for these facilities by providing energy during peak load periods when pumps are operating. This would increase the load factor for the GMU, which could allow GMU to increase its hydro allocation, thus reducing energy costs. GMU has indicated they could increase their hydro allocation if they could increase their load factor.

The solar PV system will reduce use of energy obtained based on market prices (i.e. the non-hydro allocation), since a substantial part of the energy will be produced during peak periods.

Fuel Supply

As stated previously, National Grid has indicated that it can provide about 5 MMBtu per hour of gas to ELIH, beginning in November 2016, which would be more than adequate to supply the new CCHP system. The new gas supply will assure fuel supply will be available under all operating conditions.

Based on initial discussions with National Grid, they might be able to supply the approximately 62 MMBtu per hour of gas that would be required to operate the proposed 7.4 MW plant on Moores Lane on an interruptible basis. (National Grid would need to perform a more detailed engineering study during Stage 2 to confirm the ability to supply pipeline gas.) Therefore, for now we have assumed that the project will utilize liquefied natural gas (LNG) that is transported to the plant by truck from liquefaction facilities in eastern PA.

GC has received proposals from two LNG suppliers that could supply this LNG, for a price of approximately $9-$11 per MMBtu delivered. (The delivered cost of pipeline gas would be around $2-$4 per MMBtu, depending on the commodity cost.) Truck transportation and storage of LNG is a proven technology, and would be consistent with NYSDEC regulations, which limit LNG storage to 70,000 gallons, or about 3.8 days of fuel supply at full plant output capacity. Since the average load for GMU is approximately 3.7 MW, this would provide seven days of fuel storage under average loads.

A description of the NYSDEC rules that became effective February 2015 governing transportation and storage of LNG is presented in the following link. http://www.dec.ny.gov/regulations/93069.html. The transporter would also need to get a permit from the New York City DEP for transportation of the LNG across the city. However, preliminary discussions with NYC officials indicate that it would be feasible to obtain NYC approval, since the trucks would only utilize major highways and would not make any stops in NYC.

Project Costs

It is expected that the DERs and energy efficiency measures will be funded by third party investors and/or lenders, GMU and NYSERDA grants.

3.2.2. Benefits to the Utility

The project will provide a more reliable and resilient microgrid that will help assure power for GMU's customers when the main grid is out of service. The project will also allow GMU to avoid major investments in replacing the existing diesel generators on Moores Lane, which are over 50 years old.

The project will also benefit PSEG-LI's customers on the east end of the south fork by helping to meet predicted peak power needs. As stated previously, energy from the 7.4 MW LNG-fueled plant on Moores Lane could be sent to the south fork via the 69kV dedicated underground cable across Shelter Island that connects to the Buell substation in East Hampton. This energy would reduce the need for new peaking facilities or transmission upgrades that would otherwise be required on the South Fork.

PSEG-LI projects a 63 MW transmission deficit in the South Fork of Long Island by 2022, and estimates that the cost to upgrade the transmission system would be approximately $298 million. Moreover, residents on the south fork are strongly opposed to new above ground transmission lines that would otherwise be needed to move power from western LI. In addition, there is not an adequate supply of pipeline gas on the eastern end of the South Fork (i.e. near East Hampton) to operate an adequate new gas fired power plant, and residents are strongly opposed to new diesel fired power plants. Therefore, a new gas-fueled plant in Greenport that connects directly to East Hampton would both help address peak demand needs on the east end of the south fork during normal operating conditions, and provide more reliability and resiliency for Greenport residences during main grid outages.

The utilities would not incur any costs for this project, unless PSEG-LI elects to enter into a PPA for purchase of energy and capacity from the MESCO.

3.2.3. Proposed Business Model

The business model will involve a public/private partnership between GMU and the MESCO. GMU will own and operate the CCHP system and batteries, and continue to operate its distribution system and diesel generating facility. A Microgrid Energy Services Company (MESCO) will finance own and operate the 7.4 MW electric only facility, and the new solar PV facilities. GMU and the MESCO will provide a portion of the project financing. However, the project would also depend on NY Prize funding from NYSERDA.

GMU will sell electric and thermal energy from the CHHP facility to ELIH. It is expected that GMU could sell the thermal energy at a substantial discount in comparison to ELIH's current cost for fuel oil. GMU will also dispatch the batteries to shave peak loads due to pumping at the water and waste water treatment facilities.

It is expected that the MESCO would sell energy from the 7.4 MW electric generating facility to customers outside of the GMU service area during normal conditions, and supply GMU during grid outages. However, the MESCO will explore the alternative of securing a long-term PPA for sale of energy from this plant to PSEG-LI.

The MESCO will sell energy from the new solar PV system to GMU. Behind-the-meter DERs (i.e. CCHP and likely PV) will provide power and thermal energy directly to the critical facility hosts (i.e. ELIH).

Strengths

- The project would assure reliable energy for GMU customers during outages to the main grid.
- The project will provide more reliable and lower cost energy for ELIH
- The project will reduce or eliminate the use of fuel oil at ELIH
- The battery would increase GMU's load factor, which would allow GMU to increase its hydro allocation and reduce costs.
- The MESCO can directly utilize possible tax incentives (e.g. solar investment tax credits), whereas GMU is a non-profit and could not efficiently utilize these incentives
- The project would help meet projected peak demand needs on the east end of the South Fork
- The project will reduce use of kerosene and diesel at existing liquid fueled peaking plants in Greenport, Southold, East Hampton and Shoreham, since the new gas-fueled plant will have a lower strike price than these facilities; the project will also reduce air emissions from these facilities, by reducing the number of hours they are dispatched

Weaknesses

- ELIH would need to make a long-term commitment to purchase power from GMU in order to facilitate financing
- The MESCO will need to secure customers for the new electric plant, or power will need to be sold on a merchant basis, which would increase project risk (assuming PSEG-LI is not willing to enter into a PPA)

Opportunities

- GMU could avoid the cost for new generation to replace its aging existing diesel generators, and focus its resources on other opportunities
- PSEG-LI could reduce costs for transmission or new generation on the south fork, and focus its resources on other opportunities

Threats

- Project lenders and investors may be reluctant to finance the project due to credit quality of ELIH, inadequate offtake agreements for the electric generating plant, or concern over technical and operational issues with the microgrid; (these concerns could be mitigated by innovative funding sources, such as the Green Bank, grants and tax incentives).

3.2.4. Unique Characteristics of Site or Technology

Innovative Use of Emerging Technologies

The project will involve use of the following innovative technologies and strategies:

- LNG fuel supply
- Batteries
- Microgrid controller

LNG fuel supply

Due to pipeline constraints, the electric generating facility may need to use LNG that is transported in 10,000-gallon tanker trucks, and stored in a 70,000-gallon storage tank pursuant to NYSDEC regulations. The LNG will be produced at liquefaction facilities in eastern PA. The project will use LNG if an adequate supply of pipeline gas is not available. LNG would have lower cost and fewer emissions than ultra-low sulfur diesel. We have received two proposals to deliver LNG for prices ranging from $9-$11/MMBtu. The LNG storage and re-gasification facilities will comply with NYSDEC regulations. This strategy could be used at other locations that do not have adequate supplies of pipeline gas.

Batteries

The project will include a 125-kW battery near the SCWA water storage facility and GMU's WWTP on Moores Lane. It is expected that the batteries will recharge at night when energy charges are low, and discharge during the day when energy and demand charges are high. The batteries will have discharge duration of four hours.

The batteries will help reduce peak loads due to pumping at the water and WWTP. This will reduce GMU's demand for market priced peaking power, increase GMU's load factor, which may allow GMU to increase its hydro allocation. When the main grid is out of service, the batteries will help stabilize the microgrid by assuring a balance between supply and demand.

Microgrid Controls

The Team is evaluating the current set of available commercial microgrid controllers. A best of breed selection will be made to obtain alignment with the microgrid site requirements. The controller will include monitoring and control functions to monitor voltage, frequency and line flows at multiple POIs and quickly issue commands to load and generation in the microgrid to initiate islanded mode.

3.2.5. Replicability and Scalability

All elements of the proposed project could be utilized at other microgrids that have a similar design basis. Some specific features that should be replicable at many locations are described below:

- LNG could be used for fuel in other locations that do not have access to pipeline gas.
- Sale of energy, capacity and ancillary services from the electric only generation would produce revenue that would make microgrids economically viable.
- The proposed public/private partnership could be utilized at other municipal utilities

3.2.6. Purpose and Need for Project

Greenport has experienced widespread and extended power outages as a result of extreme weather events, including hurricanes Sandy and Irene and other storms, and major bulk system outages such as the Northeastern Blackout in August 2003. These events resulted from disruptions to the main PSEG-LI grid, as well as from local distribution outages, and resulted in significant economic loss, threats to life and safety, and disruptions to public and commercial services.

Greenport has a number of critical facilities, including ELIH, which serves the entire north fork area, a distance of nearly 40 miles; village hall, Greenport High School, the fire department, a waste water treatment plant that discharges to Long Island Sound, a water supply pumping and storage facility, as well as commercial areas in downtown Greenport.

Reliability and resiliency are particularly important for Greenport because it is at the east end of the PSEG-LI transmission system, and the only transmission access is from a 69kV above ground cable that transmits power from western LI via the Southold substation. If this transmission line is disrupted, there is no other way to bring power to Greenport. (It would not generally be possible to bring power to Greenport via the Shelter Island cable, because there are significant peak power shortages and transmission constraints on the South Fork.) In addition, access roads west of Greenport have been flooded during prior storms, and are vulnerable to flooding during storm events, which could block delivery of fuel and other necessities. Therefore, it is especially important that Greenport is able to be self-sufficient in producing its own energy during outages to the main grid.

The microgrid will utilize a mix of DERs that will produce distributed energy, and reduce load. The electric power will be distributed using GMU's existing above ground feeders that will continue to be owned and operated by GMU. The feeders will be hardened in areas where there is a risk of exposure to vegetation/tree damage to ensure the functioning of the microgrid during and following storm events. Potential hardening measures include: stronger poles and cross-arms; compact construction; use of tree wire and spacer cable; more aggressive tree-trimming; removal of danger and hazard trees. These hardening measures will be coordinated with ongoing GMU storm hardening programs, initiated after recent storms. It is expected that some of the funding from the NY Prize grant would be used to pay for the costs for hardening of the distribution system. This funding will be supplemented by funding provided by GMU and third party investors.

During outages to the main grid, the new 7.4 MW electric generation facility would supply the entire GMU service area, and the CCHP facility would supply the hospital load. If pipeline gas is not available, the proposed LNG storage will provide seven days of fuel supply based on average load conditions. The existing backup generators at the hospital would provide an added level of reliability if needed.

3.2.7. Overall Value Proposition to Customers and Stakeholders

Table 3-1 Project Value Proposition

Stakeholder	Value Proposition
GMU	• DERs will reduce energy costs by reducing the need for non-hydro energy from NYPA, and from revenue it receives from the CCHP system • The DERs will increase GMU's load factor, enabling GMU to increase its hydro allocation, thus reducing energy costs • The DERs and distribution hardening measures will improve system reliability and resiliency • GMU will have the option to purchase the 7.4 MW electric generating facility to replace its aging diesel generators, and purchase the solar PV system
Eastern Long Island Hospital (ELIH)	• Reduce cost for electric energy • Reduce or eliminate use of fuel oil for heating • Provide more reliable energy supply • No capital investment
Other GMU customers	• Reduce electric energy charges • Continued power supply during outages to the main grid will assure the commercial establishments can maintain services for customers and the community • Commercial establishments will continue to earn revenue from their business operations during power outages to the main grid
National Grid	• CCHP system will provide a significant new customer (i.e. ELIH) for National Grid, with a high load factor demand profile • Pipeline reinforcements may facilitate sales to other customers
PSEG-LI	• The project will reduce load on existing transmission lines needed to deliver energy to the North Fork • The project will reduce the need for new transmission or generation needed to meet peak demand on the South Fork
Residents of the North Fork	• Residents will continue to benefit from services of ELIH and other critical and commercial facilities in Greenport during outages to the main grid
Environment	• Project will reduce air emissions by using more efficient CCHP technology to supply both electric and thermal energy • Use of LNG at the new electric only power plant, and the new gas fired CCHP plant, will reduce dispatch of diesel and kerosene fueled peaking plants in Greenport, Southold, East Hampton, and Shoreham, thus reducing emissions from these facilities, and reducing energy costs for PSEG-LI customers.
NY State	• Project would represent an innovative and financially viable microgrid and business model that could be replicated in other areas
Project investors, developers and lenders	• Will receive positive returns on investment, commensurate with project risk • Private investors and lenders will gain experience with an advanced microgrid that could enable similar future investments
Vendors and contractors	• Will generate new business by providing equipment and services • Will gain valuable experience in cutting edge project that could be applied to future microgrid projects

3.2.8. Added Revenue Streams, Savings, and/or Costs

Table 3-2 Revenue Streams, Savings, and/or Costs

Purchaser	Revenue/savings
Eastern Long Island Hospital (ELIH)	• Significant reduction of fuel cost
GMU	• Will receive additional revenue from ELIH through shared savings resulting from the CCHP system • Possible reduction in energy costs from NYPA due to lower use of market priced energy, and possible increase in hydro allocation
PSEG-LI customers	PSEG-LI customers will benefit from lower cost energy production from the new electric only LNG fired power plant, in comparison to the existing diesel and kerosene fired peaking plants on eastern LI. PSEG-LI customers on the South Fork would have power during peak periods.

3.2.9. Project Promotion of State Policy Objectives

The project helps promote NY REV by providing distributed and renewable energy that will improve system reliability and resiliency and reduce costs and emissions. The project will also reduce peak energy demand by use of batteries and load curtailment. A summary of benefits relating to the NY REV goals is presented below:

Table 3-3 Project Support of NY REV/RPS

Metric	Result Supporting NY REV/RPS
Distributed generation	Project will provide about 8,900 kW of DERs, including 375 kW of new CCHP, 7,400 kW of new electric only generation, 250 kW of new solar generation, and 125 kW of batteries with four-hour discharge.
Renewable generation	500kW (5.6% of total generation) will come from existing and new solar PV, including 250kW of new solar PV located on Moores Lane and/or at ELIH.

3.2.10. Project Promotion of New Technology

The project involves use of several emerging technologies, including batteries and microgrid control systems. Successful implementation of these technologies will encourage their use at other locations.

The project will include innovative control systems to assure that DERs maintain a balance between supply and demand in the island, and that the transition between connected and islanded modes is stable and secure. The project will also include a protection scheme that employs some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

The microgrid control system could also offer a suite of ancillary and distribution grid support services, as well as the ability to interact with the NYISO market.

Subject to evolving NY REV framework, the NYISO market rules applicable to microgrids and distributed generation, and enabling technology (to allow back-feeding in the network), it is expected that the distributed generation within the Greenport microgrid can sell energy into the larger grid though the Distribution System Platform (DSPP) model being developed within REV, but also participate in the NYISO energy, ancillary services, and capacity markets.

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

The ancillary services, including regulation up and down and spinning and non-spinning reserve can also be provided by the on-site generation subject to future market rules.

And finally, subject to qualification, on-site generation can participate in NYISO capacity auctions, and if they clear the market, they can be paid the applicable NYISO capacity prices.

The project would also promote use of LNG to power plants that do not have access to pipeline gas. In addition, the project would promote use of batteries to reduce peak loads.

3.3. Commercial Viability - Project Team

3.3.1. Securing Support from Local Partners

Global Common (GC) has a long-term relationship with the Village of Greenport, having developed a 54 MW kerosene-fired peaking plant in Greenport in 2003. GC has had numerous formal and informal meetings with Greenport officials and local residences to discuss the microgrid project and the LNG fueled plant on Moores Lane. The Board has approved a ground lease option agreement with GC to build the LNG fired power plant on Moores Lane. The project has received letters of support from the following groups:

- Mayor of Greenport
- Eastern Long Island Hospital (ELIH)
- Greenport Fire Department

- National Grid
- PSEG-LI

We have continued to update key stakeholders on development activities, including ELIH, which we expect will host the CCHP system. GMU will need to obtain final formal approval from ELIH prior to finalizing the CCHP plans.

National Grid has indicated that it can supply gas for the CCHP system as early as November 2016, and may be able to supply pipeline gas on an interruptible basis for the electric generating plant.

3.3.2. Role of Each Team Member in Project Development

A summary of key roles and responsibilities is presented below:

Table 3-4 Summary of Key Team Member Roles

Team Member	Role
ELIH	Host of CCHP system, and customer for purchase of electric and thermal energy
Greenport Municipal Utility (GMU)	Owner/operator of electric distribution system, the CCHP and battery systems;
PSEG-LI	Provides transmission and distribution to serve customers outside of GMU during normal operating conditions; the electric generating facility will use the PSEG-LI system to sell to these customers
National Grid	Supplier of pipeline gas for the CCHP system
Other critical facilities, and GMU customers	Participants in the microgrid
Vendors and contractors	To be determined; will provide DER equipment and construct the project
GE Energy Consulting, Burns Engineering, D&B Engineers	Project engineering and design services
Project investor and lender	To be determined; will provide project financing
Global Common, LLC (GC)	Project developer, principal of the Microgrid Energy Services Company (MESCO)
Microgrid Energy Services Company (MESCO)	Project company that will own and operate the electric generating plant and the new solar PV facilities

3.3.3. Public/Private Partnerships

GMU will own and operate the CCHP and battery systems, and the electric distribution system. The MESCO will own and operate the electric only plant and the solar PV facilities. GMU, third party investors and NYSERDA grants will provide funding for the project. This arrangement will utilize GMU's expertise and resources in managing generating facilities and the electric distribution system. The

MESCO will own and operate the electric generation facility because this plant will sell to customers outside of Greenport during normal operating conditions. The MESCO will own the solar PV system in order to benefit from the investment tax credits (ITCs).

3.3.4. Letter of Commitment from Utility

The project has letters of commitment from National Grid, the gas utility, and the Village of Greenport, which controls GMU. Also, National Grid has performed engineering analysis and provided written confirmation that it can supply 5 MMBtu per hour to Eastern Long Island Hospital for the CCHP system by November 2016. We have also met with Greenport officials to explain the microgrid program and GMU's role.

3.3.5. Applicant Financial Strength

The project will be developed by GC, and it is expected that GC will also have an ownership interest and management role in the project. The project will be funded by GMU, private investors who will provide non-recourse financing, and by a grant from NYSERDA. GC will continue to be the project developer, and the investors will have adequate financial resources or provide acceptable financial security to satisfy NYSERDA and project lenders.

GMU will arrange its own funding for its share of the project. The MESCO will provide traditional non-recourse project financing, with a capital structure that will include an appropriate level of equity, debt, and grant funding. Our team has extensive experience financing energy projects with similar structures. GC has identified some potential investors, and will select the preferred investment partner during Stage 2. The preferred investor would be a strategic investor, such as an ESCO, EPC contractor, or other project participant. For example, GE Capital would be a possible investor. It is expected that GC will be the applicant for Stage 2 NYSERDA funding.

3.3.6. Project Team Qualifications and Performance

A summary of qualifications is presented below and detailed qualifications and are presented in the appendices. As shown, the current project team has the capability to design and develop the microgrid and DERs, and arrange project financing. We will add other team members, including an EPC contractor, project investors and lenders, during Stage 2.

Table 3-5 Summary of Project Team Qualifications and Performance

Team Member	Qualifications
GE Energy Consulting	Extensive experience in design of microgrids, including distribution and microgrid control systems, and design of DERs; GE can also provide DER technologies, and advanced microgrid controllers.
Burns Engineering	Design and implementation of microgrids, including DERs.
D&B Engineers and Architects	Environmental/civil and electrical engineering
Global Common, LLC (Project Developer)	Project development and financing, including negotiation of power purchase agreements (PPA's), fuel supply contracts, EPC contracts, environmental permitting, and financial analyses and project structuring to satisfy lenders and investors.
MESCO	Owner and operator of the electric generating plant and solar PV system. The MESCO will be formed prior to closing on project financing.
Project investor and lender	To be determined. Investors and lender will provide financing to the MESCO. Investors will have financial strength to fund and manage the project.
GMU	Management and operations of electric distribution system, and the CCHP and battery systems.
Vendors and contractors	To be determined during Stage 2.

3.3.7. Contractors and Suppliers

Please see response to prior question. The existing and future contractors are and will be subcontractors to the applicant. The contractors, equipment suppliers and other vendors will be selected during Stage 2 based on competitive procurement or other appropriate procedures, subject to approval of project lenders, investors, and NYSERDA. The MESCO will be formed prior to closing on project financing.

The MESCO will retain an Engineering, Procurement and Construction (EPC) contractor experienced with significant energy projects, and the financial capacity to guarantee performance and satisfy the project lender, investor and NYDERDA. For example, we will consider firm such as Conti Construction, Burns & McDonnell, and Schneider Electric as possible EPC contractors. GC has received proposals to supply LNG from Gulf Oil and REVLNG, and will also obtain a quote from Philadelphia Gas Works and possibly others for supply of LNG.

3.3.8. Financiers or Investors

The project finance lenders and investors have not been identified and will be selected during Stage 2. We may engage an investment banker to assist in securing financing, or may select lenders/investors without outside advisors based on our prior relationships and evaluation of proposed financing terms. The investors will have adequate financial resources to complete the project and provide needed working capital for operations, and have experience investing in energy projects. For example, we will consider financing from GE Capital as a project investor, and we may engage Stern Brothers to provide investment banking services. We may also consider strategic investors, such as Gulf Oil, or our selected EPC contractor. The specific financing strategy will be developed during Stage 2. At this time, we do not think that most large private equity firms would be appropriate investors, because the project size is relatively small, and because their cost of capital may be too high.

We will consider cost of capital, and experience with energy projects, among other criteria. The current team members may contribute professional services, but it is not expected that the current team members will contribute cash.

3.3.9. Legal and Regulatory Advisors

There are no legal advisors on the current project team at the present time. We will retain an experienced project finance attorney during later stages of Stage 2 to assure that project documentation satisfies lenders and investors, and to assist in closing on project financing. The project attorney will have extensive experience with project financing of energy projects. GC has worked extensively with Andrews Kurth on other energy projects, and may consider using their services on this project. Andrews Kurth is a nationally recognized firm in the energy project finance area. We will also engage Twomey Latham as local counsel to assist with local regulatory and environmental matters. Twomey Latham is based in Riverhead, and has extensive experience with energy and environmental issues on LI. Twomey Latham also served as local counsel for Global Common in the development of the existing 54MW peaking plant in Greenport. It is expected that D&B Engineers will provide environmental consulting and permitting services. D&B is based in Melville, LI, and has extensive experience with environmental permitting on LI.

3.4. Commercial Viability - Creating and Delivering Value

3.4.1. Selection of Microgrid Technologies

The microgrid distributed energy resources were chosen based on a number of factors. We started overall system optimizations and initial asset selection, sizing, and configuration by using Lawrence Berkeley's Lab microgrid optimization tool, "DER-CAM." This tool takes a wide range of detailed inputs regarding DER assets, site loads, participant tariffs, site location weather, energy prices, and environmental parameters to optimize the selection and operation of DERs in the microgrid.

DER selections were further refined by considering the specific types of loads, available space, detailed asset performance characteristics and limitations given their intended function (e.g., base or peak generation) in the microgrid. Due to the significant electric and thermal base load of the hospital, cogeneration was an appropriate technology to deliver electricity and hot water.

We will utilize LNG delivered by truck if an adequate supply of pipeline gas is not available for the 7.4 MW electric-only generation unit. LNG would have lower cost and emissions in comparison to diesel fuel.

We selected a 7.4 MW unit because it closely matches GMU's peak load, and because Wartsila offers a pre-packaged, highly efficient, low cost dual fuel 7.4 MW generator; the heat rate of this unit is 8,400 BTU/kWh (over 40% efficiency), and VOM cost is only $3.83/kWh for up to 1,000 hours of dispatch. Also, Wartsila estimates that the installed cost would be approximately $1400/kW, which is very low considering construction costs on LI. However, we still intend to evaluate other technologies during Stage 2 prior to making a final decision on technology.

We decided to use batteries because the water and WWTP facilities have "spikey" load profiles due to intermittent pumping operations. The batteries will help increase the load factor for GMU, which could allow GMU to increase its allocation of low cost hydroelectricity. In addition, the batteries will help balance supply and demand when the microgrid operates in island mode.

We selected solar PV to help reduce the demand for peak energy.

In this stage, the control design focused more on functionalities and architecture than equipment or vendor specifications. Controller functionalities were chosen based on the technologies and needs of the project, and features of commercially available products from a range of vendors, including GE. These include the ability to monitor multiple POIs, fast load-shedding, and economic optimization. The ability to integrate BEMS into the control architecture and communicate with external utility systems is also highly valued.

3.4.2. Assets Owned By Applicant and/or Microgrid Owner

The project will include 500 kW of existing diesel generators that are owned by ELIH. These generators will be included in the microgrid to provide emergency backup power to the individual facilities in the event of a feeder outage. In addition, the microgrid will include 250 kW of existing solar PV at Greenport High School. The microgrid will not include GMU's existing diesel engines due to their age.

3.4.3. Generation/Load Balance

The specific demands for power matching/frequency regulation will be determined through study during Stage 2. The microgrid controller will manage assets in response to changing conditions. In connected mode (parallel to the grid), microgrid generation resources would not be required to regulate frequency, and would likely have a small role if any in voltage regulation. These services are provided by the bulk power system. However, in islanded mode, microgrid resources will need to provide for power balance/frequency control and reactive power balance/voltage control.

Some assets will provide base load power while other assets would switch to frequency control mode. The diesel generators at ELIH are excellent for black start and load-following applications, while the gas fired CCHP and electric generating facilities are better suited to base load operation than frequency control. This means the majority of fast frequency regulation would come from the diesel generator in isochronous mode, and the 125 kW - 500 kWh of battery storage near the Waste Water Treatment Plant and the SCWA facility. To augment frequency regulation, load may need to be controlled, particularly at ELIH (the largest load). Additionally, it may be necessary for solar production to be curtailed. This will also be managed by the controller.

3.4.4. Permits and/or Special Permissions

The project team expects to obtain typical construction permits as well as air permits for the CCHP and electric only generation systems. It would also be necessary to obtain an interconnection agreement with GMU based on standard interconnection requirements. In addition, it will be necessary to get Site Plan approval from the Village of Greenport to install the DERs. It would also be necessary to get a permit from NYSDEC for storage of LNG, pursuant to 6 NYCRR Part 570. The LNG transporter would also need to get approval from the New York City Department of Environmental Protection (NYDEP) for transport of LNG through the city. As stated previously, preliminary discussions with NYDEP officials indicate the transporter should be able to obtain this approval because the LNG would only be transported on major highways, and would not make any stops in NYC. The LNG permit and approval are unique to this project because most microgrids do not involve use of LNG.

3.4.5. Approach for Developing, Constructing and Operating

GC will be the project developer, and will engage investors, contractors and suppliers needed to execute the project during Stage 2. GC will also establish a MESCO that will finance, build, own, operate and maintain the electric generating and solar PV facilities. GMU will continue to own and manage the distribution system, and own and operate the CCHP and battery systems. As explained in response to Question 3.3.7, we will retain a qualified EPC contractor to build the project and guarantee performance. The MESCO and GMU will secure service agreements with vendors who will operate and maintain DERs, and the MESCO and GMU will provide the business management functions relative to their individual DERs.

3.4.6. Benefits and Costs Passed To the Community

The benefits of the microgrid will redound to the community in a number of direct and indirect ways. Most directly, ELIH will have reduced fuel costs as a result of the new CCHP system. In addition, the long-term operational continuity of critical government, hospital, fire, water and WWTP facilities and services will be ensured. Also, the project will assure that all customers in the GMU service area can maintain power during outages in the PSEG-LI grid. This reliability will benefit thousands of residents who rely on services in Greenport throughout the year.

GMU will incur part of the project cost for the CCHP system and in connection with hardening or operating the distribution system. It is expected that the project would also benefit from the NY Prize grant funding.

3.4.7. Requirements from Utility to Ensure Value

GMU will be responsible for operating and maintaining the CCHP, batteries distribution system, and the distribution system. The electrical interconnection of the facilities will use existing GMU feeders that will be hardened. GMU, the MESCO and NYSERDA may share funding for the hardening of the distribution system.

During an outage of the PSEG-LI grid, the GMU system will be disconnected from rest of the PSEG-LI system by switches and form the microgrid. Selected switches on PSEG-LI's system that define the boundaries of the microgrid will be automated to facilitate quick formation. This automation can only be accomplished in cooperation with GMU, and operation of the switches will be subject to hierarchical control from PSEG-LI's control center.

3.4.8. Demonstration of Microgrid Technologies

All of the technologies incorporated in the proposed microgrid are commercialized and proven. Combined heat and power generators and solar PV are established technologies. The feasibility of retrofitting the emergency generators to allow dual fuel operation of the existing diesel generators at ELIH will be evaluated based on input from the generator vendor. Wartsila and other vendors offer proven LNG storage and re-gasification systems, with extensive operating histories throughout the world.

The Microgrid Control design may incorporate GE's proven U90Plus Microgrid Cost Minimizer to dispatch the DERs, and the D400 RTU/Controller to implement various operational control strategies. GE is currently developing a DoE funded eMCS controller that expands upon the algorithms implemented in the U90Plus and incorporates many of the control functions that now reside in the D400. The eMCS will be tested at NREL in early 2016 and will be applied at a microgrid site on Potsdam, NY. The U90Plus algorithm is being incorporated into the D400 controller, and this solution will be deployed in mid-2016 on a Microgrid at the University of Ontario in Toronto.

Another proven solution that could be utilized is GE's proven C90Plus Fast Load Shed Controller. The C90Plus provides adaptive load shedding for loss of generation and/or a utility tie to trip non-critical load. The IEDs/relays communicate real-time load and generation values as well as status to the C90Plus via IEC 61850 GOOSE messaging. The C90Plus evaluates this information and will issue a fast trip GOOSE message to the IEDs/relays to trip non-critical loads to assure a generation-load balance. The tripping of the load breakers is initiated in less than 20ms from detection of the triggering event. This compares to 200ms to 400ms for conventional load shedding schemes. This solution was recently successfully deployed and demonstrated at the Portsmouth Naval Shipyard under a DoD Environmental Security Technology Certification Program (ESTCP) contract.

3.4.9. Operational Scheme

The operational scheme will be determined during Stage 2, based on input from the project team and project investor. It is currently expected to involve the following:

- Technical- During blue sky days, the CCHP unit at the hospital will run 95% of the time, with shutdowns for maintenance only, because the Greenport utility energy price of approximately $0.11/kWh is greater than the strike price of the unit, and the CCHP unit would reduce fuel oil use; the electric only generation system will sell contractually to customers outside the GMU service territory; GMU will dispatch batteries to meet peak demand at the water and WWTP facilities; the solar PV systems will net meter power, and/or sell to GMU. During grid outages, the microgrid will go into island mode, and the DERs will supply energy for GMU, which will use the energy to supply its customers.
- Financial- The MESCO, GMU and NYSERDA may share financing for the project. The MESCO will also secure an appropriate level of working capital needed to meet its cash flow obligations, and provide performance security if required to meet counterparty requirements.
- Transactional- GC will retain an experienced project finance attorney during Stage 2 to assure that all appropriate documentation needed to close on project financing is prepared to satisfy requirements of lenders and investors.
- Decision making- The decision making protocols will be documented in an Operating Agreement for the MESCO during Stage 2. GMU and the MESCO will also establish operating protocols that define how the DERs would operate and coordinate during normal conditions and grid outages. It is expected that the Manager (to be determined) will be responsible for day-to-day operations

of the MESCO, and that certain major decisions requiring investor approval will be defined in the Operating Agreement.

3.4.10. Plan to Charge Purchasers of Electricity Services

The project owner would enter into a Microgrid Energy Service Agreements (MESAs) to supply customers outside of the GMU service area during normal conditions. The MESCO will also establish a MESA with GMU that will define terms for providing energy for GMU in the event of an outage on the PSEG-LI grid. It is expected that the MESCO will sell energy from the electric only generating plant to customers outside the GMU service area on a contractual basis; however, GC will explore PSEG-LI's interest in establishing a PPA for sale of energy and capacity. The MESAs will include an appropriate fuel adjustment mechanism or be structured as tolling agreements to assure financial viability of the project. Revenue grade meters will record energy usage at individual sites.

3.4.11. Business/Commercialization and Replication Plans

GMU will establish an energy supply plan with ELIH consistent with its municipal tariff. The MESCO will evaluate different options for sale of its energy during Stage 2. These could include Internal Bilateral Agreements, partnering with or selling to an Energy Services Company, sale of energy and capacity to the NYISO, or establishing a PPA with PSEG-LI. The team hopes to replicate this structure at other similar projects.

3.4.12. Barriers to Market Entry

There are a number of significant barriers to market entry, including but not limited to the following:

- Complexity of design of an integrated system of DERs, distribution and controls to meet varying microgrid loads during blue-sky days and during grid outages.
- Lack of funding for design and development activities
- Limited experience with microgrids may deter lenders and investors
- Relatively small capital requirements will deter most large energy investors
- Ability to identify an EPC contractor that will provide performance guarantees for a highly complex microgrid system
- Ability to identify project lenders and investors that will provide project financing at acceptable cost of capital
- Availability of a microgrid control system that can manage multiple DERs and varying load conditions
- Lack of mechanism to place a market value on reliability and resiliency limits financial viability of many projects

3.4.13. Steps Required to Overcome Barriers

We will use the following strategies for addressing these barriers:

- Complexity of design of an integrated system of DERs, distribution and controls to meet varying microgrid loads during blue sky days and during grid outages.

  - The Project Team members have extensive experience in a full range of energy development and financing, including design and development of microgrids. GE previously performed the technical work in the 5-Site NYSERDA "Microgrids for Critical Facility Resiliency in New York State," that formed the basis for the NY Prize program. GE is also working on several other NY Prize projects.
  - Burns Engineering has a comprehensive understanding of the use of P3 for energy projects and has participated in several as both owner's engineer and engineer of record. In particular, Burns has led the multi-year planning and implementation of a microgrid at the Philadelphia Navy Yard and developed a number of P3 project structures to fund the construction and facilitate the operation and ownership of distributed generation resources central to the microgrid.
  - Global Common has developed and arranged financing for a variety of conventional and renewable energy projects in NY and throughout the US, including a anaerobic digester/CHP project in Auburn, NY, that was partially funded by NYSERDA, and a 54 MW peaking plant in Greenport, NY. Global Common is also managing two other NY Prize projects.
- Lack of funding for design and development activities
  - Design and development will be partially funded by a NY Prize Stage 2 grant, supplemented by in-kind services from the Project Team and GMU.
- Limited experience with microgrids may deter lenders and investors
  - The team's credibility and experience, project design, EPC performance guarantees, capital structure (including significant grant funding), credible revenue and cost model, and adequate financial returns should be sufficient to attract financing
- Relatively small capital requirements will exclude most large energy investors
  - Medium sized financial investors and/or strategic investors are likely to have interest in the project because they believe microgrids are a potentially significant growth opportunity
- Ability to identify an EPC contractor that will provide performance guarantees for a highly complex microgrid system
  - Medium sized EPC firms will have an interest in microgrid construction projects because of potential growth opportunities
- Ability to identify project lenders and investors that will provide project financing at acceptable cost of capital
  - Lenders and investors have an interest in participating in microgrids because of its potential for future growth, and because returns with other opportunities are relatively low
- Availability of a microgrid control system that can manage multiple DERs and varying load conditions
  - GE and others are developing sophisticated microgrid control systems, with funding assistance from US DOE.

- Lack of mechanism to place a market value on reliability and resiliency limits financial viability of many projects
  - NYSERDA grants can help subsidize projects to indirectly recognize the value of reliability and resiliency
  - Policy makers should consider other means to place a value on reliability and resiliency

3.4.14. Market Identification and Characterization

The project customers will include ELIH, GMU and other commercial and residential customers outside the GMU service area. ELIH would purchase electric and thermal energy produced by the CCHP system from GMU, and the electric only plant will sell to commercial and residential customers outside the GMU service area during normal conditions. The MESCO will explore various means to market energy from the electric plant during Stage 2, as explained in response to questions 3.4.10 and 3.4.11.

We expect that ELIH would be interested in purchasing electric and thermal energy from the CCHP system since ELIH could significantly reduce fuel oil costs. The batteries would reduce GMU's peak load by shaving peak demand from the SCWA and WWTP facilities.

Our review of PSEG-LI and NYISO prices indicates that revenue from sale of energy and capacity, combined with NYSERDA NY prize grant, would produce returns that are adequate to attract private financing. This new electric plant would be dispatched ahead of other less efficient, diesel and kerosene fueled peaking power plants on eastern LI located in Greenport, Southold, Southampton and Shoreham, since the strike price with the proposed plant would be less than these other plants due to higher efficiency and lower fuel and VOM costs.

The market value of the energy produced by the DERs, and fuel and VOM costs, are reflected in the financial analyses in Section 3.5.

3.5. Financial Viability

3.5.1. Categories of Revenue Streams

The GMU income statement shown below includes the CHP and battery systems. The projections assume that ELIH would continue to pay its current electric rates to GMU, and pay GMU 50% of its current fuel oil cost for waste heat from the CCHP unit. This scenario would also produce about $57,000 per year of cash flow for GMU. This example is presented for illustrative purposes only, as specific terms would need to be negotiated between GMU and ELIH.

Table 3-6 GMU Income statement with NY Prize Funding

	Amount ($/year)
Revenue	**$412,212**
COGS	
VOM	$60,950
Fuel	$134,090
Capacity/ancillary services/other	$8,231
Sub-total	**$203,271**
Gross Profit	$208,941
Gross margin	50.7%
FOM	**$47,428**
EBITDA	**$161,514**
Debt Service	**$104,377**
Cash flow and financial ratios	
Cash flow	$57,136
DSCR	1.55

Table 3-7 GMU Financial Results without NY Prize Funding

	Amount ($/year)
EBITDA	$161,514
Debt Service	**$201,333**
Cash flow	**$39,820**
Financial ratios	
DSCR	-0.80

The MESCO income statement includes the electric only generating plant and the solar PV facility. This analysis assumes that the project would be financed with the NY Prize grant, ITC grants and third party equity. We have assumed no debt because of the potential risk of the offtake arrangements. The revenue and costs for the electric generation are based on 973 hours of dispatch, which is based on 2015 real time NYISO prices in comparison to the strike price of the generating unit, and an LNG price of

$10.00 per MMBtu.As shown, the project would produce attractive equity returns based on these assumptions.

Table 3-8 MESCO Income Statement with NY Prize Funding

	Amount ($/year)
Revenue	**$4,185,475**
COGS	
VOM	$27,579
Fuel	$544,382
Capacity/ancillary services/other	$1,000,440
Sub-total	**$1,572,401**
Gross Profit	$2,613,075
Gross margin	62.4%
FOM	$375,683
EBITDA	**$2,237,392**
Debt Service	**$0**
Cash flow and financial ratios	
Cash flow	$2,237,392
DSCR	NA
Unlevered pre-tax IRR	37.0%

Table 3-9 MESCO Financial Results with NY Prize Funding

	Amount ($/year)
EBITDA	**$2,237,392**
Debt Service	$0
Cash flow	**$2,237,392**
Financial ratios	
DSCR	NA
Unlevered pre-tax IRR	17.9%

3.5.2. Other Incentives Required or Preferred

Sources and uses of funds are shown below. As shown, the project will require incentives from NYSERDA, as well as ITCs. It is assumed that the NY Prize grant would be provided at financial closing, which is the time when all funds needed to complete the project are unconditionally committed. The ITC grant may be provided after financial closing; this funding would initially be provided by the equity investor, who would later recover the investment from the ITC.

The costs below do not include costs for design and development, which would come from the Stage 2 NYSERDA grant plus in kind services. It is assumed that the costs below do not include development and financing fees, legal fees, interest during construction and other soft costs.

Table 3-10 Sources and Uses of Funds with NY Prize Funding

Uses of Funds		Sources of Funds	
CCHP	$1,500,000	MESCO funding	$6,069,538
Electric generation	$11,360,000	GMU funding	$1,266,247
Solar	$666,750	NY Prize Grant	$7,000,000
Battery	$300,000	ITC	$200,025
Distribution and controls	$709,060		
Total	**$14,535,810**		**$14,535,810**

Table 3-9 Sources and Uses of Funds without NY Prize Funding

Uses of Funds		Sources of Funds	
CCHP	$1,500,000	MESCO funding	$11,861,252
Electric generation	$11,360,000	GMU funding	$2,474,533
Solar	$666,750	NY Prize Grant	$0
Battery	$300,000	ITC	$200,025
Distribution and controls	$709,060		
Total	**$14,535,810**		**$14,535,810**

3.5.3. Categories of Capital and Operating Costs

Income statements showing for GMU and the MESCO are shown in Section 3.5.1. A breakdown of annual revenue and income for different DERs is shown below.

Table 3-11 Revenue and EBITDA Breakdown

DER	Revenue	VOM plus fuel	EBITDA
CHP	$361,267	$194,128	$123,788
LNG fueled electric generation	$3,739,758	$1,572,401	$1,808,923
Solar	$33,505	$0	$16,256
Battery	$50,945	$9,143	$37,726
Total	**$4,185,475**	$1,775,672	**$1,986,693**

Note: Battery "fuel" costs are based on energy purchases from the grid.

3.5.4. Business Model Profitability

The Team will assure profitability and mitigate risk using the following strategies:

- Capital structure will include adequate equity and grants to assure adequate cash flow and debt coverage, while providing acceptable returns for the investor. Please see tables above and below.
- GMU will have a long term agreement with ELIH to assure revenue for the CCHP system.
- The MESCO will seek long term contracts with customers for part if not all of its energy, capacity and ancillary services. The contracts will include traditional project finance terms satisfactory to project lenders, investors and NYSERDA.
- The low variable cost for the electric-only plant will allow it to dispatch ahead of other eastern LI plants due to lower fuel cost and higher efficiency, assuring adequate cash flow.

3.5.5. Description of Financing Structure

A preliminary permanent capital structure is presented in response to question 3.5.2.

The tables below show the capital structures for GMU and the MESCO with and without NY Prize funding. Design and development funding would be provided primarily by the NYSERDA Stage 2 grant, plus in kind services from the project team and GMU. The project investor will provide funding to cover the ITC, and the ITC will later be recovered by the investor. The lenders and investors/owners will receive project cash flows to recover their loans, and provide a return of and on investment.

Table 3-12 GMU Financing Structure with NY Prize Funding

Project cost		$2,509,060
Equity	0.0%	$0
ITC		$0
NY Prize Award		$1,208,286
CHP PON		$0
Principal	51.8%	$1,300,774

Table 3-13 GMU Financing Structure without NY Prize Funding

Project cost		$2,509,060
Equity	0.0%	$0
ITC		$0
NY Prize Award		$0
CHP PON		$0
Debt	100.0%	$2,509,060

Table 3-14 MESCO Financing Structure with NY Prize Funding

Project cost		$12,026,750
Equity		$6,035,011
ITC		$200,025
NY Prize Award		$5,791,714
CHP PON		$0
Principal	0.0%	$0

Table 3-15 MESCO Financing Structure without NY Prize Funding

Project cost		$12,026,750
Equity		$11,826,725
ITC		$200,025
NY Prize Award		$0
CHP PON		$0
Debt	0.0%	$0

3.6. Legal Viability

3.6.1. Proposed Project Ownership

GMU will own the CCHP and battery systems, and the MESCO will own the electric generation and solar PV systems. The MESCO will be owned by GC and other qualified energy professionals and investors. The specific ownership structure and participants will be determined during Stage 2. GC has relationships with a number of potential investors who may have an interest in investing in the project, assuming the project structure and returns meet their requirements. It is expected that GC will continue to manage the project and have an ownership stake in the electric generation and solar PV facilities.

3.6.2. Project Owner

The project owner/investor has not yet been identified. The project team has relationships with a number of qualified investors, one of which will be selected during Stage 2. For example, GC will explore the possibility of GE providing part of the project financing. GC will arrange project financing and likely maintain an ownership interest in the project.

3.6.3. Site Ownership

The DERs will likely utilize land owned by project participants and the village to accommodate the DER equipment. ELIH would likely benefit from reduced energy costs in lieu of lease payments. GMU has already identified potential sites for the DERs and GC will work with GMU to select the final sites and secure space required for the DERs during Stage 2.

3.6.4. Protecting of Customer Privacy Rights

All terms involving customers would be protected with standard confidentiality agreements.

3.6.5. Regulatory Hurdles

We would need to obtain standard air and site use permits. The LNG supplier would need to get approval from New York City Department of Environmental Protection (NYDEP) to transport LNG through the city. It is not expected that the NYDEP approval should be an issue, since transportation through NYC will be restricted to major highways and will not make any stops in NYC.

4. DEVELOP INFORMATION FOR BENEFIT COST ANALYSIS

Task 4: Develop Information for Benefit Cost Analysis

The project Team prepared detailed questionnaires to obtain data needed for the IEC BCA analyses, and met with or called major energy users to obtain relevant data. The Team then compiled and analyzed the data, and completed the IEC questionnaires to provide all of the data requested in Task 4. The IEC report is presented later in this section, and the completed questionnaires are shown in the Appendices.

The sections below describe the procedures and key assumptions regarding the data for the BCA analyses. In addition, this section discusses several issues and assumptions affecting results of the BCA. These include:

- Availability of use pipeline gas
- Air emissions benefits

Availability and price of Natural Gas

National Grid has indicated it may be able to supply natural gas on an interruptible basis for the 7.4 MW electric generating plant. However, National Grid would need to perform a detailed study to confirm this. Because the availability of pipeline gas is uncertain, we have conservatively assumed that the electric generating plant would use LNG that would be trucked to the plant from liquefaction facilities in PA. Based on quotes received from LNG suppliers, the delivered cost of the LNG would be $9.00 per MMBtu based on current commodity prices. In addition, the cost to store and re-gasify the LNG would be approximately $1.0 million. The delivered cost of pipeline gas would be approximately $2.00 to $3.00 per MMBtu, and there would be no cost for storage or re-gasification.

National Grid has indicated that it would be necessary to pay a fee for engineering studies to confirm the availability of pipeline gas. The team intends to pay for this study during Stage 2. In the meantime, we have assumed that the plant would use LNG.

A preliminary review of the BCA analysis indicates that use of pipeline gas rather than LNG would increase the net benefits by approximately $10 million. Therefore, we believe it is likely that the current BCA analysis significantly understates the potential benefits of this project.

Air Emissions Benefits

The BCA calculates the emissions impacts from the microgrid. However, it does not account for the reduction of emissions from reducing dispatch of other liquid fired peaking plants on eastern Long Island.

A figure showing the locations of existing liquid fueled peaking plant in the East End Load Area, and the local transmission system, is shown below.

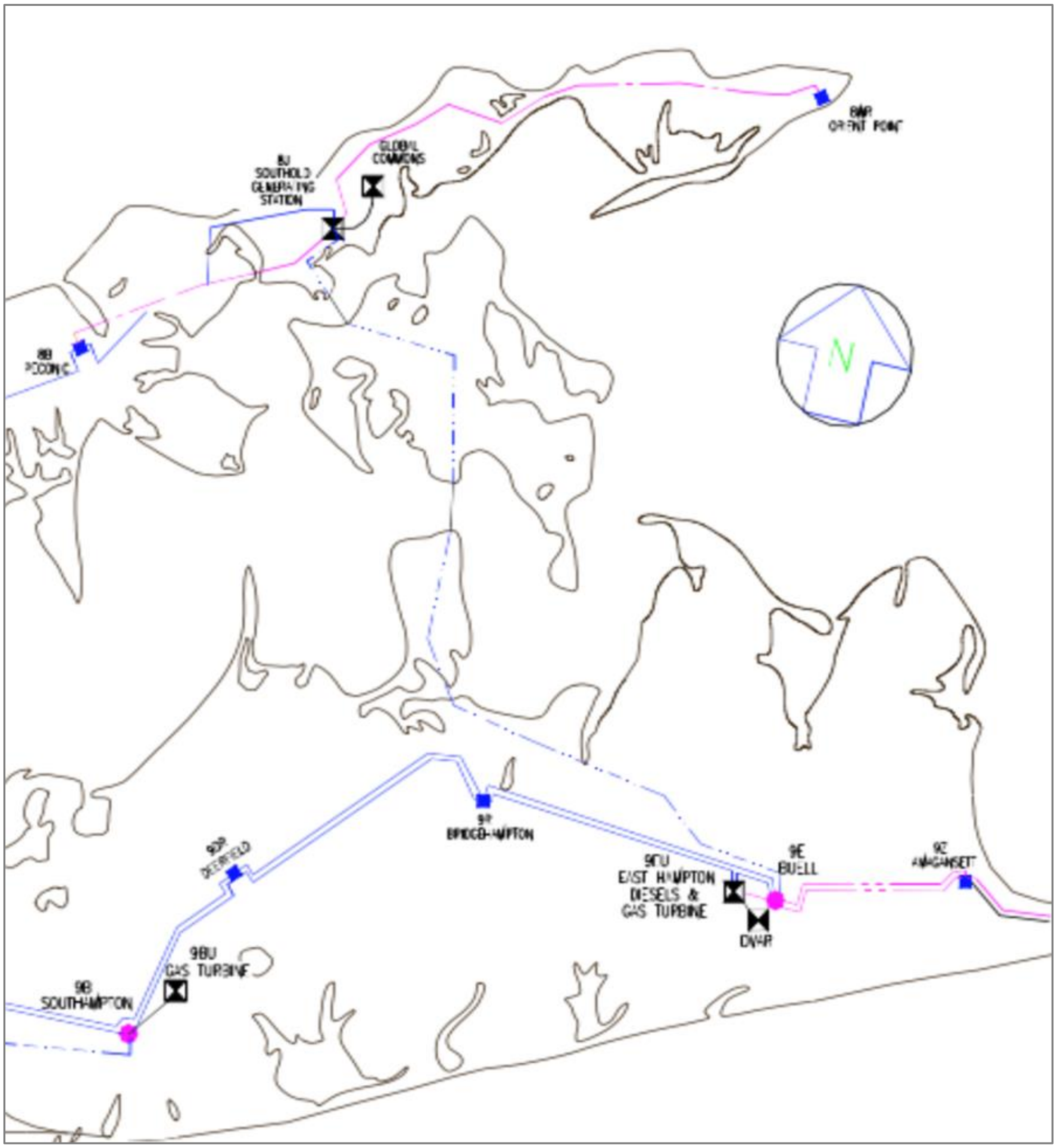


Figure 4-1 Locations of existing liquid fueled peaking plant in the East End load area

As shown in the figure, there is diesel and kerosene fired peaking plants in Greenport, Southold, East Hampton and Southampton. (Greenport is located on the map where the Global Common plant is shown on the North Fork.) These plants are older and inefficient units, but they are dispatched frequently during hot summer days. For example, the Greenport kerosene fueled peaking plant has been dispatched between 500 and 1,000 hours per year for the past five years.

Since the new gas fueled 7.4 MW LNG plant, as well as other DERs in Greenport, would have lower variable operating costs than these liquid fueled facilities, the project would reduce the need to dispatch these plants, thus significantly reducing air emissions. However, the BCA analysis does not recognize the benefits from these reductions in emissions.

4.1. Facility and Customer Description

The Team consulted with GMU and Greenport officials to identify the critical facilities and other establishments that should be included in the microgrid. We then worked closely with GMU to obtain load data for these facilities. We obtained individual electric and fuel bills for large commercial and government establishments, as well as total GMU electric use data and bills. GMU provided data on individual feeders that was used to estimate loads for smaller residential and commercial establishments. Results are shown in the appendices. Based on a review of this information, the Team decided that the microgrid should include the entire GMU service area.

4.2. Characterization of Distributed Energy Resources

The Team designed the DERs to meet peak GMU loads during grid outages, and ensure an economically viable business model during normal conditions.

The CCHP system would reduce or possibly eliminate use of fuel oil at ELIH and reduce the cost of electricity.

The 7.4 MW electric generating plant would assure that the entire GMU service area has power during grid outages. During normal conditions, this plant would sell energy and capacity to customers outside of the GMU service area on a contractual basis. (It would not be economical to use energy from this plant to replace GMU's low cost hydropower.) Since this plant would use natural gas, and have lower variable costs than other diesel and kerosene fueled plants on eastern LI, it would also significantly reduce air emissions. The facility will have a heat rate of 8400 per kWh.

The battery facility would shave peak loads at the WWTP and the SWCA water supply facility due to pumping, and help stabilize the microgrid during main grid outages. The new solar PV would further help reduce peak GMU loads.

These DERs would also help increase GMU's load factor, which could increase its allocation of low cost hydropower.

Tables showing the requested DER data are provided in the appendices.

4.3. Capacity Impacts and Ancillary Services

The project will provide peak load support and significantly reduce the need for new transmission or peak generation needed to meet projected transmission deficits on the South Fork. PSEG-LI estimates there will be a 63MW transmission deficit on the South Fork by 2022.

The project will provide 8.5 MW of peak load support, primarily from the 7.4MW electric generating plant. The 7.4 MW electric plant will reduce the need for new peaking generation or transmission on the South Fork, since this facility is connected to the Buell substation in East Hampton via a dedicated 69kV underground cable that runs from Greenport across Shelter Island. The transmission lines are shown on the East End Load Area figure above.

The project will also provide ancillary services and capacity. In addition, the CCHP system will significantly reduce or eliminate use of fuel oil use at ELIH. Finally, the project will significantly reduce emissions by reducing the need to dispatch existing diesel and kerosene fueled peaking plants, as discussed previously.

4.4. Project Costs

A breakdown of project costs is shown below.

Table 4-1 Breakdown of Project Costs

Uses of Funds	Amount
CCHP	$1,500,000
Electric generation	$11,360,000
Solar	$666,750
Battery	$300,000
Distribution and controls	$709,060
Total	**$14,535,810**

As shown, total project cost, including DERs, distribution improvements and microgrid controls, is estimated to be approximately $14.5 million, or about $1,700 per kW. The capital cost of the electric generating plant is about $1400 per kW, plus $1.0 million for LNG storage and re-gasification equipment. The electric plant would have seven days of LNG fuel supply (70,000 gallons) based on average energy demand. (As noted previously, it is possible that this plant may have access to pipeline gas, subject to further study by National Grid.)

VOM costs would be only about $3.83 per MWH, based on 1,000 hours of dispatch, or $8.96 per MWH assuming 4,000 hours of dispatch

4.5. Costs to Maintain Service during a Power Outage

Information addressing the points responding in this section is contained in the Appendices.

4.6. Services Supported by the Microgrid

The project will be able to meet peak loads for the entire GMU service area during outages to the main grid. Specific responses to the points in this section are in the Appendices.

4.7. Summary of Benefit-Cost Analysis Summary Report

To assist with the completion of the project's NY Prize Stage 1 feasibility study, Industrial Economics, Inc. (IEc) conducted a screening-level analysis of its potential costs and benefits. IEc typically considers two scenarios for the benefit cost analysis. The first scenario assumes a 20-year operation periods with no major power outages (i.e., normal operating conditions only). The second scenario calculates the average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under the first scenario. In this case, a second scenario was not needed, but two variants of the first scenario were considered.

Results of IEc's analysis for Scenario 1A (included in Appendix A) suggest that if no major power outages occur over the microgrid's assumed 20-year operating life, the project's benefits would exceed its costs.

A variant on the first scenario, Scenario 1B, was also ran with the assumption that the microgrid project would contribute to avoiding specific transmission capacity upgrades on Long Island.

The results are summarized in the table below which shows a breakdown of the benefits and costs for Scenario 1A and 1B.

Table 1 BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES		
	SCENARIO 1A: 0 DAYS/YEAR	SCENARIO 1B: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$13,600,000	$53,300,000	Not Evaluated
Benefit-Cost Ratio	1.2	2.0	Not Evaluated
Internal Rate of Return	16.5%	57.1%	Not Evaluated

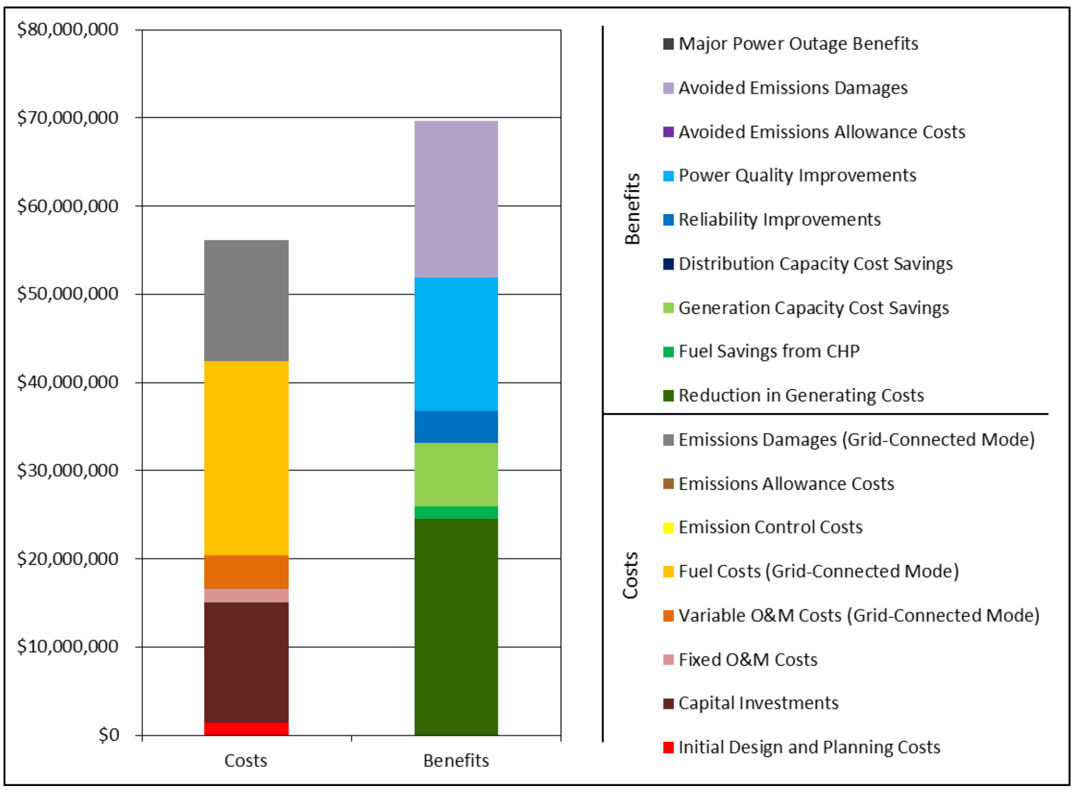


Figure 1. Present Value Results, Scenario 1A (No Major Power Outages; Default Transmission Capacity Benefits; 7 Percent Discount Rate)

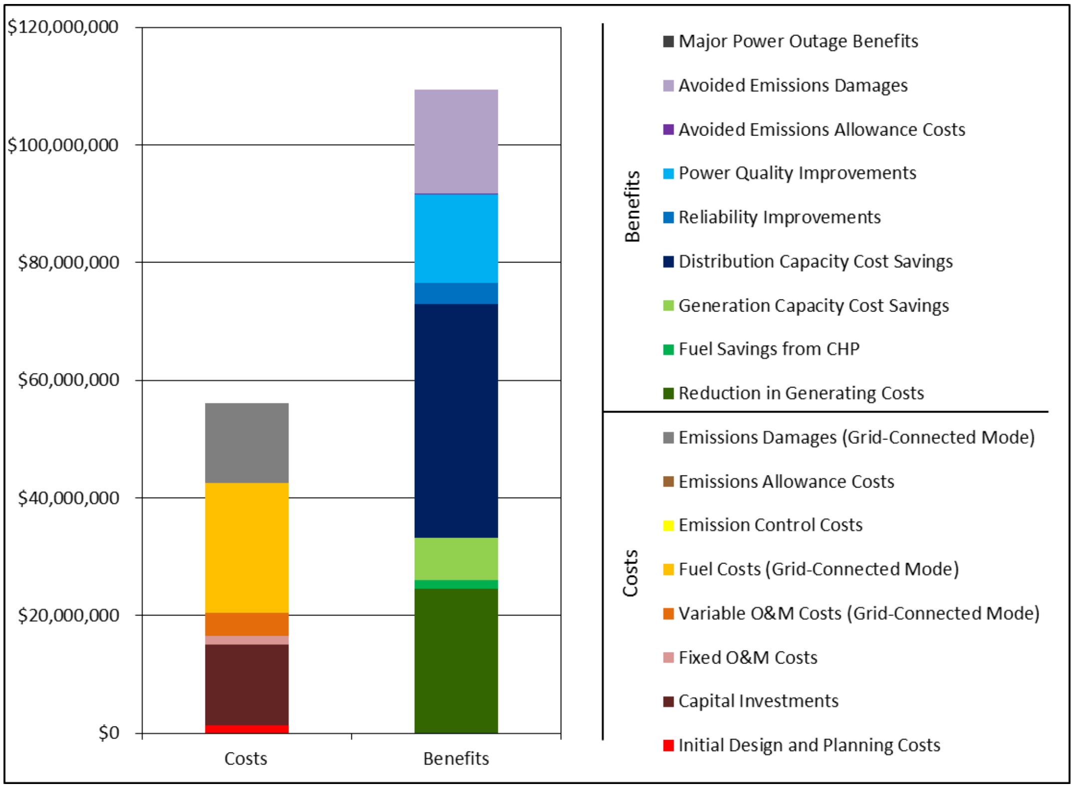


Figure 2. Present Value Results, Scenario 1B (No Major Power Outages; Avoided Transmission Capacity Upgrade Project; 7 Percent Discount Rate)

APPENDIX A - BENEFIT-COST ANALYSIS SUMMARY REPORT

Site 4 – Village of Greenport

Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the Village of Greenport has proposed development of a microgrid that would serve 1500 residential customers and 515 commercial customers in this Suffolk County community.[1] The critical service providers that would be served by the microgrid include a wastewater treatment plant, a water pumping station, and the Eastern Long Island Hospital. In addition, the microgrid would serve all facilities currently being served by the Village of Greenport's municipal utility, including Greenport High School, Greenport Village Hall, the Shelter Island Ferry station, and Greenport's Long Island Rail Road station.

Greenport's microgrid would be powered by a new 7.4 MW generator running on liquefied natural gas (LNG), a new 375 kW natural gas-fired combined cooling, heat, and power (CCHP) system, a new 250 kW solar photovoltaic array, 250 kW of existing solar photovoltaic arrays, and 125 kW – 500 kWh of battery storage. The solar arrays and cogeneration plant would produce electricity for the grid during periods of normal operation. All resources, including the LNG generator, would be available for peak load support and to support islanded operation during power outages. The system as designed would have sufficient generating capacity to meet average demand for electricity from all facilities on the microgrid during a major outage. The project's consultants also indicate that the system would be capable of providing frequency regulation, reactive power support, and black start support 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.

[1] The microgrid will be connected to a PSEG Long Island feeder line with approximately 1500 residential and 500 commercial customers. Since the project team is unable to provide detailed electricity usage information for each load group, this analysis applies PSEG Long Island's estimate of average annual residential electricity usage to the 1500 residential customers and assumes that the remaining load is split evenly among the 500 commercial customers.

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.[2] 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 the following scenarios:

- Scenario 1A: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only). For this scenario, the analysis employs the model's standard approach to valuing transmission capacity benefits.
- Scenario 1B: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only). For this scenario, the analysis values the impact of the project on transmission capacity requirements on the basis of specific transmission capacity upgrades that would be necessary in the absence of the microgrid.
- 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.[3]

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[2] 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.]

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

Results

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that although the value assigned to the project's transmission capacity impacts greatly influences the magnitude of benefits, the benefits outweigh the costs in both Scenario 1A and Scenario 1B. When the model's default estimate of the value of transmission capacity is applied and no major power outages are assumed to occur (Scenario 1A), the project's benefits exceed its costs by approximately 20 percent. If the analysis uses alternate estimates of the project's transmission capacity benefits (based on the avoided costs of specific transmission capacity augmentation projects planned for the South Fork of Long Island), the project's benefits increase by an additional $39.7 million (Scenario 1B).

Since the results of both Scenarios 1A and 1B suggest a benefit-cost ratio greater than one, the report does not present a detailed analysis of the impact of major power outages under Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio. The discussion that follows provides additional detail on the findings from Scenarios 1A and 1B.

Table 1 BCA Results (Assuming 7 Percent Discount Rate)

1. ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES		
	SCENARIO 1A: 0 DAYS/YEAR	SCENARIO 1B: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$13,600,000	$53,300,000	Not Evaluated
Benefit-Cost Ratio	1.2	2.0	Not Evaluated
Internal Rate of Return	16.5%	57.1%	Not Evaluated

Scenarios 1A and 1B

Figure 1 and Table 2 present the detailed results of the Scenario 1A analysis, while Figure 2 and Table 3 present the detailed results of the Scenario 1B analysis.

Figure 1. Present Value Results, Scenario 1A (No Major Power Outages; Default Transmission Capacity Benefits; 7 Percent Discount Rate)

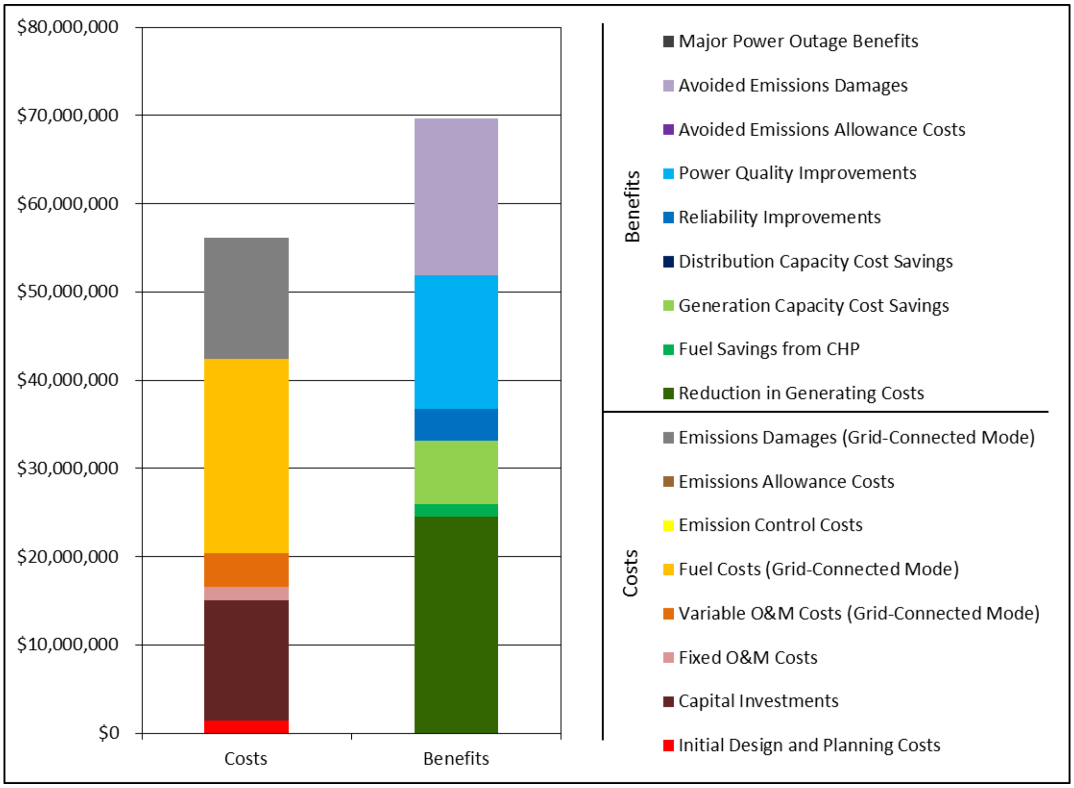

Table 2. Detailed BCA Results, Scenario 1A (No Major Power Outages; Default Transmission Capacity Benefits; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,390,000	$122,000
Capital Investments	$13,700,000	$1,190,000
Fixed O&M	$1,530,000	$135,000
Variable O&M (Grid-Connected Mode)	$3,820,000	$337,000
Fuel (Grid-Connected Mode)	$22,000,000	$1,940,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$13,700,000	$893,000
Total Costs	**$56,100,000**	
Benefits		
Reduction in Generating Costs	$24,500,000	$2,160,000
Fuel Savings from CCHP	$1,470,000	$130,000
Generation Capacity Cost Savings	$7,220,000	$637,000
Transmission/Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$3,610,000	$319,000
Power Quality Improvements	$15,100,000	$1,330,000
Avoided Emissions Allowance Costs	$11,300	$997
Avoided Emissions Damages	$17,800,000	$1,160,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$69,700,000**	
Net Benefits	**$13,600,000**	
Benefit/Cost Ratio	**1.2**	
Internal Rate of Return	**16.5%**	

Figure 2. Present Value Results, Scenario 1B (No Major Power Outages; Avoided Transmission Capacity Upgrade Project; 7 Percent Discount Rate)

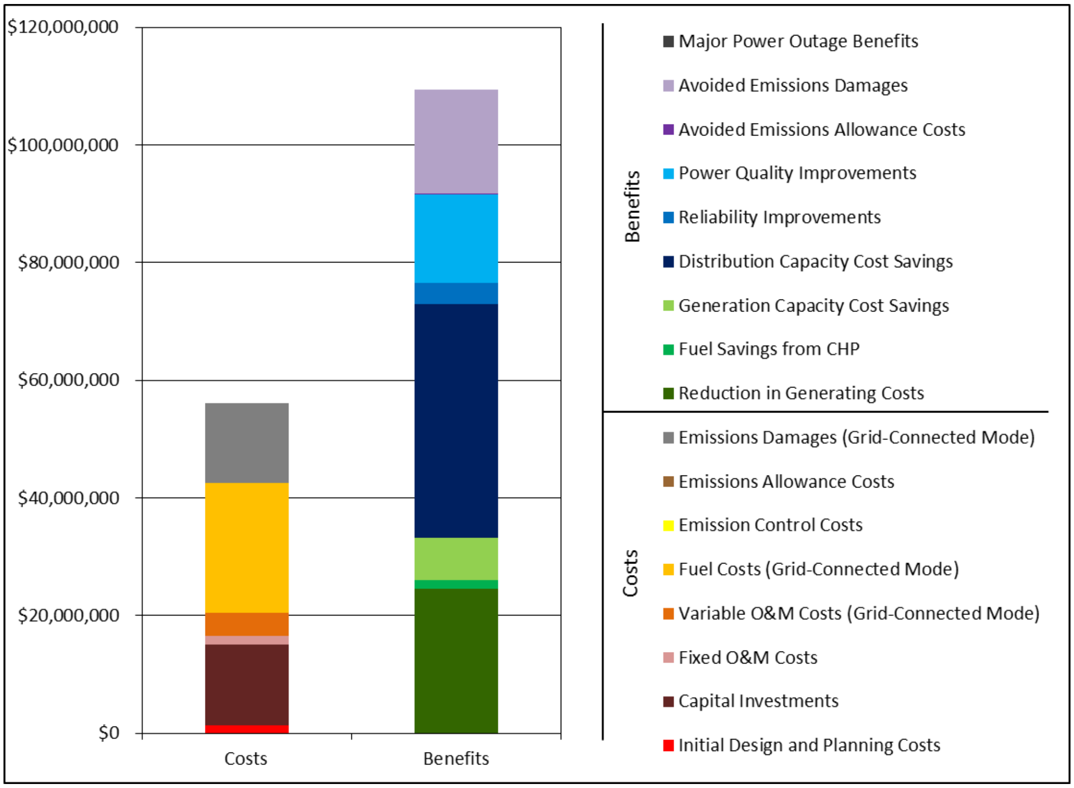

Table3. Detailed BCA Results, Scenario 1B (No Major Power Outages; Avoided Transmission Capacity Upgrade Project; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,390,000	$122,000
Capital Investments	$13,700,000	$1,190,000
Fixed O&M	$1,530,000	$135,000
Variable O&M (Grid-Connected Mode)	$3,820,000	$337,000
Fuel (Grid-Connected Mode)	$22,000,000	$1,940,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$13,700,000	$893,000
Total Costs	**$56,100,000**	
Benefits		
Reduction in Generating Costs	$24,500,000	$2,160,000
Fuel Savings from CCHP	$1,470,000	$130,000
Generation Capacity Cost Savings	$7,220,000	$637,000
Transmission/Distribution Capacity Cost Savings	$39,700,000	$3,510,000
Reliability Improvements	$3,610,000	$319,000
Power Quality Improvements	$15,100,000	$1,330,000
Avoided Emissions Allowance Costs	$11,300	$997
Avoided Emissions Damages	$17,800,000	$1,160,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$109,000,000**	
Net Benefits	**$53,300,000**	
Benefit/Cost Ratio	**2.0**	
Internal Rate of Return	**57.1%**	

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 $1.39 million. The present value of the project's capital costs is estimated at approximately $13.7 million, including the costs of the new natural gas generator ($10.36 million), new CCHP plant ($1.5 million), new solar array ($666,750), new battery storage ($250,000), and $709,060 for microgrid switches and control equipment.

The present value of the microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at $1.53 million (approximately $135,000 annually). These costs include parts, preventative maintenance, and monitoring for all energy resources, as well as software licenses, permitting, and financing fees.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's new generator and CCHP plant. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.[4] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $22 million.

The BCA also considers the project team's best estimate of the microgrid's variable O&M costs (i.e., O&M costs that vary with the amount of energy produced). These costs cover general operations and maintenance; their 20-year present value is estimated to be $3.82 million, or approximately $10.17 per MWh.

In addition, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's fuel-based generators are estimated at approximately $893,000 annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $13.7 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. In Greenport's case, these cost savings would stem both from the production of electricity by distributed energy resources and by a reduction in annual electricity use associated with development of the new CCHP plant.[5] Based on the operating profiles provided by the site team, the photovoltaic arrays and CCHP plant are expected to operate nearly continuously and would provide base load power. In contrast, the new natural gas generator, which would account for approximately 89 percent of the project's annual energy output, is only expected to operate 46 percent of the year, during periods of peak demand. The analysis therefore applies above-average energy values (top 65 percent) to estimate the project's impact on generating costs. The present value of anticipated generating cost savings over a 20-year operating period is estimated to be approximately $24.5 million. The heightened fuel efficiency of the new CCHP system would provide additional cost savings; the BCA estimates the present value of these savings over the 20-year operating period to be approximately $1.47 million. The reductions in demand for electricity from bulk energy suppliers and reduction in the use of fuel for heating and cooling purposes would also reduce emissions of CO_2, SO_2, NO_x, and particulate

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

[5] The project team estimates that installation of the CCHP plant at the Eastern Long Island Hospital would enable the facility to reduce its annual electricity use by 140 MWh.

matter, yielding emissions allowance cost savings with a present value of approximately $11,300 and avoided emissions damages with a present value of approximately $17.8 million.[6]

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity. Based on standard capacity factors for solar resources (20 percent of total generating capacity for photovoltaic solar), the project team estimates the capacity available for the provision of peak load support to be approximately 8.4 MW per year. In addition, the project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by 90 kW as a result of new demand response capabilities. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $7.22 million over a 20-year operating period.

Based on the information provided by the Greenport team, the analysis assumes that development of the microgrid would have no impact on distribution capacity requirements; however, the team indicates that the microgrid would reduce demand for transmission capacity by approximately 8.4 MW per year. As a default, the BCA model does not estimate avoided transmission capacity costs separately from other avoided costs.[7] In this case, however, the project team estimates that the project would contribute to avoiding a specific transmission capacity augmentation project, which would have an estimated cost of approximately $417,000 per MW-year.[8] The analysis therefore presents estimates of the project's transmission capacity benefits using both the model's default values (as presented in Scenario 1A) and using the alternate values associated with the transmission capacity augmentation project that would be avoided by the microgrid (as presented in Scenario 1B). Using the alternate values, the present value of the project's potential transmission capacity benefits is estimated to be approximately $39.7 million.[9]

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, in the form of frequency regulation, reactive power support, and black start support, to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is 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.

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

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

[8] The regional electricity provider, PSEG Long Island, projects a 63 MW transmission deficit in the South Fork of Long Island by 2022. To cover this deficit, they estimate that $298 million in transmission reinforcement projects will need to be built by 2022.Therefore, this analysis assumes that each MW of additional transmission capacity avoids approximately $4.73 million in expenditures by PSEG Long Island. While Greenport is not located on the South Fork of Long Island, existing power plants in Greenport routinely provide peak load support to the South Fork via a dedicated underground 69 kV transmission line that leads into the Buell Substation, an area identified as in need of critical transmission support by 2022. See: https://www.psegliny.com/files.cfm/SFRFP1.pdf and https://www.psegliny.com/files.cfm/Utility20-Document-100614.pdf].

[9] This estimate likely overestimates the true value of the project's transmission capacity benefits because a portion of these benefits is already accounted for in the analysis's estimates of other avoided costs.

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $319,000 per year, with a present value of $3.61 million over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[10]

- System Average Interruption Frequency Index (SAIFI) – 0.48 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 134.4 minutes.[11]

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.[12] 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. It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

It is important to note that the analysis of reliability benefits assumes that development of a microgrid would insulate the facilities the project would serve from outages of the type captured in SAIFI and CAIDI values. The distribution network within the microgrid is unlikely to be wholly invulnerable to such interruptions in service. All else equal, this assumption will lead the BCA to overstate the reliability benefits the project would provide.

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. In Greenport's case, the project team has indicated that the development of the microgrid would enable its customers to avoid approximately three power quality events each year. Assuming that each customer in the proposed microgrid would experience these improvements in power quality, the model estimates the present value of this benefit to be approximately $15.1 million over a 20-year operating period.[13] In reality, some customers for whom power quality is

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[10] www.icecalculator.com.

[11] The analysis is based on SAIFI and CAIDI values for the Village of Greenport's municipal utility.

[12] Where data was not provided by the project team, this analysis used the ICE calculator's default values for NY State.

[13] Importantly, the model relies on average costs per power quality event for customers across the United States, based on a meta-analysis of data collected through 28 studies of electric utility customers between 1989 and 2005. These values reflect the distribution of customers by economic sector in the areas studied, as well as other key characteristics of these customers, such as the percentage equipped with backup generators or power conditioning systems. The characteristics of these customers may not be representative of the characteristics of the customers that would be served by the proposed microgrid. This is likely to be the case for the Village of Greenport. Based on information provided by the site team, Greenport's proposed microgrid will serve few, if any, customers in the construction, manufacturing, and mining sectors, which typically incur the highest costs when power quality is poor. Instead, the proposed microgrid's customers are more likely to fall into the retail and public administration sectors. Power quality costs for facilities in these sectors are likely to be lower than the average values the model employs. [See: Sullivan, Michael J. *et al*. Estimated Value of Service Reliability for Electric Utility Customers in the United States. LBNL-2132E: June 2009.]

important (e.g., medical facilities) may already have systems in place to protect against voltage sags, swells, and momentary outages. If this is the case in Greenport, the BCA may overstate the power quality benefits the project would provide.

Summary

The analysis of Scenarios 1A and 1B yields benefit/cost ratios of 1.2 and 2.0, respectively; i.e., the estimate of project benefits is in both cases greater than that of project costs. Accordingly, the analysis does not consider the potential of the microgrid to mitigate the impact of major power outages in Scenario 2. Consideration of such benefits would further increase the net benefits of the project's development.

APPENDIX B - FACILITY QUESTIONNAIRE

Facility Questionnaire

This questionnaire requests information needed to estimate the impact that a microgrid might have in protecting the facilities it serves from the effects of a major power outage (i.e., an outage lasting at least 24 hours). For each facility, we are interested in information on:

I. Current backup generation capabilities.

II. The costs that would be incurred to maintain service during a power outage, both when operating on its backup power system (if any) and when backup power is down or not available.

III. The types of services the facility provides.

I. Backup Generation Capabilities

1. Do any of the facilities that would be served by the microgrid currently have backup generation capabilities?
   a. ■ No - proceed to Question 4
   b. ☐ Yes - proceed to Question 2

2. For each facility that is equipped with a backup generator, please complete the table below, following the example provided. Please include the following information:
   a. **Facility name:** For example, "Main Street Apartments."
   b. **Identity of backup generator:** For example, "Unit 1."
   c. **Energy source:** Select the fuel/energy source used by each backup generator from the dropdown list. If you select "other," please type in the energy source used.
   d. **Nameplate capacity:** Specify the nameplate capacity (in MW) of each backup generator.
   e. **Standard operating capacity:** Specify the percentage of nameplate capacity at which the backup generator is likely to operate during an extended power outage.
   f. **Average electricity production per day in the event of a major power outage**: Estimate the average daily electricity production (MWh per day) for the generator in the event of a major power outage. In developing the estimate, please consider the unit's capacity, the daily demand at the facility it serves, and the hours of service the facility requires.

g. **Fuel consumption per day:** Estimate the amount of fuel required per day (e.g., MMBtu per day) to generate the amount of electricity specified above. This question does not apply to renewable energy resources, such as wind and solar.

h. **One-time operating costs:** Please identify any one-time costs (e.g., labor or contract service costs) associated with connecting and starting the backup generator.

i. **Ongoing operating costs:** Estimate the costs ($/day) (e.g., maintenance costs) associated with operating the backup generator, excluding fuel costs.

Note that backup generators may also serve as distributed energy resources in the microgrid. Therefore, there may be some overlap between the information provided in the table below and the information provided for the distributed energy resource table (Question 2) in the general Microgrid Data Collection Questionnaire.

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/ Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/day)
						Quantity	Unit		
Eastern Long Island Hospital	*Unit 1*	*Diesel*	*0.500*	*80*	*9.6*	*116.8*	*MMBtu/ Day*	*200.00*	*182.40*

Note: The information in the table is only applicable to the current “pre-microgrid” case. When the microgrid is fully operational in islanded mode, this existing unit will not be needed to meet the microgrid load during the emergency period. The new planned generation units and load curtailment will be more than sufficient to meet the microgrid peak load during emergency. But it will be available for peak load support, when needed.

II. Costs of Emergency Measures Necessary to Maintain Service

We understand that facilities may have to take emergency measures during a power outage in order to maintain operations, preserve property, and/or protect the health and safety of workers, residents, or the general public. These measures may impose extraordinary costs, including both one-time expenditures (e.g., the cost of evacuating and relocating residents) and ongoing costs (e.g., the daily expense of renting a portable generator). The questions below address these costs. We begin by requesting information on the costs facilities would be likely to incur when operating on backup power. We then request information on the costs facilities would be likely to incur when backup power is not available.

A. Cost of Maintaining Service while Operating on Backup Power

3. Please provide information in the table below for each facility the microgrid would serve which is currently equipped with some form of backup power (e.g., an emergency generator). For each facility, please describe the costs of any emergency measures that would be necessary in the event of a widespread power outage (i.e., a total loss of power in the area surrounding the facility lasting at least 24 hours). In completing the table, please assume that the facility's backup power system is fully operational. In your response, please describe and estimate the costs for:

   a. One-time emergency measures (total costs)

   b. Ongoing emergency measures (costs per day)

   Note that these measures do not include the costs associated with running the facility's existing backup power system, as estimated in the previous question.

   In addition, for each emergency measure, please provide additional information related to when the measure would be required. For example, measures undertaken for heating purposes may only be required during winter months. As another example, some commercial facilities may undertake emergency measures during the work week only.

   As a guide, see the examples the table provides.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Eastern Long Island Hospital	Ongoing Measures	OEM Measures - Turn on and check backup power. Notify of issue, send many people home	10,000.0	$/day	In the event of loss of power

Note: The information in the above table is applicable to the current "pre-microgrid" case. If the microgrid is operations, then the new planned generation and load curtailment will be in operation during the emergency period.

B. Cost of Maintaining Service while Backup Power is Not Available

4. Please provide information in the table below for each facility the microgrid would serve. For each facility, please describe the costs of any emergency measures that would be necessary in the event of a widespread power outage (i.e., a total loss of power in the area surrounding the facility lasting at least 24 hours). In completing the table, please assume that service from any backup generators currently on-site is not available. In your response, please describe and estimate the costs for:

   a. One-time emergency measures (total costs)

   b. Ongoing emergency measures (costs per day)

In addition, for each emergency measure, please provide additional information related to when the measure would be required. For example, measures undertaken for heating purposes may only be required during winter months. As another example, some commercial facilities may undertake emergency measures during the work week only.

As a guide, see the examples the table provides.

Please note below: Non-critical loads costs calculated as follows: One time measures-500x$2000=$1,000,000; 500x$2800 per day= $1,400,000 per day.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Eastern Long Island Hospital	*One-Time Measures*	*Hooking up additional portable generator*	4500	$	Year Round
Eastern Long Island Hospital	*Ongoing Measures*	*Renting additional portable generator*	5400	$/day	Year Round
Greenport Waste Water Treatment Plant	*One-Time Measures*	*Hooking up additional portable generator*	2600	$	Year Round
Greenport Waste Water Treatment Plant	*Ongoing Measures*	*Renting additional portable generator*	1700	$/day	Year Round
Suffolk County Water Authority (SCWA)	*One-Time Measures*	*Hooking up additional portable generator*	2600	$	Year Round
Suffolk County Water Authority (SCWA)	*Ongoing Measures*	*Renting additional portable generator*	1700	$/day	Year Round
Greenport High School	*One-Time Measures*	*Hooking up additional portable generator*	2800	$	5 days a week, September-June
Greenport High School	*Ongoing Measures*	*Renting additional portable generator*	1900	$/day	5 days a week, September-June
Greenport Fire Department	*One-Time Measures*	*Hooking up additional portable generator*	2400	$	Year Round
Greenport Fire Department	*Ongoing Measures*	*Renting additional portable generator*	8700	$/day	Year Round
Village Hall	*One-Time Measures*	*Hooking up additional portable generator*	2000	$	Year Round, 5 days a week
Village Hall	*Ongoing Measures*	*Renting additional portable generator*	800	$/day	Year Round, 5 days a week
Service Station: (GMS Grocery - Mr. Roberts Convenience Food Store)	*One-Time Measures*	*Hooking up additional portable generator*	2800	$	Year Round

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Service Station: (GMS Grocery - Mr. Roberts Convenience Food Store)	*Ongoing Measures*	*Renting additional portable generator*	1900	$/day	Year Round
Shelter Island Ferry	*One-Time Measures*	*Hooking up additional portable generator*	2000	$	Year Round
Shelter Island Ferry	*Ongoing Measures*	*Renting additional portable generator*	800	$/day	Year Round
Long Island Rail Road	*One-Time Measures*	*Hooking up additional portable generator*	2000	$	Year Round
Long Island Rail Road	*Ongoing Measures*	*Renting additional portable generator*	800	$/day	Year Round
M&M Auto	*One-Time Measures*	*Hooking up additional portable generator*	2000	$	Year Round, 5 days a week
M&M Auto	*Ongoing Measures*	*Renting additional portable generator*	800	$/day	Year Round, 5 days a week
IGA Grocery	*One-Time Measures*	*Hooking up additional portable generator*	2800	$	Year Round
IGA Grocery	*Ongoing Measures*	*Renting additional portable generator*	1900	$/day	Year Round
Non-Critical Load	*One-Time Measures*	*Hooking up additional portable generator*	1,000,000	$	Year Round
Non-Critical Load	*Ongoing Measures*	*Renting additional portable generator*	1,400,000	$/day	Year Round

III. Services Provided

We are interested in the types of services provided by the facilities the microgrid would serve, as well as the potential impact of a major power outage on these services. As specified below, the information of interest includes some general information on all facilities, as well as more detailed information on residential facilities and critical service providers (i.e., facilities that provide fire, police, hospital, water, wastewater treatment, or emergency medical services (EMS)).

A. Questions for: All Facilities

5. During a power outage, is each facility able to provide the same level of service when using backup generation as under normal operations? If not, please estimate the percent loss in the services for each facility (e.g., 20% loss in services provided during outage while on backup power). As a guide, see the example the table provides.

Facility Name	Percent Loss in Services When Using Backup Gen.
Eastern Long Island Hospital	0%

Note: With the existing or rented backup generators in place, there would not be any loss of service for any of the listed critical facilities during an outage.

6. During a power outage, if backup generation is not available, is each facility able to provide the same level of service as under normal operations? If not, please estimate the percent loss in the services for each facility (e.g., 40% loss in services provided during outage when backup power is not available). As a guide, see the example the table provides.

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
Eastern Long Island Hospital	100%
Greenport Waste Water Treatment Plant	100%
Suffolk County Water Authority (SCWA)	100%
Greenport High School	100%
Greenport Fire Department	40%
Greenport Village Hall	100%
Service Station: (GMS Grocery - Mr. Roberts Convenience Food Store)	100%
Shelter Island Ferry	100%
Long Island Rail Road	100%
M&M Auto	100%
IGA Grocery	100%
Non-Critical Load	100%

B. Questions for facilities that provide: Fire Services

7. What is the total population served by the facility?

4000

8. Please estimate the percent increase in average response time for this facility during a power outage:

100

9. What is the distance (in miles) to the nearest backup fire station or alternative fire service provider?

5 MI

C. Questions for facilities that provide: ***Emergency Medical Services (EMS)***

10. What is the total population served by the facility?

32,000

EMS services provided by Eastern Long Island Hospital

11. Is the area served by the facility primarily:

☐ Urban

■ Suburban

☐ Rural

☐ Wilderness

12. Please estimate the percent increase in average response time for this facility during a power outage:

100%

13. What is the distance (in miles) to the next nearest alternative EMS provider?

22 MI

D. Questions for facilities that provide: ***Hospital Services***

14. What is the total population served by the facility?

32,000

15. What is the distance (in miles) to the nearest alternative hospital?

22 MI

16. What is the population served by the nearest alternative hospital?

200,000

E. Questions for facilities that provide: ***Police Services***

17. What is the total population served by the facility?

18. Is the facility located in a:

☐ Metropolitan Statistical Area

☐ Non-Metropolitan City

☐ Non-Metropolitan County

19. Please estimate:

a. The <u>number</u> of police officers working at the station under normal operations.

b. The <u>number</u> of police officers working at the station during a power outage.

c. The <u>percent reduction</u> in service effectiveness during an outage.

F. Questions for facilities that provide: Wastewater Services

20. What is the total population served by the facility?

3,500

21. Does the facility support:

☐ Residential customers

☐ Businesses

■ Both

G. Questions for facilities that provide: Water Services

22. What is the total population served by the facility?

3,000

23. Does the facility support:

☐ Residential customers

☐ Businesses

■ Both

H. Questions for: Residential Facilities

24. What types of housing does the facility provide (e.g., group housing, apartments, nursing homes, assisted living facilities, etc.)?

Single family

25. Please estimate the number of residents that would be left without power during a complete loss of power (i.e., when backup generators fail or are otherwise not available).

400

APPENDIX C - MICROGRID QUESTIONNAIRE

Microgrid Questionnaire

This questionnaire solicits information on the community microgrid you are proposing for the NY Prize competition. The information in this questionnaire will be used to develop a preliminary benefit-cost analysis of the proposed microgrid. Please provide as much detail as possible. The questionnaire is organized into the following sections:

A. Project Overview, Energy Production, and Fuel Use

B. Capacity Impacts

C. Project Costs

D. Environmental Impacts

E. Ancillary Services

F. Power Quality and Reliability

G. Other Information

If you have any questions regarding the information requested, please contact Industrial Economics, Incorporated, either by email (NYPrize@indecon.com) or phone (929-445-7641).

Microgrid site: 7. Town of Southampton

Point of contact for this questionnaire:

Name: Bob Foxen
Address: 95 Brook Street
Garden City, New York 11530
Telephone: 516-528-8396
Email: bob_foxen@globalcommon.com

A. Project Overview, Energy Production, and Fuel Use

1. The table below is designed to gather background information on the facilities your microgrid would serve. It includes two examples: one for Main Street Apartments, a residential facility with multiple utility customers; and another for Main Street Grocery, a commercial facility. Please follow these examples in providing the information specified for each facility. Additional guidance is provided below.

   - **Facility name:** Please enter the name of each facility the microgrid would serve. Note that a single **facility** may include multiple **customers** (e.g., individually-metered apartments within a multi-family apartment building). When this is the case, you do not need to list each customer individually; simply identify the facility as a whole (see Table 1, "Main Street Apartments," for an example).

- **Rate class:** Select the appropriate rate class for the facility from the dropdown list. Rate class options are residential, small commercial/industrial (defined as a facility using less than 50 MWh of electricity per year), or large commercial/industrial (defined as a facility using 50 or more MWh of electricity per year).
- **Facility/customer description:** Provide a brief description of the facility, including the number of individual customers at the facility if it includes more than one (e.g., individually-metered apartments within a multi-family apartment building). For commercial and industrial facilities, please describe the type of commercial/industrial activity conducted at the facility.
- **Economic sector:** Select the appropriate economic sector for the facility from the dropdown list.
- **Average annual usage:** Specify the average annual electricity usage (in MWh) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from average annual usage for the facility as a whole.
- **Peak demand:** Specify the peak electricity demand (in MW) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from peak demand for the facility as a whole.
- **Percent of average usage the microgrid could support in the event of a major power outage:** Specify the percent of each facility's typical usage that the microgrid would be designed to support in the event of a major power outage (i.e., an outage lasting at least 24 hours that necessitates that the microgrid operate in islanded mode). In many cases, this will be 100%. In some cases, however, the microgrid may be designed to provide only enough energy to support critical services (e.g., elevators but not lighting). In these cases, the value you report should be less than 100%.
- **Hours of electricity supply required per day in the event of a major power outage:** Please indicate the number of hours per day that service to each facility would be maintained by the microgrid in the event of a major outage. Note that this value may be less than 24 hours for some facilities; for example, some commercial facilities may only require electricity during business hours.

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Eastern Long Island Hospital	Large Commercial/Industrial	Hospital	*All other industries*	2,688.000	0.650	100%	24
Greenport Waste Water Treatment Plant	Large Commercial/Industrial	Municipal Building	*All other industries*	552.000	0.097	100%	24
Village of Greenport - Sewer Shed & Garage	Large Commercial/Industrial	Town Building	*All other industries*	24.379	0.019	100%	24
Village of Greenport - WWTP Office	Small Commercial/Industrial	Office Building	*All other industries*	13.944	0.009	100%	8
Suffolk County Water Authority (SCWA)	Large Commercial/Industrial	Municipal Building	*All other industries*	109.500	0.050	100%	24
Greenport High School	Large Commercial/Industrial	School	*All other industries*	357.783	0.105	100%	8
Greenport Fire Department	Large Commercial/Industrial	Town building	*All other industries*	95.400	0.059	100%	24
Greenport Village Hall (Village of Greenport - Village Hall)	Small Commercial/Industrial	Town Building	*All other industries*	17.120	0.006	100%	8
Greenport Village Hall (Village of Greenport - Village Trailer)	Small Commercial/Industrial	Town Building	*All other industries*	25.012	0.007	100%	8
Service Station: (GMS Grocery - Mr. Roberts Convenience Food Store)	Small Commercial/Industrial	Gas Station + Market	*All other industries*	152.960	0.039	100%	12
Shelter Island Ferry (North Ferry)	Small Commercial/Industrial	Transportation	*All other industries*	7.577	0.001	100%	12
Long Island Rail Road (Eastern Terminus-Diesel Powered Rail)	Small Commercial/Industrial	Transportation	*All other industries*	13.990	0.002	100%	24
Greenport Village Hall (Village of Greenport - General Department - LIRR Building)	Small Commercial/Industrial	Town Building	*All other industries*	25.354	0.019	100%	8

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Service Station: Meter A (M&M Auto - Empire Service Station)	Small Commercial/Industrial	Gas Station + market	*All other industries*	15.156	0.007	100%	12
IGA Grocery (Chasmure Supermarket)	Large Commercial/Industrial	Grocery Store	*All other industries*	449.600	0.166	100%	12
Extra Feeder Load[1]	Residential	2,000 residential and commercial customers, excluding critical facilities. Estimated 500 commercial establishments.	*Residential*	28,383,000	5,382	100%	24

2. Extra Feeder Load represents additional non-critical commercial and residential loads connected to the microgrid feeders.

3. In the table below, please provide information on the distributed energy resources the microgrid will incorporate. Use the two examples included in the table as a guide.

- **Distributed energy resource name:** Please identify each distributed energy resource with a brief description. In the event that a single facility has multiple distributed energy resources of the same type (e.g., two diesel generators), please use numbers to uniquely identify each (e.g., "Diesel generator 1" and "Diesel generator 2").
- **Facility name:** Please specify the facility at which each distributed energy resource is or would be based.
- **Energy source:** Select the fuel/energy source used by each distributed energy resource from the dropdown list. If you select "other," please type in the energy source used.
- **Nameplate capacity:** Specify the total nameplate capacity (in MW) of each distributed energy resource included in the microgrid.
- **Average annual production:** Please estimate the amount of electricity (in MWh) that each distributed energy resource is likely to produce each year, on average, **under normal operating conditions.** The benefit-cost analysis will separately estimate production in islanded mode in the event of an extended power outage. **If the distributed energy resource will operate only in the event of an outage, please enter zero.**
- **Average daily production in the event of a major power outage:** Please estimate the amount of electricity (in MWh per day) that each distributed energy resource is likely to produce, on average, **in the event of a major power outage.** In developing your estimate for each distributed energy resource, you should consider the electricity requirements of the facilities the microgrid would serve, as specified in your response to Question 1.
- **Fuel consumption per MWh:** For each distributed energy resource, please estimate the amount of fuel required to generate one MWh of energy. This question does not apply to renewable energy resources, such as wind and solar.

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
Existing Backup Generator	Eastern Long Island Hospital	Diesel	0.500	0.000	0.000	12.167	MMBtu/MWh
PV	High School-existing	Solar	0.250	418.818	1.147	N/A	Choose an item.
PV	Eastern Long Island Hospital	Solar	0.250	418.818	1.147	N/A	Choose an item.
Battery	Moores Lane	Electricity	0.125	182.500	0.500	202.770	kWh
CCHP	Eastern Long Island Hospital	Natural Gas	0.375	3,122.892	4.846	11.374	MMBtu/MWh
Generator	Moores Lane site	Liquefied Natural Gas	7.400	7,400.000	89.900	8.400	MMBtu/MWh

(Note: The existing backup generation is not needed during microgrid islanded operation, due to the sufficiency of additional new generation and load curtailment).

Load Curtailment during emergency is will be based on 65 kW from Eastern Long Island Hospital, 10 kW from Greenport Waste Water Treatment Plant, and 15 kW from IGC Grocery. Same resources will also provide demand response during normal days (please see Table 5).

Note: The Combined Cool & Heat & Power (CCHP) unit is equipped with a 100 kW equivalent absorption chiller.

Absorption Chiller saves 140.296 MWh of electricity, if same cooling load was provided by a central chiller, i.e., the 140.296 MWh is the Electric Cooling Load Offset by absorption chiller which is powered by the recovered heat from CCHP.

Generator notes: Generator powered by 7.4 MW Wartsila dual fuel reciprocating engine. Approximately 1000 hours per year of dispatch, based on NYISO Day Ahead Market Prices, and strike price of $87.83/MWH (assuming fuel cost for LNG of $10/MMBTUs). Average daily energy production based on average use for Greenport Municipal Utility.

B. Capacity Impacts

4. Is development of the microgrid expected to reduce the need for bulk energy suppliers to expand generating capacity, either by directly providing peak load support or by enabling the microgrid's customers to participate in a demand response program?

☐ No – proceed to Question 6

☒ Yes, both by providing peak load support and by enabling participation in a demand response program – proceed to Question 4

☐ Yes, by providing peak load support only – proceed to Question 4

☐ Yes, by enabling participation in a demand response program only – proceed to Question 5

Provision of Peak Load Support

5. Please provide the following information for all distributed energy resources that would be available to provide peak load support:

- **Available capacity:** Please indicate the capacity of each distributed energy resource that would be available to provide peak load support (in MW/year).
- **Current provision of peak load support, if any:** Please indicate whether the distributed energy resource currently provides peak load support.

Please use the same distributed energy resource and facility names from Question 2.

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does distributed energy resource currently provide peak load support?
Backup Generator-existing	Eastern Long Island Hospital	0.400	☐ Yes
PV-existing	High School	0.100	☐ Yes
PV-new	Eastern Long Island Hospital and/or Moores Lane	0.100	☐ Yes
Generator -new	Moores Lane	7.400	
CCHP -new	Eastern Long Island Hospital	0.375	☐ Yes
Battery-new	Moores Lane	0.125	

If development of the microgrid is also expected to enable the microgrid's customers to participate in a demand response program, please proceed to Question 5. Otherwise, please proceed to Question 6.

Participation in a Demand Response Program

6. Please provide the following information for each facility that is likely to participate in a demand response program following development of the microgrid:

- **Available capacity:** Please estimate the capacity that would be available to participate in a demand response program (in MW/year) following development of the microgrid.
- **Capacity currently participating in a demand response program, if any:** Please indicate the capacity (in MW/year), if any, that currently participates in a demand response program.

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently
Eastern Long Island Hospital	0.065	0
Greenport Waste Water Treatment Plant	0.010	0
IGA Grocery	0.015	0

7. Is development of the microgrid expected to enable utilities to avoid or defer expansion of their transmission or distribution networks?

   ☐ Yes – proceed to Question 7

   ☒ No – proceed to Section C

8. Please estimate the impact of the microgrid on utilities' **transmission** capacity requirements. The following question will ask about the impact on distribution capacity.

Impact of Microgrid on Utility Transmission Capacity	Unit
8.5	MW/year

Note: Greenport is in PSEG-LI's East End Load Area, and connects to the Buell Substation in East Hampton via dedicated underground 69kV cable. See transmission diagram at end of Microgrid Questionnaire. The Greenport project will therefore reduce need for peak power or transmission upgrades on the South Fork.

9. Please estimate the impact of the microgrid on utilities' **distribution** capacity requirements.

Impact of Microgrid on Utility Distribution Capacity	Unit
0	MW/year

C. Project Costs

We are interested in developing a year-by-year profile of project costs over a 20-year operating period. The following questions ask for information on specific categories of costs.

Capital Costs

10. In the table below, please estimate the fully installed cost and lifespan of all equipment associated with the microgrid, including equipment or infrastructure associated with power generation (including combined heat and power systems), energy storage, energy distribution, and interconnection with the local utility.

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
Switchgear, transformers, etc.	220,000	30	Microgrid switchgear, transformers, etc.
Generator	11,360,000	20	7,400kW electric only generator, plus LNG storage and re-gasification equipment.
CCHP	1,500,000	20	375KW CCHP unit with 100 kW Absorption Chiller
Solar	666,750	18	Moore's Lane and/or hospital
Battery	250,000	20	125kW batter; 4 hour discharge
Communication & Control	489,060	20	Microgrid communication and control installation

Initial Planning and Design Costs

11. Please estimate initial planning and design costs. These costs should include costs associated with project design, building and development permits, efforts to secure financing, marketing the project, and negotiating contracts. Include only upfront costs. Do not include costs associated with operation of the microgrid.

Initial Planning and Design Costs ($)	What cost components are included in this figure?
1,388,581	Planning and design, development, permitting, financing fees

Fixed O&M Costs

12. Fixed O&M costs are costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces each year (e.g., software licenses, technical support). Will there be any year-to-year variation in these costs for other reasons (e.g., due to maintenance cycles)?

☒ No – proceed to Question 12

☐ Yes – proceed to Question 13

13. Please estimate any costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces each year.

Fixed O&M Costs ($/year)	What cost components are included in this figure?
135,000	Software License upgrades and annual testing; also, FOM for CHP and electric only generation (assumes FOM for electric only is $80,000 per year)

Please proceed to Question 14.

14. For each year over an assumed 20-year operating life, please estimate any costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces.

Year	Fixed O&M Cost ($)	What cost components are included in this figure?
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		

Year	Fixed O&M Cost ($)	What cost components are included in this figure?
20		

Variable O&M Costs (Excluding Fuel Costs)

15. Please estimate any costs associated with operating and maintaining the microgrid (excluding fuel costs) that are likely to vary with the amount of energy the system produces each year. Please estimate these costs per unit of energy produced (e.g., $/MWh).

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
0	$/MWh	Solar installations at Eastern Long Island Hospital and Greenport High School
23	$/MWh	CCHP VOM
$3,83	$/MWh	Generator VOM

Fuel Costs

16. In the table below, please provide information on the fuel use for each distributed energy resource the microgrid will incorporate. Please use the same distributed energy resource and facility names from Question 2.

- **Duration of design event:** For each distributed energy resource, please indicate the maximum period of time in days that the distributed energy resource would be able to operate in islanded mode without replenishing its fuel supply (i.e., the duration of the maximum power outage event for which the system is designed). **For renewable energy resources, your answer may be "indefinitely."**
- **Fuel consumption:** For each distributed energy resource that requires fuel, please specify the quantity of fuel the resource would consume if operated in islanded mode for the assumed duration of the design event.

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
PV	High School	Indefinite	N/A	N/A
PV	Eastern Long Island Hospital	Indefinite	N/A	N/A
Generator 1	Existing Power Plant Area	7	44,755.2	MMBtu
CCHP	Eastern Long Island Hospital	7	385.796	MMBtu
Existing Backup Generator	Eastern Long Island Hospital	7	0.000	MMBtu

17. Will the project include development of a combined heat and power (CHP) system?

☒ Yes – proceed to Question 17

☐ No – proceed to Question 18

18. If the microgrid will include development of a CHP system, please indicate the type of fuel that will be offset by use of the new CHP system and the annual energy savings (relative to the current heating system) that the new system is expected to provide.

Type of Fuel Offset by New CHP System	Annual Energy Savings Relative to Current Heating System	Unit
Fuel oil	10,180	MMBtu
Electricity (by CCHP Absorption Chiller)	140.296	MWh

Note: The Combined Cool & Heat & Power (CCHP) is equipped with a 100 kW equivalent absorption chiller.

Absorption Chiller saves 140.296 MWh of electricity, if same cooling load was provided by a central chiller, i.e., the 140.296 MWh is the Electric Cooling Load Offset by absorption chiller which is powered by the recovered heat from CCHP.

Emissions Control Costs

19. We anticipate that the costs of installing and operating emissions control equipment will be incorporated into the capital and O&M cost estimates you provided in response to the questions above. If this is not the case, please estimate these costs, noting what cost components are included in these estimates. For capital costs, please also estimate the engineering lifespan of each component.

Cost Category	Costs ($)	Description of Component(s)	Component Lifespan(s) (round to nearest year)
Capital Costs ($)	0		
Annual O&M Costs ($/MWh)	0		
Other Annual Costs ($/Year)	0		

20. Will environmental regulations mandate the purchase of emissions allowances for the microgrid (for example, due to system size thresholds)?

☐ Yes

☒ No

D. Environmental Impacts

21. For each pollutant listed below, what is the estimated emissions rate (e.g., tons/MWh) for the microgrid?

Emissions Type	Emissions per MWh	Unit
CO_2	0.30487	Tons/MWH
SO_2	0.000004	Tons/MWH
NO_x	0	NA
PM	0	NA

E. Ancillary Services

22. Will the microgrid be designed to provide any of the following ancillary services? If so, we may contact you for additional information.

Ancillary Service	Yes	No
Frequency or Real Power Support	☒	☐
Voltage or Reactive Power Support	☒	☐
Black Start or System Restoration Support	☒	☐

F. Power Quality and Reliability

23. Will the microgrid improve power quality for the facilities it serves?

☒ Yes – proceed to Question 23

☐ No – proceed to Question 24

24. If the microgrid will result in power quality improvements, how many power quality events (e.g., voltage sags, swells, momentary outages) will the microgrid avoid each year, on average? Please also indicate which facilities will experience these improvements.

Number of Power Quality Events Avoided Each Year	Which facilities will experience these improvements?
3	All facilities on the microgrid

25. The benefit-cost analysis model will characterize the potential reliability benefits of a microgrid based, in part, on standard estimates of the frequency and duration of power outages for the local utility. In the table below, please estimate your local utility's average **outage frequency per customer** (system average interruption frequency index, or SAIFI, in events per customer per year) and average **outage duration per customer** (customer average interruption duration index, or CAIDI, in hours per event per customer).

For reference, the values cited in the Department of Public Service's 2014 Electric Reliability Performance Report are provided on the following page. If your project would be located in an area served by one of the utilities listed, please use the values given for that utility. If your project would be located in an area served by a utility that is not listed, please provide your best estimate of SAIFI and CAIDI values for the utility that serves your area. In developing your estimate, please ***exclude*** outages caused by major storms (a major storm is defined as any storm which causes service interruptions of at least 10 percent of customers in an operating area, and/or interruptions with duration of 24 hours or more). This will ensure that your estimates are consistent with those provided for the utilities listed on the following page.[1]

Estimated SAIFI	Estimated CAIDI
0.76	1.42

SAIFI and CAIDI Values for 2014, as reported by DPS

Utility	SAIFI (events per year per customer)	CAIDI (hours per event per customer)
Central Hudson Gas & Electric	1.62	3.74
ConEdison	0.11	3.09
PSEG Long Island	0.76	1.42
National Grid	1.17	2.87
New York State Electric & Gas	1.34	2.97
Orange & Rockland	1.19	2.4
Rochester Gas & Electric	0.85	2.32
Statewide	*0.68*	*2.7*
Source: New York State Department of Public Service, Electric Distribution Systems Office of Electric, Gas, and Water. June 2015. 2014 Electric Reliability Performance Report, accessed at: http://www3.dps.ny.gov/W/PSCWeb.nsf/All/D82A200687D96D3985257687006F39CA?OpenDocument.		

[1] The DPS service interruption 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 Con Edison's underground network system). SAIFI and CAIDI 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. The BCA model treats the benefits of averting lengthy outages caused by major storms as a separate category; therefore, the analysis of reliability benefits focuses on the effect of a microgrid on SAIFI and CAIDI values that exclude outages caused by major storms.

G. Other Information

26. If you would like to include any other information on the proposed microgrid, please provide it here.

Greenport is part of PSEG-LI's East End Load Area, and connects to the Buell Substation in East Hampton via a dedicated 69kV underground cable. This will allow the Greenport microgrid project to reduce the need for new peaking power or transmission upgrades needed to serve the South Fork, since power dispatched by the Greenport DERs, could be sent to the South Fork, or free up power from the Global Common plant also located on Moores Lane in Greenport. If you zoom in on the diagram below, you can observe that the existing 51 MW Global Common peaking plant on Moores Lane in Greenport supplies energy for the South Fork via this same 69kV cable across Shelter Island. The need for additional peaking power and/or transmission upgrades is documented in PSEG-LIs 2015 SF RFP.