10 - Town of North Hempstead (Port Washington)

August 2016

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Port Washington Community Microgrid

Final Report – NY Prize Stage 1: Feasibility Assessment

Submitted to:
NYSERDA
17 Columbia Circle
Albany, NY 12203-6399

Submitted by:
The Town of North Hempstead
Hitachi Microgrids
Johnson Controls, Inc.
The National Renewable Energy Laboratory

April 2016

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PROJECT TEAM

North Hempstead

- Erin Reilley, Chief Sustainability Officer– Community Project Lead
- Dina DeGiorgio, Town Councilwoman

Residents for a More Beautiful Port Washington

- Tom Havens
- Roy Smitheimer

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- Erica Hauver
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- Josh Patten
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- Alan Houghton
- Derek Price

National Renewable Energy Laboratory

- Samuel Booth

Pace University

- Jordan Gerow

PROJECT STAKEHOLDERS

- North Hempstead Government (Town of North Hempstead)
- Landmark on Main Street Senior Housing
- Port Washington Union Free School District
- Port Washington Public Library
- Port Washington Fire Department
- Port Washington Water District

PORT WASHINGTON COMMUNITY MICROGRID - KEY OVERVIEW METRICS

Team

Lead (Awardee):	The Town of North Hempstead
Technical Lead:	Hitachi Microgrids
Additional Consultants:	National Renewable Energy Laboratory, Johnson Controls, Inc., Pace University Law School

Utilities

Electric:	PSE&G Long Island/Long Island Power Authority
Gas:	National Grid

Microgrid System Design

Size:	926	kW
Load Served:	4,957,372	kWh/yr

DER	Qty	Capacity
Combined Heat & Power:	11	616 kW
Photovoltaic:	6	310 kW
Existing Photovoltaic:	1	40 kW
Energy Storage Systems:	10	150 kWh
Existing Emergency Gen:	7	1,712 kW

Microgrid Financials*

Total Installed Cost:	$ 4,347,000
Net Cost (after ITC deduction):	$ 3,596,000
Resiliency Savings:	$ 351,877/yr
GHG Offset:	$ 42,000/yr
Current Avg Cost of Electricity :	$ 0.164/kWh

**Estimates based on financial modeling*

Supporting Organizations

- Town of North Hempstead
- Port Washington Fire Department
- Port Washington Union Free School District
- Town of North Hempstead Animal Shelter
- The Landmark on Main
- Port Washington Library
- Port Washington Water District

Customer Types

Gov't Administrative:	2
Emergency Services:	3
Municipal Services:	1
Education	2
Health Care:	1
Large Commercial:	4
Small Commercial:	12**
Multi-Unit Residential:	1
Total:	**24**

***Potential participants*

Electric Demand & Consumption with Microgrid

	Max kW	Avg kW	kWh / yr
Node 1	700	123	1,078,244
Node 2	1,969	424	3,715,034
Node 3	19	2	21,845
Node 4	48	10	88,694
Node 5	76	6	53,555
Total	**2,812**	**566**	**4,957,372**

Benefit Cost Analysis Outputs

	Scenario 1	Scenario 2
Days of Major Outage	0 days/yr	0.7 days/yr
Total Benefits**	$ 6,630,000	$ 12,000,000
Total Costs**	$ 11,600,000	$ 11,600,000
Net Benefits**	$ -4,990,000	$ 361,000
Benefit/Cost Ratio	0.6	1.0

***Net Present Value*

EXECUTIVE SUMMARY

The New York State Energy Research and Development Program (NYSERDA) established the New York Prize program to stimulate adoption and deployment of community microgrids throughout the state to:

- Reduce energy costs
- Increase the reliability of the power supply and community resilience
- Promote cleaner sources of energy

This report describes the results of Stage 1 of the NY Prize Feasibility Assessment for the Port Washington Community Microgrid. Hitachi Microgrids worked with Johnson Controls and the National Renewable Energy Laboratory (NREL) to develop the microgrid design based both on NYSERDA's requirements and the specific needs and priorities of community stakeholders. The design was developed using an iterative process that supports optimization of the design based on cost, emissions, and resilience goals. The Town of North Hempstead led the feasibility assessment. Various community organizations and partners, including the future customers of the Port Washington Community Microgrid, lent additional support.

Community Overview

Port Washington is a hamlet on the north shore of Long Island and is directly governed by the Town of North Hempstead. The hamlet serves as the terminus of the Port Washington branch of the Long Island Rail Road, and many of the public services within serve the entire peninsula. This coastal community was hit hard by Hurricane Sandy in 2012 and has made improving energy resilience a local priority since then.

The Port Washington Community Microgrid is focused in two main nodes – the first including the Landmark on Main Street, the library and two fire stations, and the second centered on the high school and middle school. Three tertiary nodes pick up loads at other critical facilities, including the water district, the Fire Department headquarters and the Town of North Hempstead animal shelter.

Community Requirements and Microgrid Capabilities

The Port Washington Community Microgrid is designed to meet specific needs within the community. These include the need to harden infrastructure against storm damage and power outages, and to ensure the safety of vulnerable populations.

First, the Port Washington Community Microgrid is designed to harden infrastructure against damage, particularly that caused by increasingly frequent severe weather events. The microgrid provides reliable power to facilities housing critical first responders in the community. The microgrid will also power local schools to prevent students from missing class and parents/guardians from missing work during a grid outage. One of these schools is designated as a Red Cross Emergency Shelter, and both could be used as emergency shelter space should the need arise.

The microgrid is also designed to protect the safety and welfare of the most vulnerable populations in Port Washington. The Landmark on Main Street is a senior housing facility with 59 separate units. This facility currently does not have a backup generator and its residents cannot easily relocate in the case of power outage. The North Hempstead Animal Shelter houses an entirely different at-risk population. The animals housed at this facility would be difficult to relocate in an outage, and the Shelter accepts animals from the entire County in times of emergency

The Port Washington Community Microgrid is designed to address these resiliency needs with clean, efficient, and cost effective technologies and architecture. Energy produced by the microgrid will reduce greenhouse gas (GHG) emissions.

The microgrid is also designed to provide some benefit to the utility. The site of the microgrid is within an Opportunity Zone for NY Prize and in an area in need of congestion reduction, as identified by PSE&G Long Island. In addition to bringing new distributed generation onto the grid, the microgrid will facilitate participation in PSE&G LI's demand response programs, which will help the utility to cost effectively meet peak demands.

Technical Design

Analysis of the Port Washington Community Microgrid design indicates that the project is technically viable and meets the community's requirements with commercially available and proven technologies.

The proposed design for the Port Washington Community Microgrid is based on the strategic placement of microgrid resources among the included facilities. The resources in the microgrid design include solar photovoltaics (PV), natural gas powered combined heat and power (CHP), energy storage systems (ESS), and existing backup generators. No new backup generators will be installed. The microgrid resource selection is based on Hitachi's *Microgrid Portfolio Approach* to microgrid design*.* This approach uses a careful analysis of energy requirements and the electric load profile of all covered facilities to determine optimal size and specification of distributed energy resources (DER). The goal of this approach is to enable microgrid resources to serve the microgrid loads more efficiently, more cost effectively, and with lower emissions per unit of energy consumed.

Under this strategy, base-load CHP will be designed to run its design output for a majority of the hours per year. All critical facility services can be provided by a set of continuously operating microgrid resources operating in conjunction with the grid for the majority of hours in a year. To meet the load that varies above the base load, PV and ESS will be integrated into the system. ESS are specified based on their capability to address PV intermittency support, PV load shifting, peak shaving (to manage utility imports), supporting CHP loading, and stabilize island mode operations. The design also incorporates active microgrid controls that enable optimal operation of energy storage, PV, and building management systems to manage load and reduce the afternoon peak load when needed.

The microgrid is designed to include critical facilities located throughout the Port Washington community. In order to include non-adjacent facilities, the design is based on five separate nodes, each of which have their own microgrid resources and are able to island individually. In grid connected mode, the resources will be dispatched to minimize costs and emissions. The table below, which also appears in the report that follows, summarizes the DER, new and existing, that will be included in the proposed microgrid design.

Executive Summary Table 1 - Microgrid Resources Comparison

Node	Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW
1	Business as Usual	700	1	40	-	-	-	-	3	165
	Microgrid	572	5	130	3	25/50	5	100	3	165
2	Business as Usual	1,969	-	-	-	-	-	-	-	-
	Microgrid	1,402	1	150	4	35/70	2	496	-	-
3	Business as Usual	19	-	-	-	-	-	-	1	22
	Microgrid	4	-	-	1	5/10	1	5	1	22
4	Business as Usual	48	-	-	-	-	-	-	2	1,400
	Microgrid	33	1	30	1	5/10	1	5	2	1,400
5	Business as Usual	76	-	-	-	-	-	-	1	125
	Microgrid	39	-	-	1	5/10	2	10	1	125

Executive Summary Table 2, which also appears in the body of this report, gives an overview of the normal operation of the proposed microgrid design in terms of electricity demand and consumption, thermal load, and thermal recovery (through new CHP systems) by node.

Executive Summary Table 2 - Microgrid Energy Overview: Grid Connected Operation

	Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
Node	Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
1	700	123	1,078,244	89,854	10,285,589	857,132	1,813,534	151,128
2	1,969	424	3,715,034	309,586	20,898,746	1,741,562	9,684,143	807,012
3	19	2	21,845	1,820	315,081	26,257	78,779	6,565
4	48	10	88,694	7,391	600,812	50,068	110,945	9,245
5	76	6	53,555	4,463	709,868	59,156	180,112	15,009
Total	**2,812**	**566**	**4,957,372**	**413,114**	**32,810,097**	**2,734,175**	**11,867,513**	**988,959**

The microgrid controller will operate the microgrid to maximize economic benefits, minimize emissions, and maximize reliability of service in the event of a fault on the grid. The microgrid controller will also track the hours of operation of each microgrid resource, and will employ a predictive maintenance strategy to schedule maintenance before any failure occurs and dispatch a technician in the event of an alarm. As the microgrid operates, a history of performance, trending, and signature analyses will develop, adding to the microgrid's ability to anticipate and avoid failures.

The ability of the Port Washington Community Microgrid to provide critical facilities with an uninterrupted supply of electricity and heat during power outages depends on successful transitions into and out of "island mode." Island mode refers to the mode of operation in which the microgrid disconnects from the utility grid and powers critical facilities solely from on-site resources.

The microgrid controller will manage all microgrid resources for island mode operational and performance objectives. The microgrid design ensures a seamless transition into and out of island mode operation. The microgrid controller will have the capability to provide information to the electric utility.

Financial Feasibility

The project team developed a budget estimate for the Port Washington Community Microgrid project and incorporated it into the technical model to ensure that the design meets both the technical and economic requirements of the project. This budget includes costs for engineering, permitting, capital equipment, site preparation, financing, construction, controls, start-up, commissioning, professional services and training. The budget also includes costs for some of the energy efficiency measures which were identified at facilities to be included in the microgrid. The cost for these efficiency measures is approximately $110,000. The cost associated with "site preparation" includes the addition and modification of electrical infrastructure, PCC controls, monitoring, and protection equipment. Some of these infrastructure costs may be paid to the electric utility. The estimated installed cost for this project is $4,347,000 with an accuracy of +/- 25% (within the +/- 30% set by NYSERDA). The net cost with the federal investment tax credit (ITC) that was recently extended by the US Congress is $3,596,000. This cost does not include other incentives that may be applicable to the project that would be applied during the detailed analysis in Stage 2.

The outputs of the technical modeling process described above were used to evaluate the financial viability of the proposed microgrid from two perspectives. First, the project team analyzed the financial strength of the project when deployed under a model in which the microgrid is owned by a special purpose entity (SPE) eligible to claim the federal investment tax credit. Under this model, the project is funded through external investment and debt which is recouped through a power purchase agreement (PPA) with each facility. In addition, NYSERDA contracted with Industrial Economics, Incorporated (IEc) to perform a benefit-cost analysis. The focus of this analysis is to evaluate the societal benefit of the microgrid, including benefits from emissions reductions, cost reductions, and resilience improvements.

Business Model Financial Results: Under the SPE business model, external parties would fund all development and construction of the microgrid, own and operate the assets, and sell the energy generated from the microgrid to community customers through PPAs. The microgrid off-takers would incur no costs to build the project and would receive all of the benefits of energy resilience during a grid outage, and improved sustainability. The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately $0.164/kWh. Based on assumed project financing costs, and the 25 year contract term, the study supports a PPA electric rate approximately equal to the current average blended rate paid by microgrid participants of 16.4 cents per kilowatt hour.

Benefit-Cost Analysis Results: NYSERDA contracted with IEc to conduct a benefit-cost analysis. The project team provided detailed information to IEc to support this analysis. IEc ran two scenarios for this proposed microgrid. The first scenario modeled no power outages, and evaluated the grid connected mode of operation. The second scenario modeled the number of days (or partial days) outage at which the costs of the microgrid would be equal to its various benefits, thus yielding a cost benefit ratio of 1. For the Port Washington Community Microgrid, the breakeven outage case is 0.7 days of major power outage per year. The cost benefit results are presented in Executive Summary Table 3.

Executive Summary Table 3 – Cost Benefit Analysis Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 0.7 DAYS/YEAR
Net Benefits - Present Value	-$4,990,000	$361,000
Total Costs – Present Value	$11,600,000	$11,600,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	N/A	7.8%

This benefit-cost analysis differs from the financial feasibility analysis performed by the project team in several ways. In addition to the differing objectives of these two analyses, the underlying assumptions used in each also differed. A few of these differences affected the results of these analyses in significant ways, including:

- Gas rates used in IEc's benefit-cost analysis were based on a state-wide average for commercial end-use customers. The rates used in Port Washington's financial feasibility analysis are based on available rate data from National Grid, and assumptions about likely discounts associated with CHP deployments (based on experience with other New York utilities). This resulted in year 1 gas rates of $6.34 and $4.30, for the benefit-cost analysis and the financial feasibility analysis, respectively. If National Grid's distributed generation rate were applied to the benefit-cost analysis, net benefits would be increased by $990,000.
- The financial feasibility assessment incorporates the tax benefits of the Federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit reduces the capital cost of the project by $751,000.
- Capital replacement costs used in the benefit-cost analysis BCA were calculated as a full replacement costs, whereas the project team assumed a 'rebuild' cost that is not equal to the full cost of replacement. The rebuild cost for the Port Washington Community Microgrid is $480,000 less than the full cost of replacement.

- The benefit-cost analysis derives a price for electricity based on average wholesale energy costs, whereas the financial feasibility assessment evaluates the savings to the community based on actual costs paid by community participants.
- The period of analysis in the benefit cost analysis is 20 years and the third party ownership model is based on a period of analysis of 25 years.

The entirety of the IEc analysis can be found in Appendix D of this report.

Conclusions and Next Steps

The NY Prize feasibility assessment indicates that the Port Washington Community Microgrid is technically viable, and may be economically viable, assuming the willingness of microgrid participants to pay a rate for electricity at or slightly higher than their current rate. Economic viability strengthens if future grants are awarded from NYSERDA in NY Prize Stages 2 and 3 (and if other incentives for microgrid technologies are incorporated into the project financial analysis). The microgrid will protect the operation of critical facilities in the two primary nodes, ensuring that many community services for vulnerable populations and the community at large can continue uninterrupted, while the schools can be used as emergency shelters. Additional microgrid nodes will protect other important facilities and functions including the hamlet's water district and animal shelter.

The Port Washington Community Microgrid is designed to directly address the vulnerabilities associated with the hamlet's location, hardening the hamlet's infrastructure and making services more resilient. This project should yield considerable lessons for other communities threatened by storms and flooding from their proximity to water and can serve as a model for similar microgrids around the state and across the country.

Key findings from the NY Prize feasibility assessment include:

1. ***Engaged Stakeholders***: The larger loads in the Port Washington Community Microgrid are all at facilities and institutions that are well established, and committed to the project, including many that are directly managed by municipal government entities. This commitment by municipal leadership strengthens the proposal, but also restricts the financial parameters of the project, since municipal entities will be unable or unwilling to pay a premium for electricity
2. ***Many Small Distributed Systems***: The fact that the microgrid includes several nodes, and that several of them are quite small, contributes to a higher total installed cost.
3. ***Natural Gas Costs***: The cost of natural gas for CHP is not firm. The estimate that the project team used for the financial analysis was made using available data from National Grid and assumptions based on distributed generation discounts from other New York utilities. However, going forward, the project team will need to work closely with National Grid to establish a final, firm natural gas rate for the CHP installations included in the microgrid plan.

4. ***Community Microgrid Financing Costs***: The cost of project financing is high for community microgrids. This is due to the fact that there are numerous stakeholders and potential customers, and that each stakeholder has its own procurement requirements. The project team will need to seek out a financier that is knowledgeable about these projects, and can help keep transaction costs to a minimum.
5. ***Financial Prospects:*** As modeled, the Port Washington Community Microgrid project is likely to meet the financial requirements for third party financing and/or ownership assuming that all currently proposed microgrid participants are willing to pay for electricity at a cost that is at or slightly above their current rate. In order to strengthen the prospects for stakeholder participation and for securing financing on reasonable terms for the microgrid project, one or more of the following would be desirable:
    a. The award of Stage 2 and Stage 3 NY Prize grants from NYSERDA
    b. The inclusion of additional commercial customers with higher electric costs
    c. Removal of smaller facilities and nodes
    d. The use of PPA rates above the current average cost of energy.

The next steps that the Port Washington community will need to undertake are to finalize the ownership structure to be proposed, and identify a team of partners to engage in the detailed design phase of the project.

Port Washington Community Microgrid
Final Report – NY Prize Stage 1: Feasibility Assessment

TECHNICAL DESIGN

The proposed microgrid solution will focus on community resiliency based on distributed resources co-located at or near the critical facilities serving the community emergency response and elderly, student, and animal populations of Port Washington. The strategy is to develop a community microgrid that consists of multiple site-specific microgrids that that may or may not be connected from an electrical perspective but are controlled as a single entity. One of the challenges of community microgrids is that the facilities and the microgrid resources are distributed. To maximize the economics, reliability, and emissions reduction potential of the community microgrid, the microgrid controller architecture must have the capability to coordinate and control different groups of resources as well as provide control for localized operations.

A screening process was developed and implemented to select the best sites for the microgrid based upon a set of criteria. The proposed microgrid will include fire stations, schools, senior housing, water treatment, and an animal emergency center. Collectively, there are a total of 5 "nodes" that make up the Port Washington Community Microgrid.

The five Port Washington nodes and included facilities and functions are listed in the table below.

Table 1 – Overview of Microgrid Nodes

Microgrid Node #	Facilities	Functions
1	• Port Washington Public Library • Landmark on Main Street • Protection Fire Engine Company No. 1 • Atlantic Hook and Ladder Company	• Community Services • Fire and Emergency Response • Senior Housing
2	• Paul D. Schreiber High School • Carrie Palmer Weber Middle School • School Administration Building • Bible Church of Port Washington (potential participant) • Port Washington Commercial Businesses (potential participants – includes a pharmacy and bank with ATM)	• Education • Emergency Shelter • Community Services
3	• Port Washington Fire Department Headquarters	• Fire and Emergency Response
4	• Port Washington Water District	• Water Treatment
5	• North Hempstead Animal Shelter	• Animal Medical Services and Emergency Shelter

The utility feeders are mainly overhead lines, which cannot be relied upon in the event of a major storm. The microgrid design employs underground cabling to support each microgrid node in key areas where it is cost effective for the overall project. While this greatly improves resiliency within a microgrid node, the cost of the underground cabling limits the reach of the node. The same general protection schemes are employed in each microgrid node as are used in utility distribution networks. Some pole-top transformers will be replaced with pad-mount distribution transformers, and additional isolating switches and breakers will be added at the PCC.

Table 2 – Community Stakeholders to Benefit from the Microgrid

Organization	Benefits from Port Washington Community Microgrid
PSE&G Long Island and LIPA	By serving the local load and providing resilient energy, the system will allow the utilities to delay potential investments in the existing substation equipment. This system will also help the utility meet its customer-sited renewable energy target under New York's proposed Clean Energy Standard.
Long Island Regional Economic Council	Improved local energy resilience may be a positive factor in attracting new businesses to the area. The system will also help demonstrate how an investment like this can help other businesses and communities in the area to achieve their resilience and sustainability goals.
Port Washington Crisis Relief Team	The microgrid will ensure critical facilities are powered in the case of grid outage. This will give the Crisis Relief Team access to shelters and command facilities that they might not be able to utilize otherwise.
Residents of Port Washington	The microgrid will ensure critical facilities are powered in the case of grid outage. This will give the residents of Port Washington access to shelters and potentially to retail that they might not be able to utilize otherwise.
Town of North Hempstead Department of Public Safety	The microgrid will ensure critical facilities are powered in the case of grid outage. This will give the Department of Public Safety access to shelters and command facilities that they might not be able to utilize otherwise.
Greater Port Washington Business Improvement District	Improved local energy resilience may be a positive factor in attracting new businesses to the area. The system will also help demonstrate how an investment in a microgrid can help other businesses and communities in the area to achieve their goals.
Port Washington Chamber of Commerce	Improved local energy resilience may be a positive factor in attracting new businesses to the area. The system will also help demonstrate how an investment in a microgrid can help other businesses and communities in the area to achieve their goals.

Key Features of the Microgrid

Community Microgrid Controller

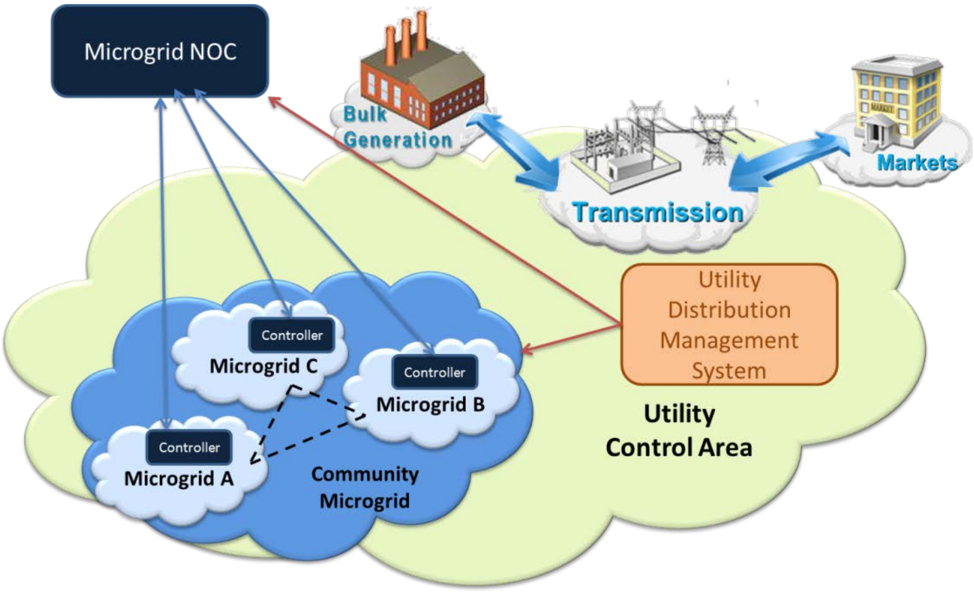
One of the challenges of community microgrids is that the facilities and the microgrid resources are distributed. To maximize the economics, reliability, and emissions reduction potential of the community microgrid, the microgrid controller architecture must have the capability to coordinate and control different groups of resources as well as provide control for localized operations.

The Hitachi team has developed a project concept for the community microgrid that allows for simultaneous control of multiple microgrids in the community as well as coordination with the local utility. Specifically, the solution includes local controllers in each microgrid part as well as a hosted controller in the Microgrid network operating center (NOC) that can operate each microgrid part separately or collectively.

In the grid-connected mode, the primary operations will focus on maximizing economic benefits and minimizing emissions across all the microgrids within the community. In some cases, the aggregation of the microgrid resources can be leveraged to support utility firming request and/or RTO/ISO ancillary services such as demand response and frequency regulation. However, during a reliability event, the operation of each individual microgrid controller will focus on the load and generation assets only within its control. The local controller will transition to island mode while maintaining proper voltage and frequency.

Figure 1 presents the Hitachi team's design approach for the community microgrid controller architecture.

Figure 1: Project Concept for Community Microgrid



The microgrid controller will have an active management and control architecture that supports the 10 EPRI/ORNL Use Cases:

1. **Frequency control**: In normal operations, the microgrid may not have enough resources to affect frequency on the grid. It could participate in the ancillary services markets by increasing output to support the frequency in the local grid, but total impact would be small. Nevertheless, the system will monitor frequency along several thresholds, providing a discrete high-low range; the system will detect if frequency is out of range and respond by taking resources off-line or dispatch other resources to manage frequency. Also, the system will analyze data to detect subtler trends that do not exceed thresholds but provide evidence of a possible problem.
2. **Voltage control**: In both grid-connected and islanded modes, the voltage control application will be used to provide stability to the microgrid and connected circuits. Voltage control leverages line sensing and metering to provide control actions when necessary. This application will take into account traditional volt/VAr instruments such as tap changers and cap banks along with inverter-based resources, which should provide a greater degree of optimization.
3. **Intentional islanding**: For each microgrid node, the islanding process will be semi-automatic so that a utility operator or local energy manager will be able to move through each step before opening the PCC. The utility operator will provide the appropriate permissives for opening the PCC. The local microgrid controller for each microgrid node will be responsible for setting the voltage source and load following resource.
4. **Unintentional islanding**: The designed PCC structure, coupled with additional analysis compliant with IEEE 1547.4, enables the utility-controlled breaker or switch to immediately open (frequency = 59.3 Hz) on loss of the grid. The microgrid managed synchronizing breaker will remain closed for a few more milliseconds until microgrid frequency reaches 57.0 Hz. Since the inverters and generator controls are keying off the synchronizing breaker, these few additional milliseconds enable the energy storage and power electronics to better manage the transient as the microgrid resources pick up the portion of the load served by the utility grid just before the grid was lost. When, or if, the frequency dips to 57.0 Hz and the synchronizing breaker opens, the microgrid will move into island mode. The microgrid controller will adjust all microgrid resources for the new state and island performance objectives.
5. **Islanding to grid-connected transition**: As with intentional islanding, the utility operator will provide the appropriate permission to close in the PCC. The local microgrid controller will support the reconfiguration of each dispatchable resource.
6. **Energy management**: The microgrid design incorporates a portfolio of resources. The EPRI Use Case takes a traditional energy management approach– economic dispatch, short-term dispatch, optimal power flow, and other processes typical in utility control room environments. The microgrid controller will have corresponding applications that manage a set of controllable generation and load assets. Within that portfolio, the system will also optimize the microgrid based on load forecast, ancillary services events, changes in configuration, outage of specific equipment, or any other kind of change to determine the optimal use of assets 48 hours ahead.

7. **Microgrid protection**: The microgrid controller will ensure two primary conditions. The first is that each protection device is properly configured for the current state of the microgrid, either islanded or grid-connected. The second condition is that after a transition, the microgrid controller will switch settings or test that the settings have changed appropriately. If the test is false in either condition, the controller will initiate a shutdown of each resource and give the appropriate alarm.
8. **Ancillary services**: The controller will provide fleet control of the nested microgrid parts. Specifically, the utility operation will have the ability to request and/or schedule balance up and balance down objectives for the fleet. The cloud-based controller will take the responsibility to parcel out the objectives for each microgrid part based on the available capacity.
9. **Black start**: The local microgrid controller will provide a workflow process for restarting the system. Each microgrid part will have a unique sequence of operations for predetermined use cases. One objective will be to provide this function both locally and remotely to meet the reliability requirements of the overall design.
10. **User interface and data management**: The solution provides local controllers in each microgrid part as well as a hosted controller that can operate each microgrid part separately or collectively. The primary actors are the utility operator, local energy managers, maintenance personnel, and analyst. The user experience for each actor will be guided by a rich dashboard for primary function in the system around Operations, Stability, Ancillary Services, and Administration.

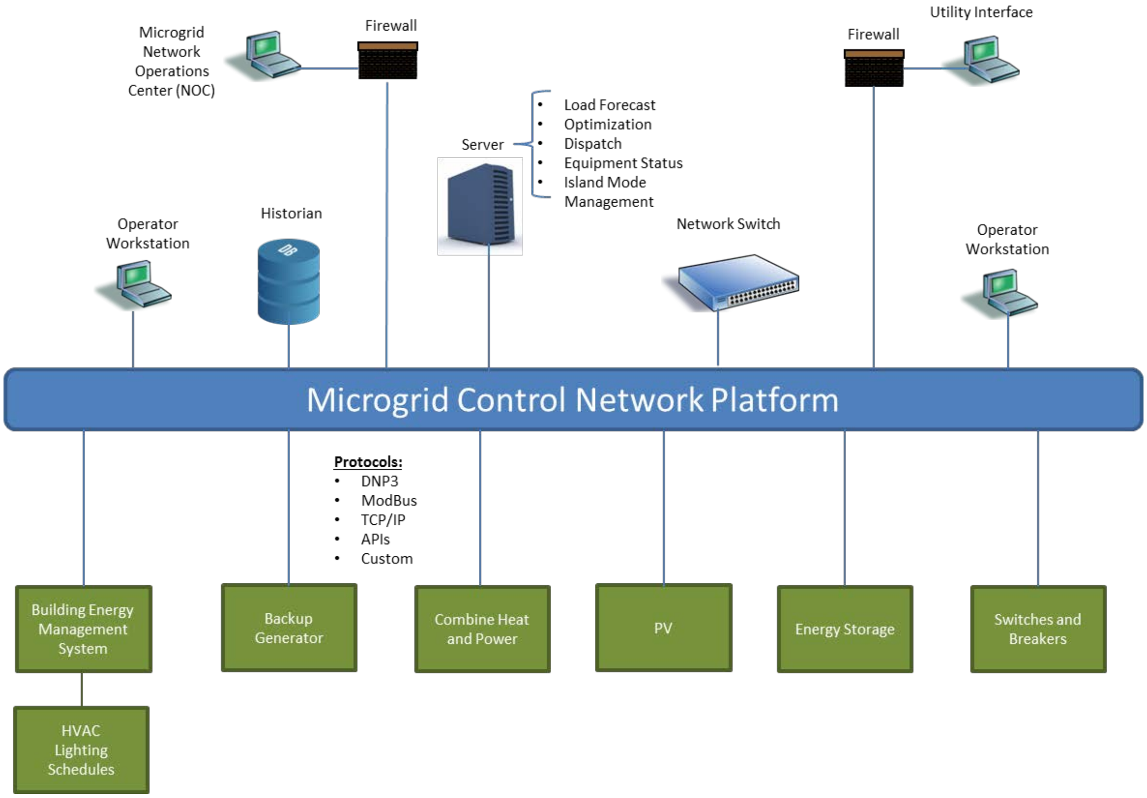
In addition, the microgrid controller will:

- Forecast variable aspects: load, solar, storage
- Dispatch of DER to maximize economic benefit
- Continuously monitor and trend health of all system components
- Take into account utility tariffs, demand response programs, and ancillary service opportunities
- Understand operational constraints of various DER and vendor-specific equipment
- Interface to local utility
- Meet rigid and proven cyber security protocols

Ultimately, the control system will perform all of the functions above to continuously optimize the operation of the microgrid for economic, resiliency, and emissions performance.

A microgrid controller design needs to be reliable and have redundancy comparable to the other microgrid resources. A standard controller approach such as central controller or PLC design will therefore not be sufficient. The architecture must support the capability to interface with field devices, provide a platform for communications and data management, provide for both local and remote operator access, have a data historian, and provide for applications to meet the microgrid Use Cases highlighted above. A conceptual controller topology is presented in Figure 2.

Figure 2 – Conceptual Microgrid Controller Topology



To support the community node approach, the microgrid control scheme will provide for a secure external access to the NOC that can coordinate the various nodes within the community. In addition, remote access to the utility will be provided to inform them and their distribution operators of the microgrid status and to communicate protection relay permissives for the island-mode transitions. The system will be designed so the core control functions are located within the microgrid and so that loss of communication with the NOC will not significantly impact the local operations of any node. The NOC monitors equipment performance and coordinates across nodes. In the event of an outage, all control will move to local controllers and focus on site specific optimization and operations.

The microgrid controller will leverage existing equipment to the greatest extent possible. This will include building energy management systems, backup generators, and local area networks. For the purposes of reliability and security, the microgrid control system will consist of new and independent infrastructure.

Telecommunications Infrastructure

Each microgrid node will have a wireless LAN specific to the microgrid, powered by microgrid resources, and extended to every resource, device, sensor, and load interface (e.g., building management system). This communications infrastructure will be designed with dual-redundant access points to ensure reliable onboard communications.

The architecture will conform to requirements established by the SGIP and generally accepted communications protocols, such as ModBus (TCP/IP), DNP3 (TCP/IP), and 61850, as well as field networks for buildings such as LonWorks and BACnet. ModBus will be used throughout the microgrid nodes for communications, as it is currently the most prominent communications protocol within the DER and inverter community. Communications with the utility distribution management systems will use DNP3, as that is the prominent protocol used by the utility industry.

In addition, the NIST IR 7628, "Guidelines for Smart Grid Cyber Security," will be followed in the architecture and design of the microgrid controls' IT and communications to ensure security and continuity of operations in all modes. Finally, the IT/telecommunications infrastructure will be new to secure the microgrid controls network separately from existing IT and communications systems at the facilities.

Communications – Microgrid and Utility

Communications between the microgrid and the utility will occur in two forms: (1) utility DMS will interface with the microgrid controls for monitoring and managing the PCC utility-controlled isolating switch and microgrid-controlled synchronizing breaker, and (2) a dashboard served by the microgrid controls to the utility via the internet will give the utility insight into the day to day operations of the microgrid.

In accordance with the EPRI/ORNL Microgrid Use Case 4, the microgrid will transition into island-mode operations upon loss of communications between the utility DMS and the microgrid, assuming loss of grid. No specific microgrid action will be taken on loss of the utility dashboard service via the Internet.

The microgrid control system will be local to the microgrid node in a secure, conditioned space, (e.g., electrical room) in one of the critical facilities within the microgrid node. This ensures that real-time control of the microgrid resources and loads will be maintained in the event of a loss of communications with the utility DMS and Internet services. Although economic optimization will be reduced for a period of time, the reliability and resiliency optimization will be maintained because those algorithms are in the microgrid control system local to the microgrid node and do not require off-board communications to function.

The onboard communications within the microgrid LAN will be a dual-redundant architecture, where every LAN access point is backed up by another access point.

Distributed Energy Resources Characterization

A variety of generation sources are planned for the community microgrid. They include:

- CHP
- PV
- ESS
- Building Load Control
- Energy Efficiency Measures (EEMs)
- Utility Grid
- Backup Generators

The Port Washington microgrid design is focused on the development of an overall energy strategy that incorporates both demand-side management and new distributed generation resources to support the microgrid's operational objectives. During operation in the grid-connected mode, the resources will typically be dispatched in an economic optimization mode. This approach will ensure that the microgrid will operate in a manner that the energy delivered to the critical facilities is at or lower than that the cost of electricity that could be purchased from the local utility. In this scenario, the CHP will operate in a constant output mode at its maximum efficiency and lowest emissions, the PV generation profile will be taken into account, the energy storage will operate in a manner to maximize microgrid benefits, and the grid will operate in a load following mode. The connection to the grid will also be used to manage the voltage and frequency of the microgrid.

The microgrid will take advantage of DER to remain in operation when the utility grid is not available. The microgrid controller will monitor island mode frequency and voltage and adjust equipment operation accordingly to maintain circuit stability. Existing backup generators will be leveraged to support island operations in conjunction with the new DER. New DER will minimize the need for the backup generator operation to minimize natural gas and diesel fuel usage. The microgrid will also support the transition back to the grid when the utility service is restored. The design ensures that the return to the grid is a seamless transition and is coordinated with the utility through appropriate protocols, safety mechanisms, and switching plans (to be communicated to the microgrid controller by the utility distribution management system).

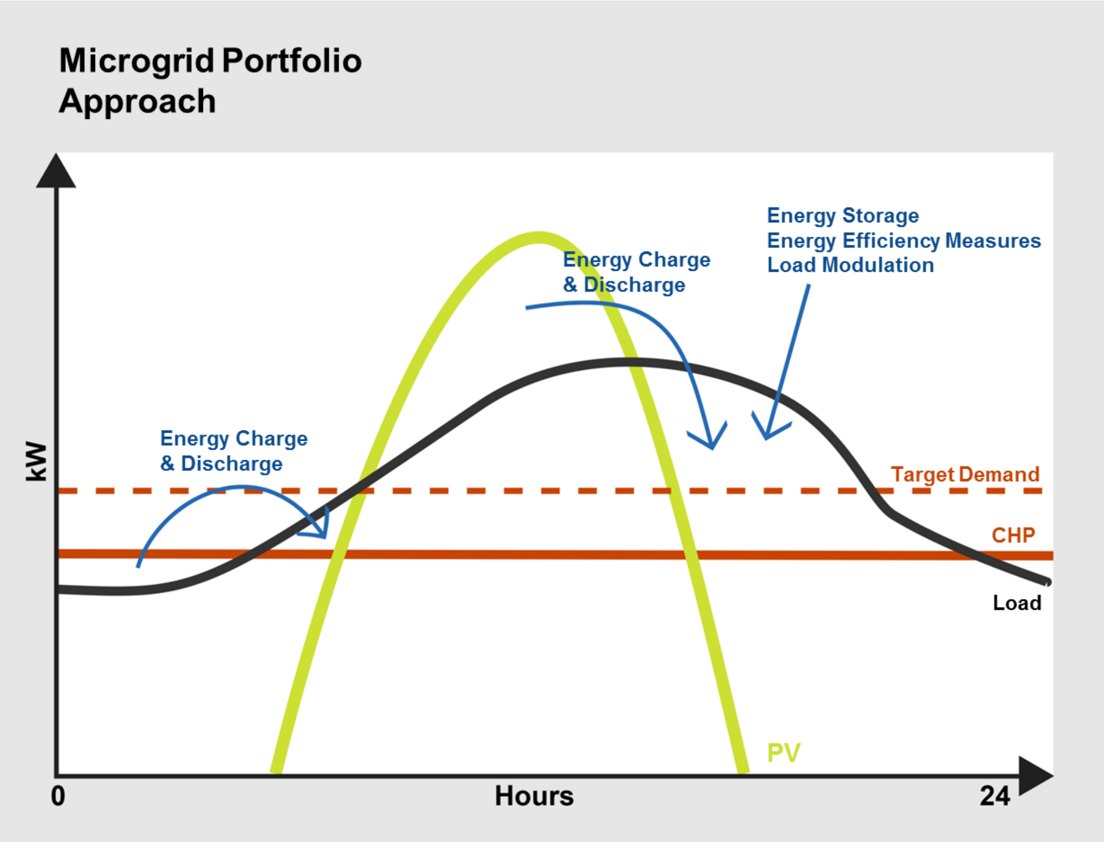
To support steady-state frequency requirements, as well as the ANSI 84.1-2006 standard voltage requirements and to support the customer power quality requirements at PCC, the microgrid controller will actively manage the dispatch of generation resources; actively manage the charge and discharge of energy storage; provide observability of microgrid-wide telemetry including frequency, power factor, voltage, currents and harmonics; provide active load management; and provide advance volt-VAr variability algorithms and other stability algorithms based on steady state telemetry of the system.

Normal and Emergency Operations

The microgrid DER selection is based on our *Microgrid Portfolio Approach* that focuses on energy requirements and a close match to the electric load profile of all covered facilities. The peak demand for critical facilities in the community occurs only a few hours per year. This means all critical facility services can be provided by continuously operating microgrid resources for the majority of hours in a year without over-building. The goal of this approach is to enable microgrid resources to serve the microgrid loads more efficiently, more cost effectively, and with lower emissions per unit of energy consumed.

Under this strategy, base-load CHP will be designed to run at design output for a majority of the hours per year.] To meet the load that varies above the base load, PV and ESS will be integrated into the system. ESS are specified based on their capability to address PV intermittency support, PV load shifting, peak shaving (to manage utility imports), supporting CHP loading, and stabilize island mode operations. The design also incorporates active microgrid controls that enable optimal operation of energy storage, PV, and building management systems to manage load and reduce the afternoon peak load when needed. This concept is presented in Figure 3.

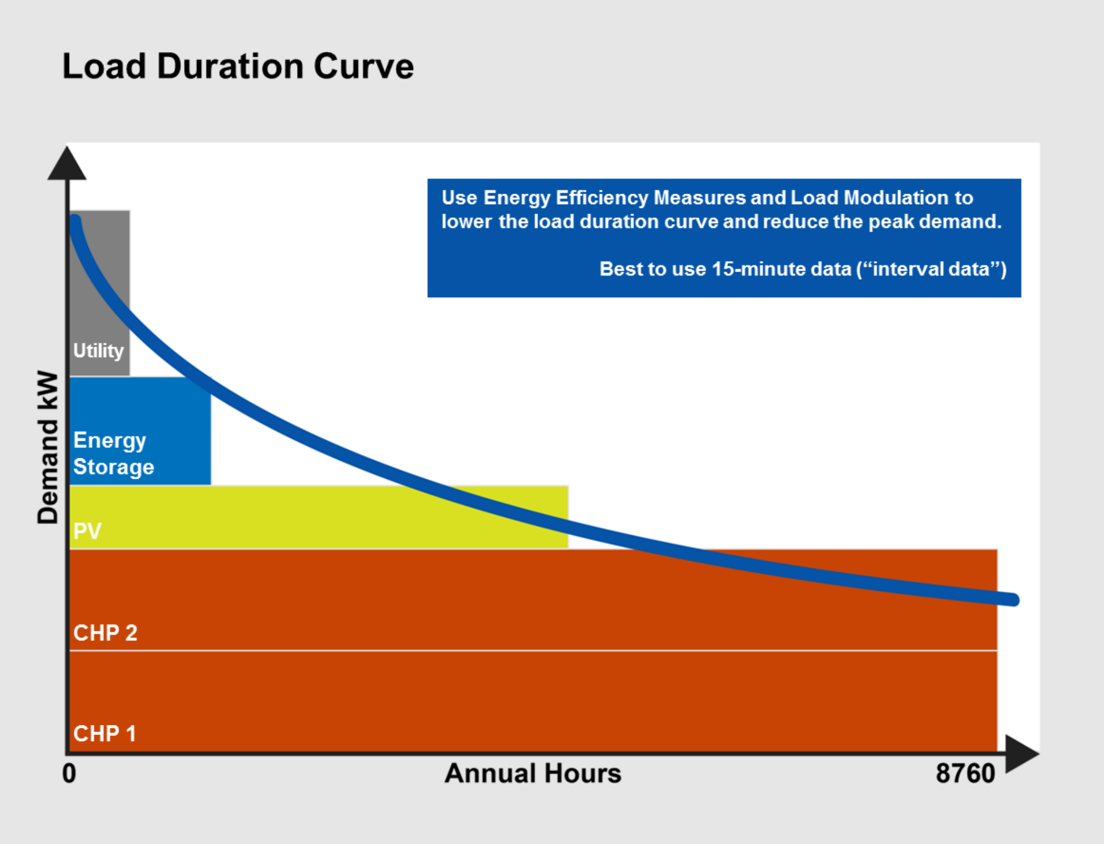
Figure 3 – Microgrid Portfolio Approach



From a long-term operations and maintenance standpoint, the Portfolio Approach enables the microgrid to operate energy resources within their design envelope. This keeps maintenance costs and fuel costs at a minimum, and helps to lower the total cost of ownership. The design also incorporates active microgrid controls that enable optimal operation of energy storage, PV, and building management systems to manage load and reduce the afternoon peak load when needed.

The load duration curve presented in Figure 4 illustrates another element of the resource selection and sizing strategy for the Port Washington Community Microgrid. When operating in a grid-connected mode, the microgrid uses the grid as a resource to meet intermittent peak demand periods. When operating in island mode, the microgrid supply and demand will be managed through the dispatch of microgrid generation resources, load management, and to a minimum extent, the use of existing backup generation. This methodology allows the designers to evaluate the appropriate balance of grid service, generation resources, and load management capabilities, and provide both a technical and economic solution.

Figure 4 – Load Duration Curve



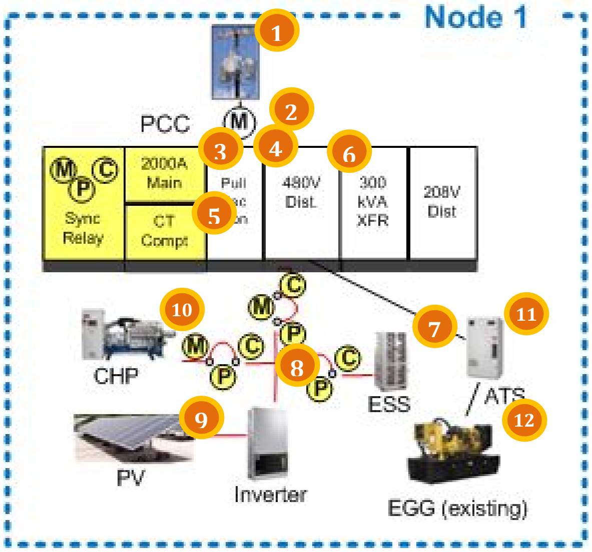
One of the most important attributes of the Port Washington Community Microgrid will be the ability to operate when the utility grid is not available. The methods of transitioning into an island mode are characterized as either a (1) planned transition or (2) unplanned transition.

- Planned Transition*:* In a planned transition, outside information is used to ramp up resources so there is zero grid import to the microgrid. A seamless transition occurs into island operations at the appropriate time. Outside information includes weather forecasts, grid frequency deviations, local voltage sags, or other information provided by the utility.

- Unplanned Transition*:* In an unplanned transition, an unanticipated outage takes place such as the loss of a transformer or a car hitting a distribution power pole. Depending on the microgrid resources operating at the time, an outage may take place that requires the microgrid to establish itself through a black start sequence of operation.

The figure below includes a brief explanation of the elements included in the one-line diagram.

Figure 5 – One-Line Diagram Explanation



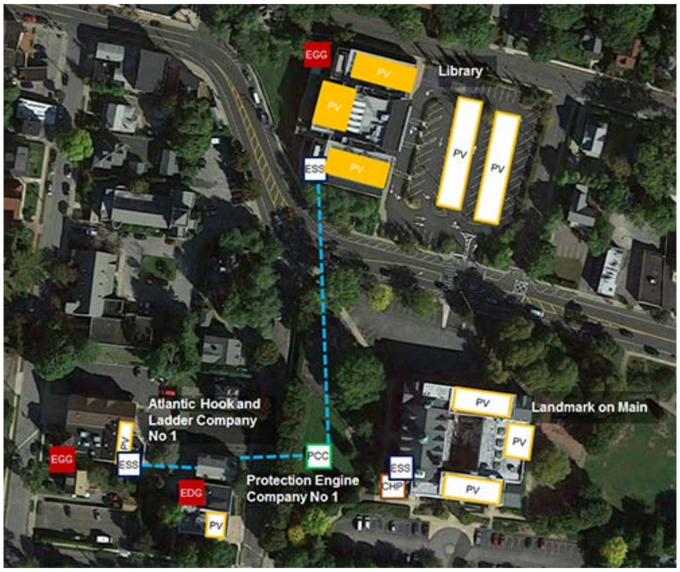
1. Transformer to the critical facility
2. Utility meter
3. Synchronizing relay controls / main breaker with monitoring (M), protection relays (P), and controls (C)
4. Main disconnect (pull section)
5. Instrument current transformer compartment
6. Main 480V 3-phase distribution panel; step-down transformer and 208V 1-phase distribution panel
7. Energy storage system (ESS) with M, P, C
8. New 480 Volt 3-phase cable (red)
9. Solar PV array and associated inverter with M, P, C
10. Combined Heat & Power (CHP) with M, P, C
11. Automatic transfer switch (ATS)
12. Emergency generators: Emergency Gas Generator (EGG) or Emergency Diesel Generator

The following pages highlight the layout design and one-line diagram subsection for the five nodes as well as a brief explanation of included energy resources.

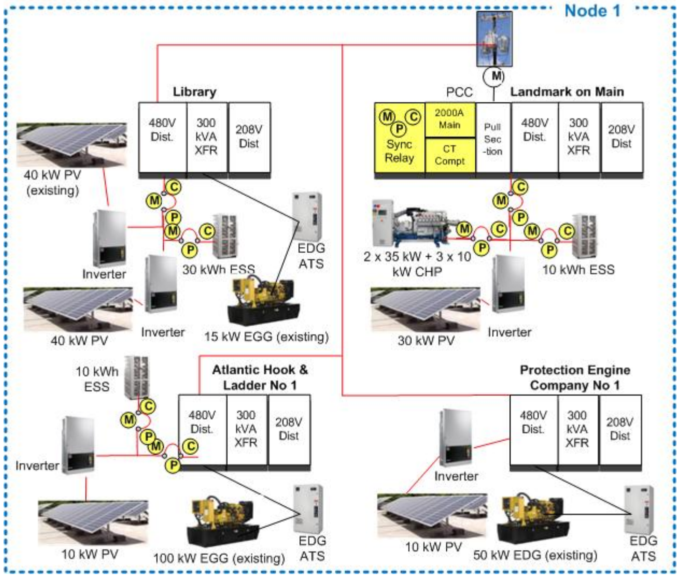
Geospatial Diagrams and One-Line Subsections

Node 1 System Configuration

Geospatial Diagram



One-Line Diagram



Facility

- Port Washington Public Library
- Landmark on Main St
- Protection Fire Engine Company No. 1
- Atlantic Hook and Ladder Company No. 1

Description

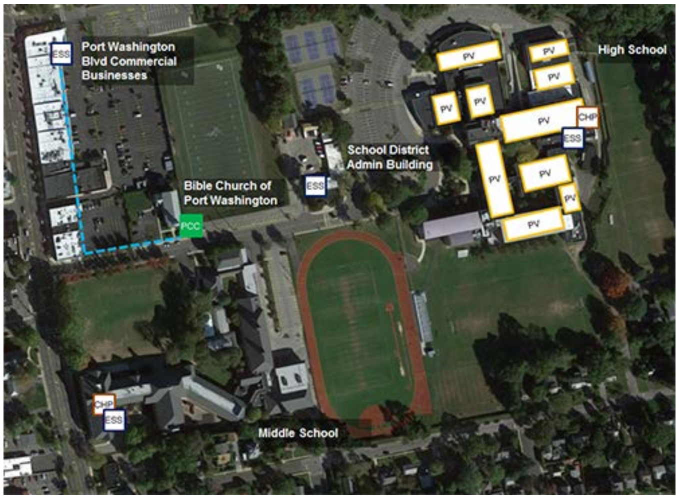
Node 1 consists of four facilities. This node includes an existing rooftop PV system (40 kW) at the Library as well as three existing backup generators at the Library, Protection Engine Company No 1, and the Atlantic Hook and Ladder Company (15 kW, 50 kW, and 100 kW respectively). The PCC will be located in the open space west of Landmark on Main. In addition, 640 feet of new underground cable will connect the facilities.

As part of the microgrid, the following technologies have been evaluated::

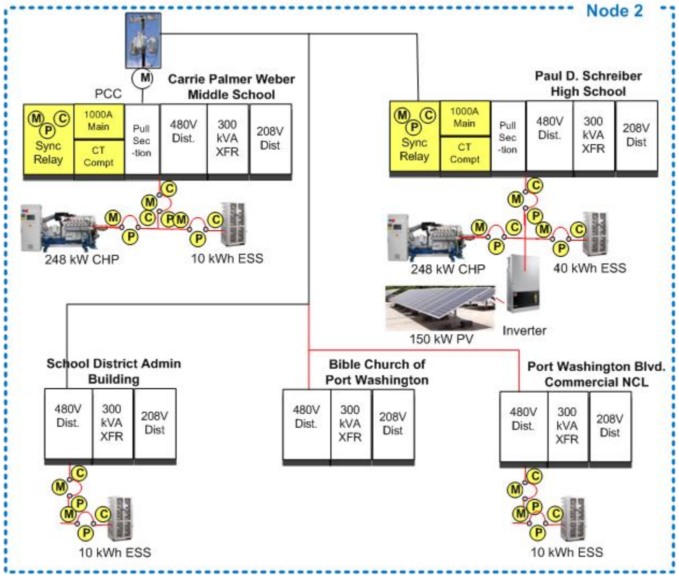
- **PV (40 kW):** A covered parking PV system outside the library.
- **PV (10 kW):** A PV system on the roof of the Atlantic Hook and Ladder No 1 building.
- **PV (30 kW):** A PV system on the roof of the Landmark on Main building.
- **PV (10 kW):** A PV system will be placed on the roof of the Protection Engine Company No 1 building.
- **CHP (100 kW):** A CHP system outside the Landmark on Main building.
- **ESS (30 kWh):** An ESS unit inside the Library.
- **ESS (10 kWh):** An ESS unit inside the Atlantic Hook and Ladder No 1 building.
- **ESS (10 kWh):** An ESS unit inside the Landmark on Main building.
- **Energy Efficiency Measures (EEM)**: A total of 164,000 kWh/year of savings was identified. This includes lighting and HVAC upgrades, and building envelope/ weatherization measures. The estimates implementation costs are $420K, which Hitachi did not include in the microgrid budget.

Node 2 System Configuration

Geospatial Diagram



One-Line Diagram



Facility

- Paul D. Schreiber High School
- Carrie Palmer Weber Middle School
- School Administration Building
- Bible Church of Port Washington (potential)
- Port Washington Commercial Businesses (potential)

Description

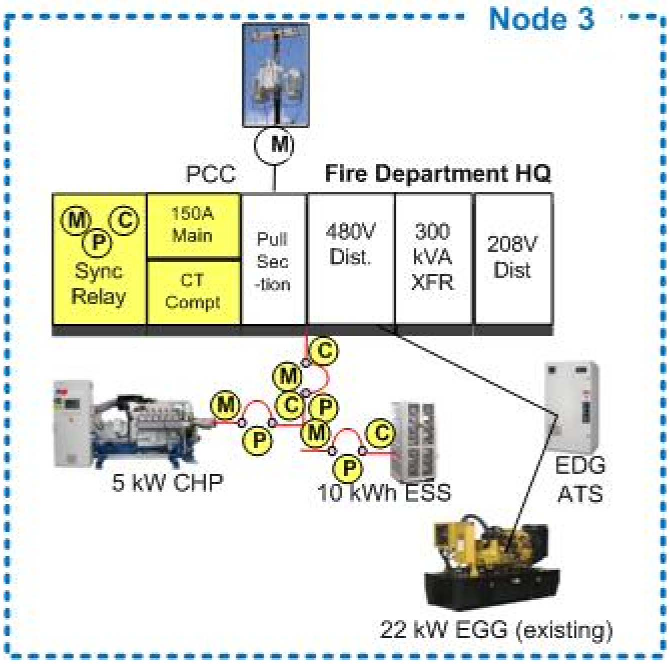
Node 2 consists of at least three, and as many as five facilities. The PCC will be located across the street from the Middle School. Underground cable exists among school facilities, and approximately 960 feet of new underground cable would be installed to connect the church and retail properties (includes pharmacy and bank) to this node. The cost of installing this cable underground was included in the project budget.

- As part of the microgrid, the following technologies have been evaluated:**PV (150 kW):** Multiple PV systems will be installed on the available roof space of the High School.
- **CHP (248 kW):** A CHP system located outside the High School
- **CHP (248 kW):** A CHP system outside the Middle School.
- **ESS (40 kWh):** An ESS unit inside the High School.
- **ESS (10 kWh):** An ESS unit inside the Middle School.
- **ESS (10 kWh):** An ESS unit inside the School District Admin building.
- **ESS (10 kWh):** An ESS unit may be placed inside a commercial facility (non-critical load).
- **Energy Efficiency Measures (EEM)**: A total of 500,000 kWh/year of savings was identified for the schools. These items include lighting and HVAC upgrades, renewable energy measures, and installation of an energy management system. These items have been included in a separate energy performance contract but not yet implemented.

Node 3 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- Port Washington Fire Department Headquarters

Description

Node 3 is a single facility node. It includes an existing emergency gas generator (22 kW). The PCC will be located near the street in front of the building.

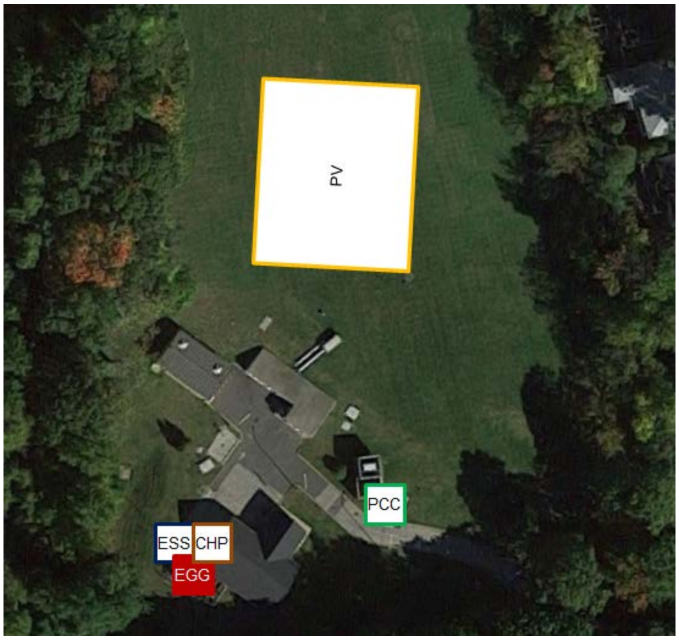
As part of the microgrid, the following technologies have been evaluated:

- **CHP (5 kW):** A CHP unit outside of the facility.
- **ESS (10 kWh):** An ESS unit inside the facility.
- **Energy Efficiency Measures (EEM)**: A total of 6,000 kWh/year of savings was identified. This includes lighting and HVAC upgrades and building weatherization. The estimated implementation costs is $25 K, which Hitachi did not include in the Microgrid budget.

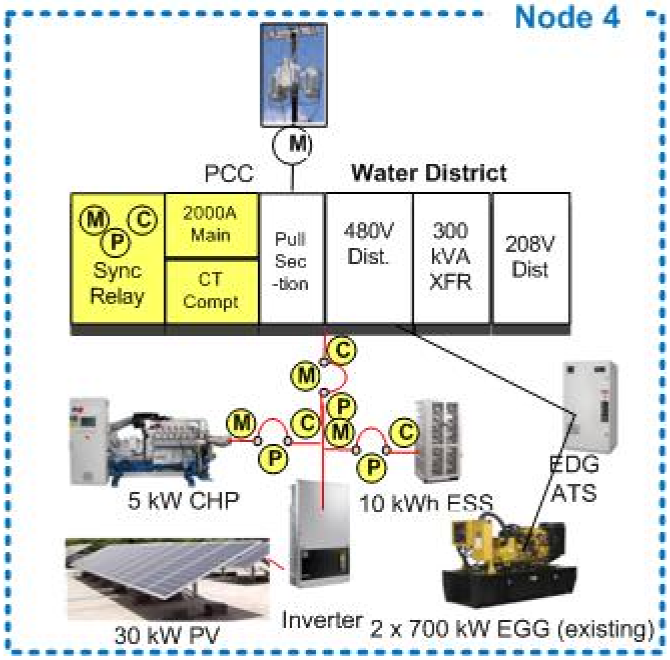
Note that PV is not included in the node due to substantial shading issues.

Node 4 System Configuration

Geospatial Diagram



One-Line Diagram



Facilities

- Port Washington Water District

Description

Node 4 is a single facility node. It includes existing emergency gas generation (1,400 kW) that is dedicated to the booster pumps. The facility was optimized such that these gas generators are not needed to operate the rest of the facility during an outage, and continue to be dedicated to the booster pumps. The PCC will be located at the front of the building.

- As part of the microgrid, the following technologies have been evaluated:**PV (30 kW):** A ground-mounted PV system in the open field behind the building.

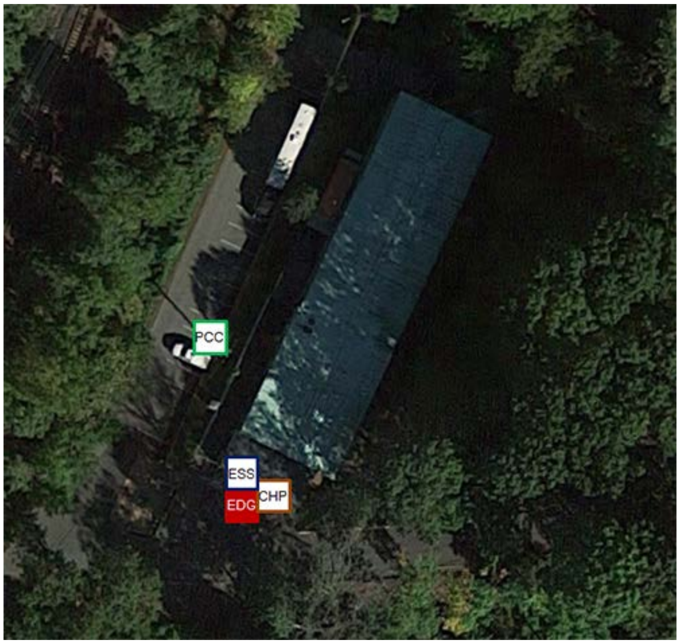
- **CHP (5 kW):** A small CHP unit in the back near the emergency generator.

- **ESS (10 kWh):** An ESS unit inside the facility near the existing backup generators.

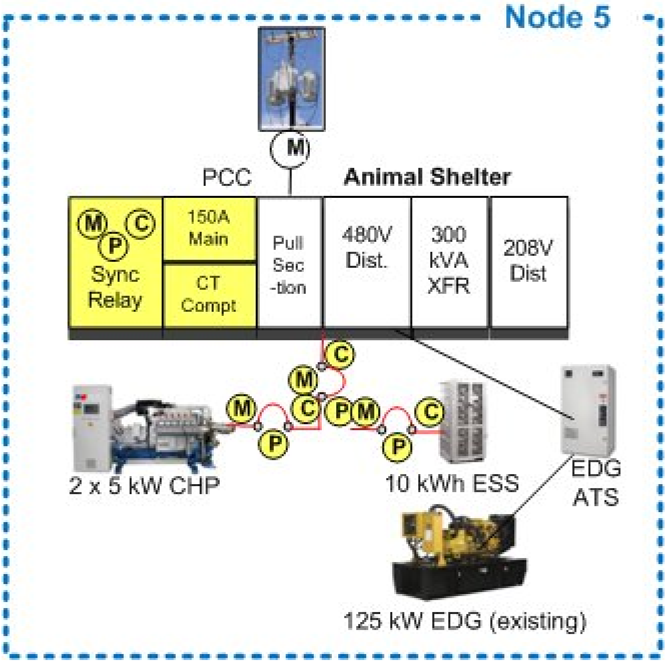
- **Energy Efficiency Measures (EEM)**: A total of 4,700 kWh/year of savings was identified. This includes lighting and transformer replacements. The estimated implementation cost is $11k, which Hitachi did not include in the Microgrid budget.

Node 5 System Configuration

Geospatial Diagram



One-Line Diagram



Facilities

- Town of North Hempstead Animal Shelter

Description

Node 5 is a single facility node. It includes an existing emergency diesel generator (125 kW). The PCC will be located near the parking lot.

As part of the microgrid, the following technologies have been evaluated:

- **CHP (10 kW):** Two small CHP systems outside of the shelter near the emergency generator.
- **ESS (10kWh):** An ESS unit inside the building.
- **Energy Efficiency Measures (EEM)**: A total of 30,000 kWh/year of savings was identified. This includes lighting and HVAC upgrades and building weatherization. The implementation cost is approximately $67K, which Hitachi did not include in the microgrid budget.

Note that PV is not included in the node due to substantial shading issues.

Modeling Methodology

The microgrid was modeled with HOMER Pro software. HOMER Pro is a microgrid software tool originally developed at the NREL and enhanced and distributed by HOMER Energy. HOMER nests three integrated tools in one software product, allowing microgrid design and economics to be evaluated concurrently. The key features of HOMER Pro are:

- **Simulation:**
  HOMER simulates the operation of a hybrid microgrid for an entire year, in time steps from one minute to one hour.
- **Optimization:**
  HOMER examines all possible combinations of system types in a single run, and then sorts the systems according to the optimization variable of choice. The many solutions are optimized for the levelized cost of energy.
- **Sensitivity Analysis:**
  HOMER allows the user to run models using hypothetical scenarios. The user cannot control all aspects of a system and cannot know the importance of a particular variable or option without running hundreds or thousands of simulations and comparing the results. HOMER makes it easy to compare thousands of possibilities in a single run.

Load Description

The microgrid design team modeled and optimized each of the five nodes separately. Table 3 presents an overview of the annual energy operations of the microgrid by node. The microgrid will have a maximum demand of 2,812 kW and an average demand of 566 kW. This peak demand, compared to the average demand, is unusually high. Normally, a peak demand for a 566 kW average demand would be roughly 1,000 kW. Upon examination of the data, this high peak demand is driven by a single 15-minute interval in 2015 for Node 2. This is an outlier and is not considered in the design of the microgrid. The energy efficiency measures and energy storage planned for Node 2 will greatly mitigate this unusual, single data point, peak demand. The microgrid will deliver approximately 5,000,000 kWh per year. The thermal loads in the microgrid will be approximately 32,800,000 kBTU per year, of which approximately 11,900,000 kBTU will be recovered from the CHP systems and reused to support on-site thermal loads.

Table 3 –Microgrid Energy Overview: Grid Connected Operation

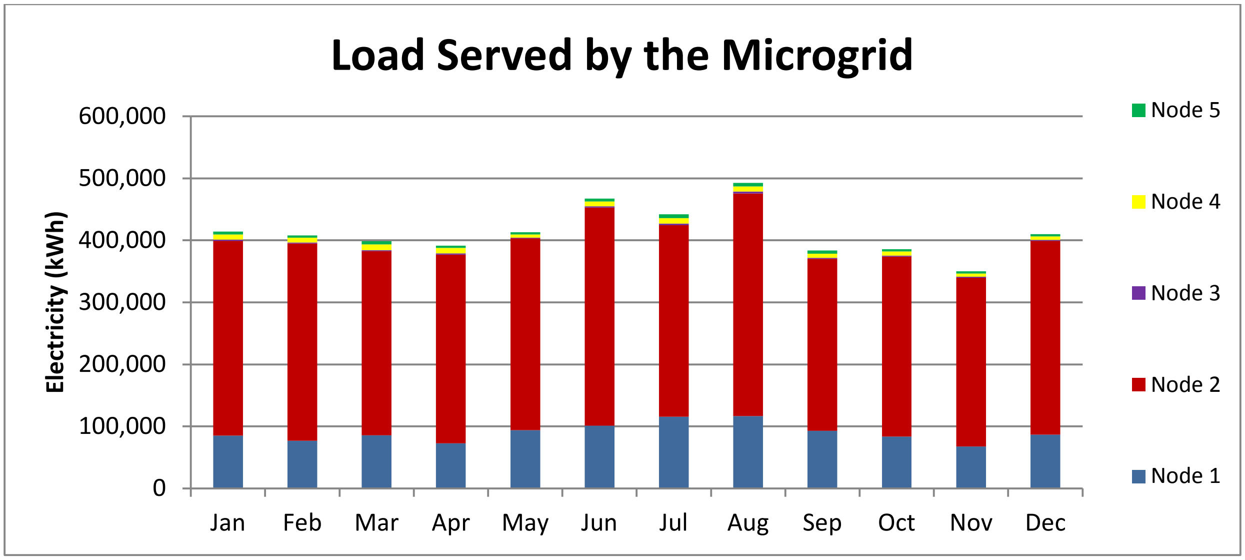
	Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
Node	Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
1	700	123	1,078,244	89,854	10,285,589	857,132	1,813,534	151,128
2	1,969	424	3,715,034	309,586	20,898,746	1,741,562	9,684,143	807,012
3	19	2	21,845	1,820	315,081	26,257	78,779	6,565
4	48	10	88,694	7,391	600,812	50,068	110,945	9,245
5	76	6	53,555	4,463	709,868	59,156	180,112	15,009
Total	**2,812**	**566**	**4,957,372**	**413,114**	**32,810,097**	**2,734,175**	**11,867,513**	**988,959**

The monthly energy delivery by microgrid node is presented in Table 4 and presented graphically in Figure 6.

Table 4 –Monthly Grid Connected Operation by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
	(kWh)					
Jan	85,175	314,163	1,994	8,375	4,350	414,058
Feb	76,902	318,001	1,682	7,554	4,035	408,173
Mar	85,554	297,030	1,504	9,347	5,210	398,645
Apr	72,687	304,431	1,868	9,061	3,508	391,554
May	93,860	309,189	1,503	4,983	3,707	413,242
Jun	101,074	351,603	2,332	7,497	4,960	467,466
Jul	115,390	309,311	2,345	9,021	6,208	442,275
Aug	116,678	359,137	2,744	8,512	5,602	492,674
Sep	92,983	277,285	1,264	7,143	4,937	383,612
Oct	83,720	290,281	1,503	6,391	3,676	385,571
Nov	67,635	272,097	1,344	5,188	3,585	349,848
Dec	86,586	312,507	1,763	5,622	3,776	410,253
Total	**1,078,244**	**3,715,034**	**21,845**	**88,694**	**53,555**	**4,957,372**

Figure 6 - Monthly Grid Connected Operation by Node



The Port Washington microgrid is designed for a majority of the energy supply from on-site resources, with the remainder of the energy coming from the grid when the grid is operating. The microgrid treats the utility grid as an additional resource and incorporates it in the optimization of economics, emissions and reliability.

The reliability of the Port Washington Community Microgrid will be ensured with the following measures:

- The use of multiple, distributed, smaller unit sizes to help minimize generation loss and ensure that the microgrid can gracefully accommodate the failure
- The use of distributed energy storage systems that can accommodate short periods of high loading if the resource loss reason is known and quickly recoverable (15 minutes)
- Increasing the energy dispatch from the grid (in grid-connected mode - 99% of the time), to accommodate the loss of a resource until recovered
- The use of a combination of ESS and load modulation (up to 20% without curtailment) in island mode to accommodate the loss of a resource for a few hours. Beyond a few hours, non-critical loads will be shut down until the resource is recovered
- Much greater use of underground cabling and indoor infrastructure than is seen in the traditional utility grid

These techniques are employed in the Port Washington Community Microgrid design so that equipment loss is mitigated or accommodated in the specific microgrid nodes for this community, under grid-connected and islanded modes of operation. Table 5 summarizes the microgrid resources in each node in terms of number of devices and the total installed capacity by technology.

Table 5 - Microgrid Node Resources Comparison

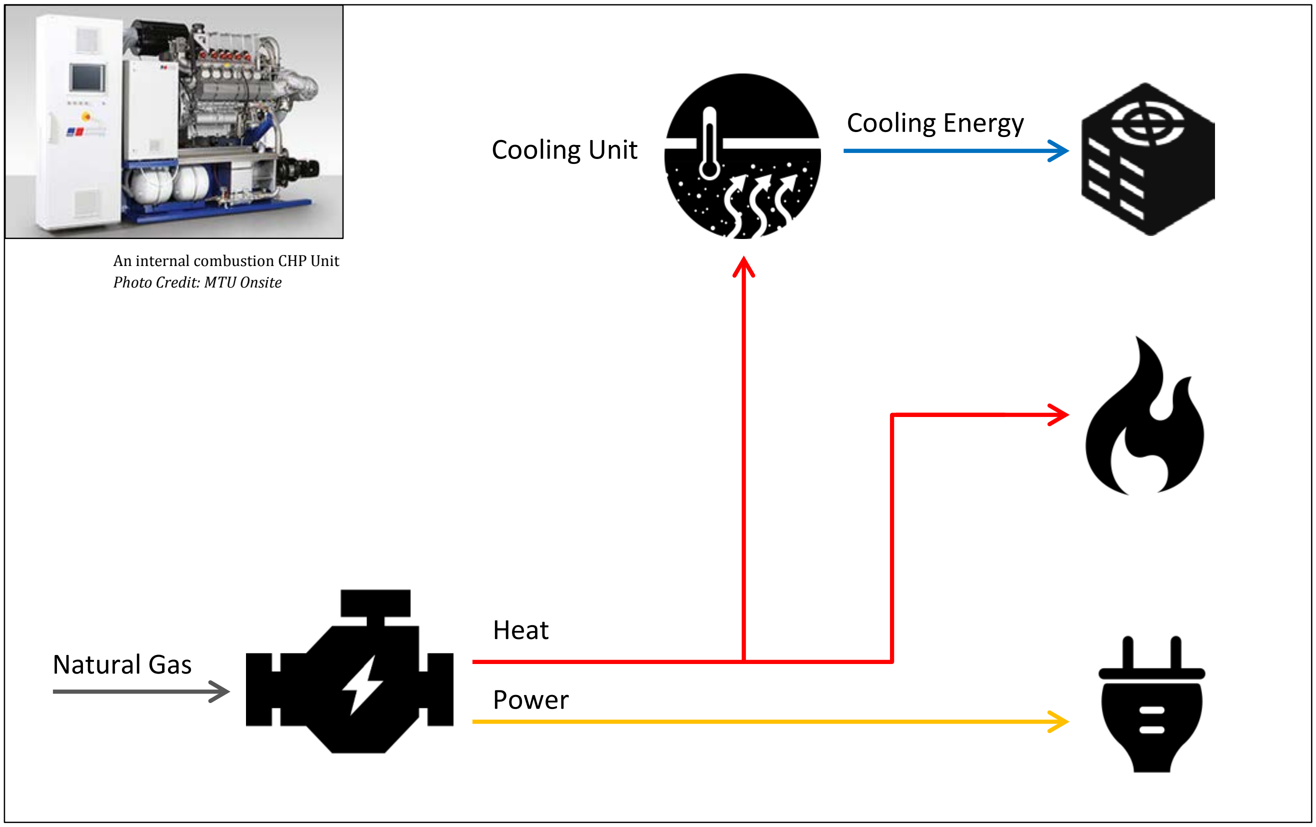
Node	Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW
1	Business as Usual	700	1	40	-	-	-	-	3	165
	Microgrid	572	5	130	3	25/50	5	100	3	165
2	Business as Usual	1,969	-	-	-	-	-	-	-	-
	Microgrid	1,402	1	150	4	35/70	2	496	-	-
3	Business as Usual	19	-	-	-	-	-	-	1	22
	Microgrid	4	-	-	1	5/10	1	5	1	22
4	Business as Usual	48	-	-	-	-	-	-	2	1,400
	Microgrid	33	1	30	1	5/10	1	5	2	1,400
5	Business as Usual	76	-	-	-	-	-	-	1	125
	Microgrid	39	-	-	1	5/10	2	10	1	125

An overview of each technology, installation, operating strategy, and modeled operation are presented in this section.

Combined Heat and Power

CHP generators provide electrical and thermal energy from a single source. The use of fuel to generate both heat and power makes CHP systems more cost effective than traditional power generation. Most power generation produces heat as a byproduct, but because power is generated far from the end user, the heat is lost. CHP units take advantage of the fact that they are collocated with the end user and make use of thermal energy for heating and sometimes even cooling nearby buildings. For this microgrid application, internal combustion engine based CHP systems have been modeled. Internal combustion engines, also called reciprocating engines, use a reciprocating motion to move pistons inside cylinders that turn a shaft and produce power. Internal combustion engines typically range between 5 kW-7 MW and are best suited for load-following applications. An image of an internal combustion engine generator is presented in Figure 5.

Figure 7 – CHP System Overview



An internal combustion CHP Unit
Photo Credit: MTU Onsite

Benefits of CHP

- Reduces utility costs and improves economic competitiveness
- Increases power reliability and self-sufficiency
- Reduces GHG emissions and other pollutants
- Reduces demand for imported energy supplies
- Capable of operating on renewable or nonrenewable resources
- Suite of proven, commercially available technologies for various applications
- Additional financial incentives through the NYSERDA and investment tax credits available for eligible customers

CHP Approach

- Co-locate generators near thermal loads on the customer-side of the meter
- Design for base load and to maximize heat recovery when grid connected
- Support microgrid operations when the electric grid is not available along with PV, energy storage, and building load control
- Design to serve specific winter Heat Recovery Loads, such as a boiler plant, space heating, domestic hot water (DHW), and pool heating

- Design to serve specific summer Heat Recovery Loads, including space cooling, DHW, and pool heating

CHP in the Microgrid

The size and location of the planned CHP units is presented in the layout diagram and single-line diagram presented in the Appendix. Table 6 summarizes the CHP components by node of the microgrid.

Table 6 - Microgrid CHP Resources by Node

Node	Natural Gas Engine or CHP	
	Qty	**Total kW**
1	5	100
2	2	496
3	1	5
4	1	5
5	2	10
Total	**11**	**616**

The following tables and figures summarize the annual operation of the CHP fleet in the Port Washington microgrid on a monthly basis for each node.

Table 7 - Microgrid CHP Electric Production by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Total
	Electric Production (kWh)					
Jan	50,691	255,588	2,810	3,203	4,482	316,775
Feb	45,586	244,110	2,520	2,764	4,080	299,060
Mar	50,771	247,802	2,490	3,015	4,744	308,822
Apr	46,010	245,772	2,249	2,905	4,047	300,981
May	50,676	253,649	1,787	1,129	4,088	311,329
Jun	56,398	247,065	2,749	2,119	4,547	312,878
Jul	59,222	256,473	2,814	2,855	4,967	326,331
Aug	59,428	260,038	2,971	2,526	4,951	329,914
Sep	48,799	241,758	1,404	2,192	4,638	298,791
Oct	49,547	251,693	1,734	2,133	4,151	309,259
Nov	45,183	240,719	2,158	1,964	4,116	294,141
Dec	52,225	244,161	2,782	2,555	4,388	306,111
Total	**614,537**	**2,988,826**	**28,467**	**29,362**	**53,201**	**3,714,393**

Figure 8 – Microgrid CHP Electric Production

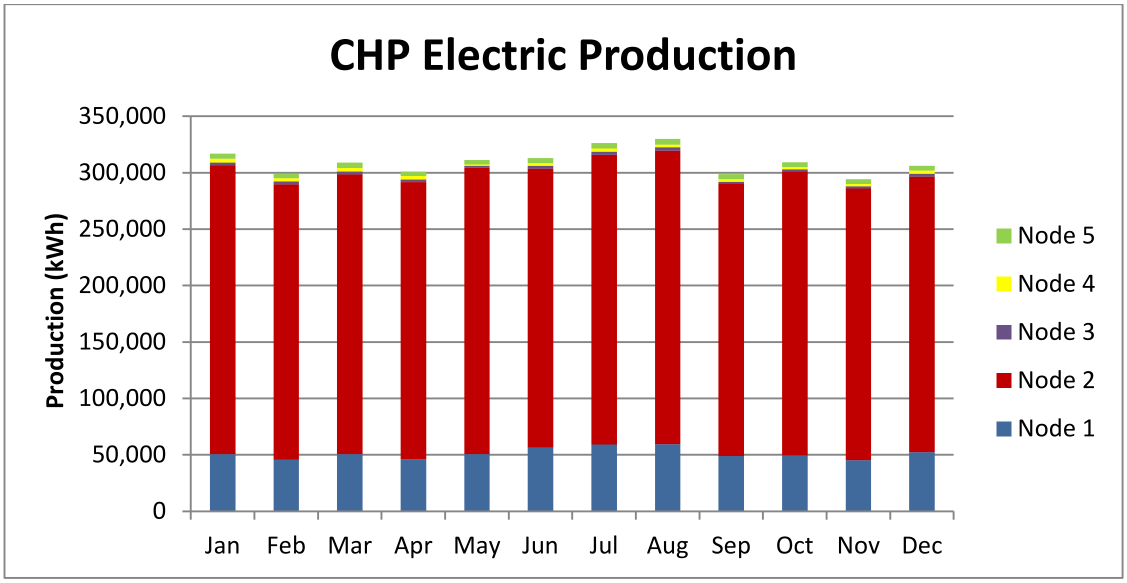


Table 8 - Microgrid CHP Heat Recovery by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Total
Heat Recovery (kBTU)						
Jan	180,317	1,355,377	12,446	14,188	19,853	1,582,182
Feb	162,157	1,264,075	11,160	9,280	18,070	1,464,742
Mar	180,601	1,322,170	11,026	10,681	21,012	1,545,491
Apr	163,663	1,168,083	9,801	10,143	17,920	1,369,610
May	177,242	108,618	1,494	4,909	17,795	310,058
Jun	105,386	110,389	2,401	1,527	13,827	233,530
Jul	93,967	100,770	2	9,854	4,933	209,526
Aug	105,053	124,755	0	11,187	3,721	244,716
Sep	122,408	338,893	1,213	9,710	8,865	481,088
Oct	176,247	1,148,143	7,357	9,449	16,560	1,357,757
Nov	160,722	1,310,478	9,558	8,700	18,120	1,507,577
Dec	185,771	1,332,393	12,321	11,315	19,436	1,561,236
Total	**1,813,534**	**9,684,143**	**78,779**	**110,945**	**180,112**	**11,867,513**

Figure 9 – Microgrid CHP Heat Recovery

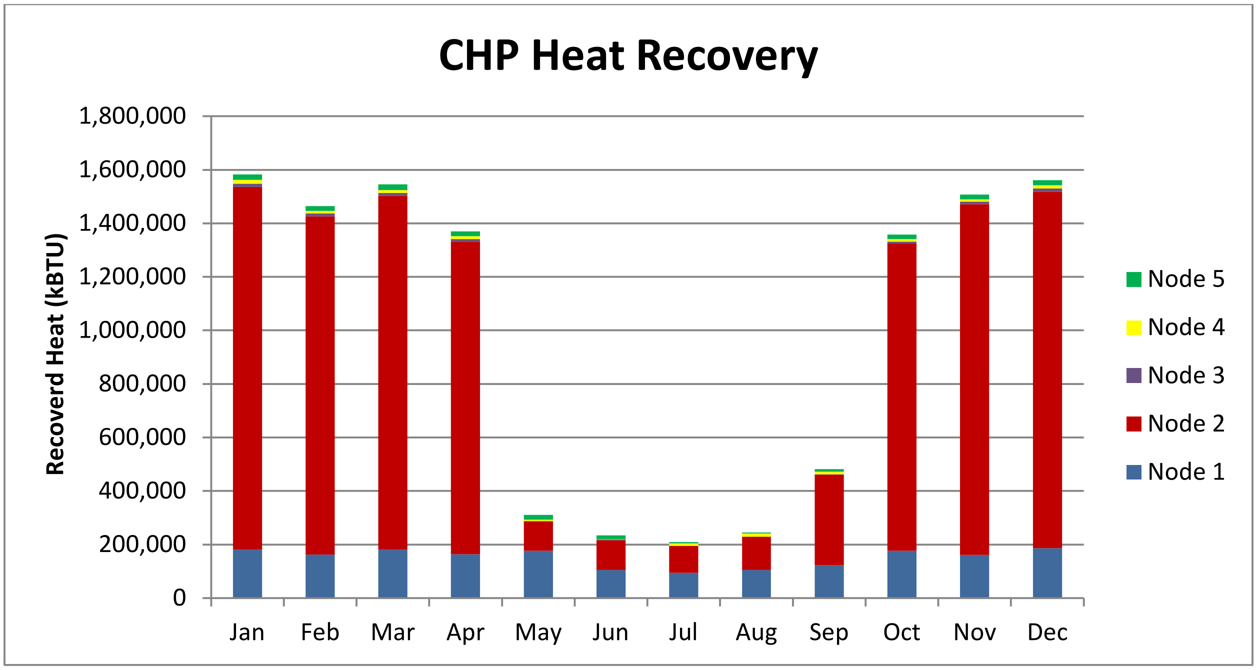
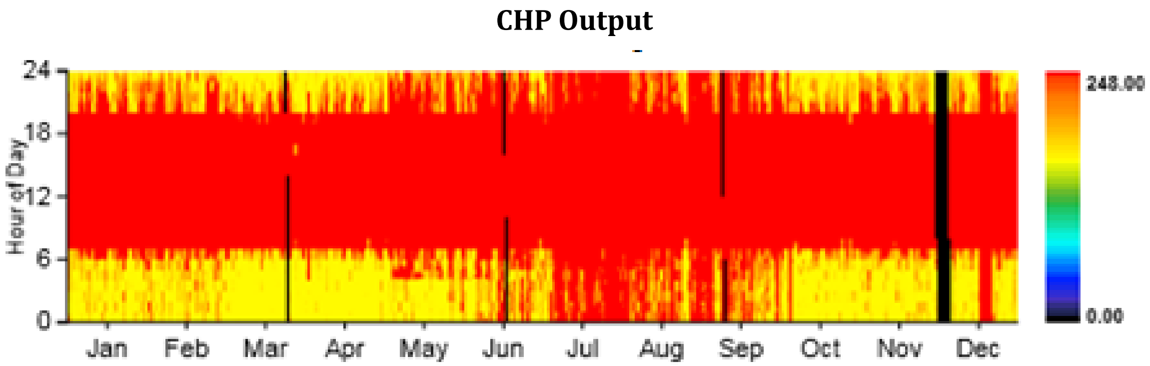


Figure 10 presents the hourly operation of the CHP in an example node in the form of a heat map. This representation demonstrates that the CHP unit is operating near full capacity for a majority of hours (red), then does some electric load following during the other hours (orange) but is loaded at an overall high level of output during the course of the year.

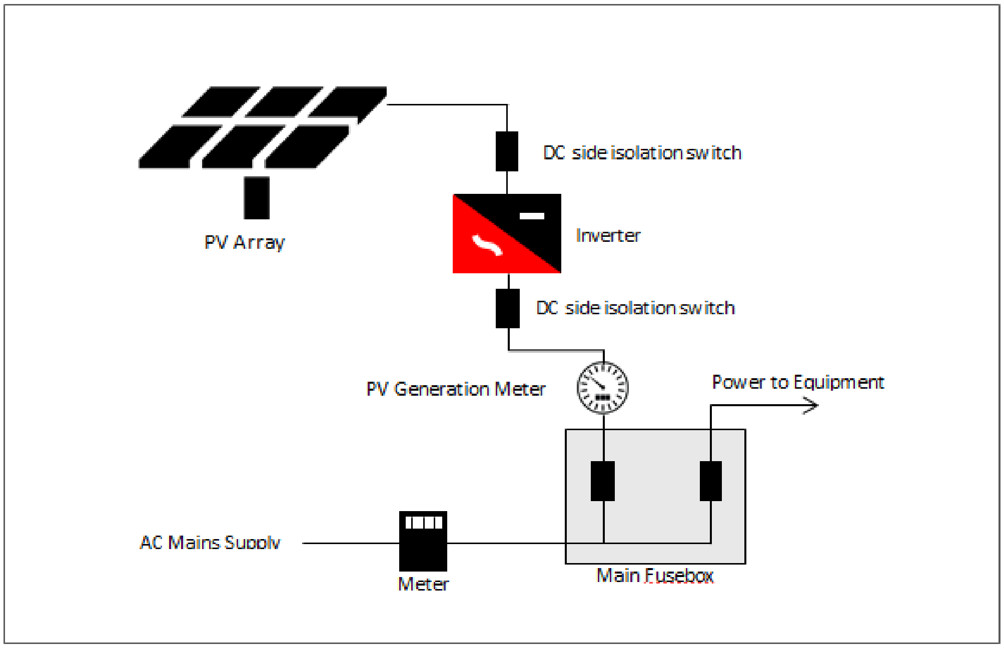
Figure 10 – Example Node CHP Operational Summary



Solar Photovoltaics

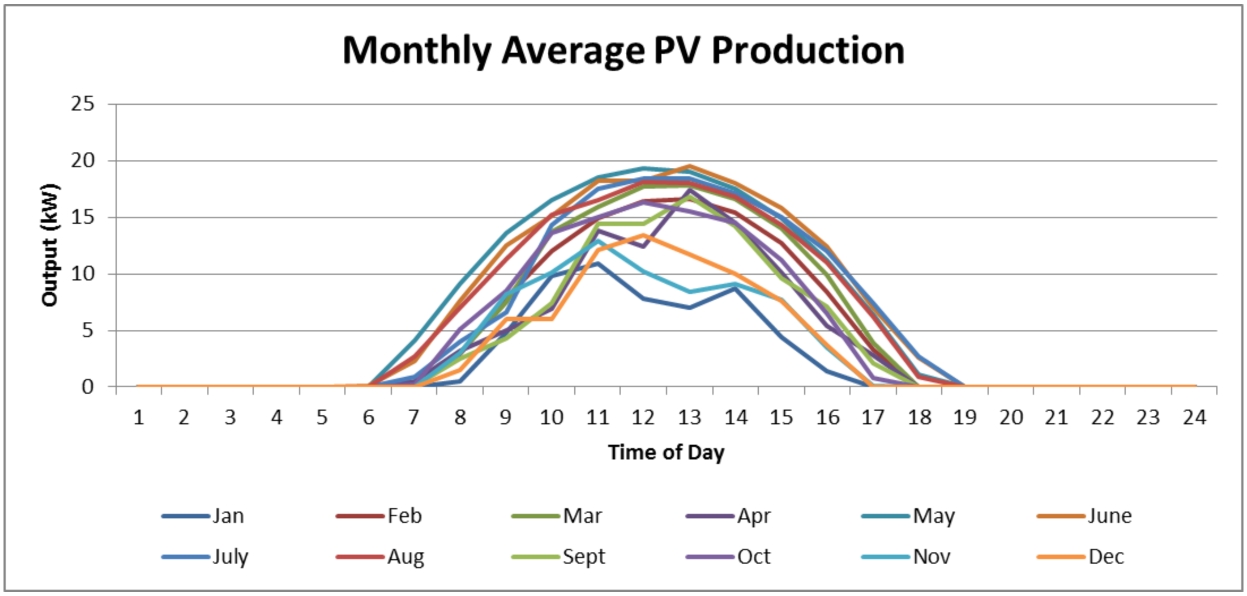
The solar PV will be rooftop, parking lot, or ground mounted using hail-rated solar panels. PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by photons and can be induced to travel through an electrical circuit, resulting in the flow of electrons to create energy in the form of direct current. The direct current is transformed into usable alternating current through the use of an inverter. A typical customer-side of the meter PV installation is presented in Figure 11.

Figure 11 – PV Installation Diagram (Customer Side of Meter)



Since the PV systems are driven by sunlight, the electric production profile varies with the position of the sun and is impacted by the level of cloud cover. Figure 12 presents the typical average daily PV generation profiles by month and demonstrates the seasonal variation of PV as a generation resource. The HOMER model takes this variability into account when simulating and optimizing the sizing of PV as a microgrid resource.

Figure 12 – Typical PV Daily Generation Profiles



PV systems are planned for rooftops, parking spaces, and ground-mount configurations. Figure 13 presents examples of each these types of installations

Figure 13 – PV Installation Options.

Benefits of PV

- Reduces utility costs and improves economic competitiveness
- Increases power reliability and self-sufficiency
- Reduces GHG emissions and other pollutants
- Reduces demand for imported energy supplies
- Fueled by a renewable resource
- Based on a suite of proven, commercially available technologies for a variety of applications
- Competitive market for hardware and installation services
- Federal and state incentives available for eligible customers

PV Approach

- Co-locate PV systems on the customer-side of the meter to support resiliency
- Install on roofs, ground mount and covered parking
- Provide renewable energy resource (reduce site emissions and no fuel cost)
- Support day-time load requirements and annual energy loads (grid connected operation)
- Support microgrid operations when the electric grid is not available along with CHP, energy storage, and building load control

PV in the Microgrid

The size and locations of the planned PV systems is presented in the layout diagram and single-line diagram in the Appendix. Table 9 summarizes the PV components by node of the microgrid.

Table 9 - Microgrid PV Resources by Node

Node	PV	
	# of Inverters	Total kW
1	5	130
2	1	150
3	0	0
4	1	30
5	0	0
Total	**7**	**310**

The table and figures below present the monthly operation of the PV fleet by node.

Table 10 – Microgrid PV Fleet Electric Production

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Total
Electric Production (kWh)						
Jan	11,825	13,645	0	2,729	0	28,199
Feb	12,924	14,912	0	2,982	0	30,818
Mar	17,710	20,435	0	4,087	0	42,232
Apr	16,078	18,552	0	3,710	0	38,341
May	16,914	19,516	0	3,903	0	40,333
Jun	16,206	18,699	0	3,740	0	38,645
Jul	15,787	18,215	0	3,643	0	37,645
Aug	15,743	18,165	0	3,633	0	37,541
Sep	15,656	18,064	0	3,613	0	37,333
Oct	14,338	16,544	0	3,309	0	34,190
Nov	11,089	12,796	0	2,559	0	26,444
Dec	10,679	12,322	0	2,464	0	25,465
Total	**175,079**	**201,864**	**0**	**40,373**	**0**	**417,316**

Figure 14 – Microgrid PV Fleet Electric Production

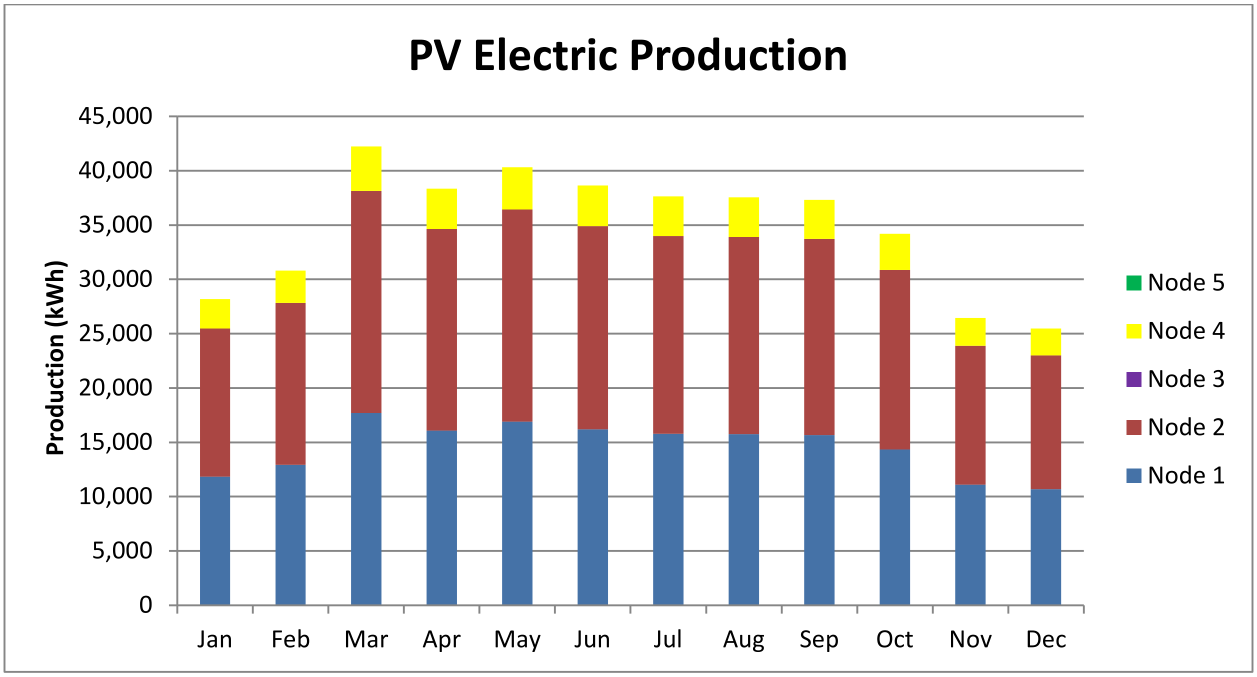
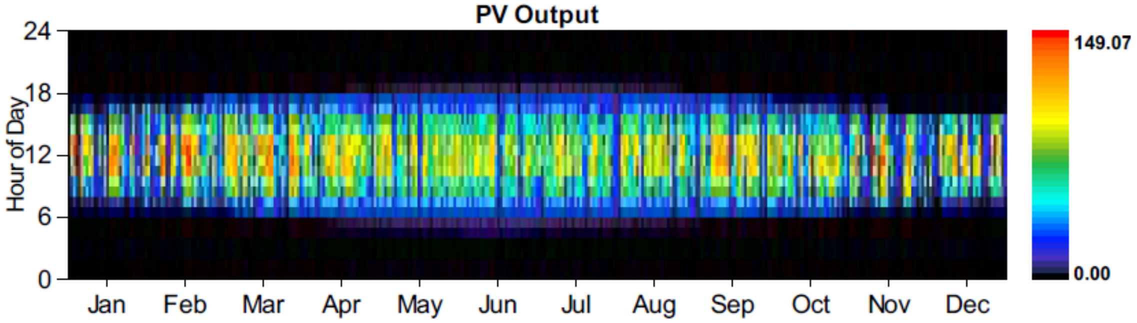


Figure 15 presents the hourly operation of the PV in an example node in the form of a heat map. This representation demonstrates how the PV units operate during hours of sunshine with maximum production in the middle of the day, ramping up in the mornings and ramping down in the afternoon hours. This also illustrates the trend of narrower daily bands of production in the winter and then expansion to maximum production in the summer.

Figure 15 – Example Node PV Operational Summary



As part of this study, the National Renewable Energy Laboratory (NREL) was asked to evaluate how the presence of a microgrid impacts the potential of future renewable deployments. Their analysis, included as Appendix E, demonstrates that a microgrid would have a mixture of effects (some positive and some negative) with those effects considerably impacted by the energy sources included in the initial microgrid.

Energy Storage Systems

Energy storage in a microgrid can improve the payback period for the whole system by enabling an increase in the penetration of renewable energy sources, shifting the energy produced by PV, enabling peak load management, managing PV intermittency, providing volt/VAr support, and supporting island mode transitions. The technology specified for the Port Washington microgrid is Lithium Ion (Li-ion) batteries, which have a fast reaction response to changes in load, a fairly small footprint, and a relatively high round trip efficiency. Li-ion batteries have some unique operational characteristics:

- The usable energy capacity is between a 15% and 95% state of charge (SOC)
- The life of the batteries are impacted by temperature and charge rate
- Most systems are capable of approximately 3,000 deep discharge cycles (+/- 80% SOC cycles)
- Most systems are capable of more than 100,000 shallow discharge cycles (+/- 15% SOC cycles)

- The batteries are at a high risk of failure if the system is discharged to a zero percent sate of charge
- The systems typically have different rates (kW) for charge and discharge
- Most Li-ion systems have accurate methods of determining the system SOC
- Typical power electronic systems provide multiple modes of operation
- Systems are typically capable of four quadrant operation

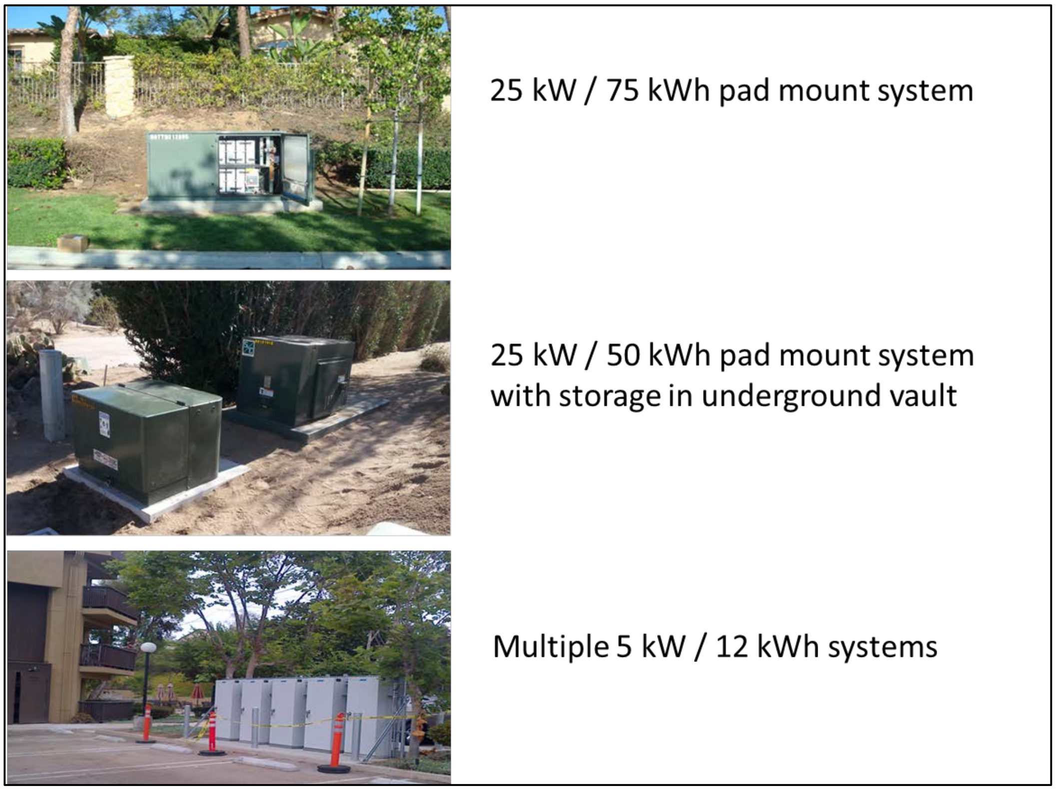
Benefits of Energy Storage

- Reduces utility costs and improves economic competitiveness
- Increases power reliability and self-sufficiency
- Reduces GHG emissions and other pollutants
- Reduces demand for imported energy supplies
- Supports system with a high level of renewable energy penetration
- Based on a suite of proven, commercially available technologies for a variety of applications
- Competitive market for hardware and installation services
- Provides multiple functions and benefits to the microgrid:
    - Peak Load Management
        - Balancing the supply of electricity with the electrical load
    - Load Shifting
        - Using a local energy storage system to compensate for the facility's large energy consumption during peak hours of the day
    - Frequency Regulation
        - A gap between power generation and demand on the grid causes the grid frequency to move away from its nominal value
    - Reactive Power Support
        - Quantity normally defined for alternating current (AC) electrical systems
    - PV Support
        - Mitigation of the variability of the solar PV output as well as extending the useful hours of the PV array
    - Demand Response
        - Program designed to enable customers to contribute to energy load reduction during times of peak demand
    - Energy Arbitrage
        - charging the energy storage at low cost parts of the day and subsequently discharging the stored energy at higher cost parts of the day to offset that higher cost

- Backup Power
    - Independent source of electrical power that supports important electrical systems on loss of normal power supply

Figure 16 presents examples of energy storage installations for the technologies addressed for this microgrid design.

Figure 16 – Example ESS Installations



Energy Storage Approach

- Collocate with PV systems on the customer-side of the meter to support resiliency
- Install indoors or outdoors (indoor installation better for resiliency)
- Maximize functional benefits for the microgrid
- Support microgrid operations when the electric grid is not available along with CHP, PV, and building load control

ESS in the Microgrid

The size and location of the planned ESS systems is presented in the layout diagram and single-line diagram presented in the Appendix. Table 11 summarizes the ESS components by node of the microgrid.

Table 11 - Microgrid ESS Resources by Node

Node	Battery Energy Storage		
	Qty	kW	kWh
1	3	25	50
2	4	35	70
3	1	5	10
4	1	5	10
5	1	5	10
Total	**10**	**75**	**150**

Unlike the other microgrid resources, the ESS both consumes and produces energy. When properly used, the net energy consumed is very small. The annual operation of the ESS in an example node is presented in Table 12, which shows both the charge and discharge modes of operation. The net value is positive which takes into account the operational losses for the systems.

Table 12 – Microgrid ESS Operation Example Node

Month	Charge	Discharge	Net Loss to operation
	(kWh)		
Jan	1,520	1,341	179
Feb	1,226	1,132	94
Mar	1,369	1,256	113
Apr	1,315	1,210	105
May	1,427	1,313	114
Jun	1,328	1,221	106
Jul	1,413	1,300	113
Aug	1,427	1,313	114
Sep	1,241	1,141	99
Oct	1,457	1,340	117
Nov	1,435	1,320	115
Dec	1,343	1,236	107
Total	**16,499**	**15,122**	**1,377**

Figure 17 – Microgrid ESS Operation

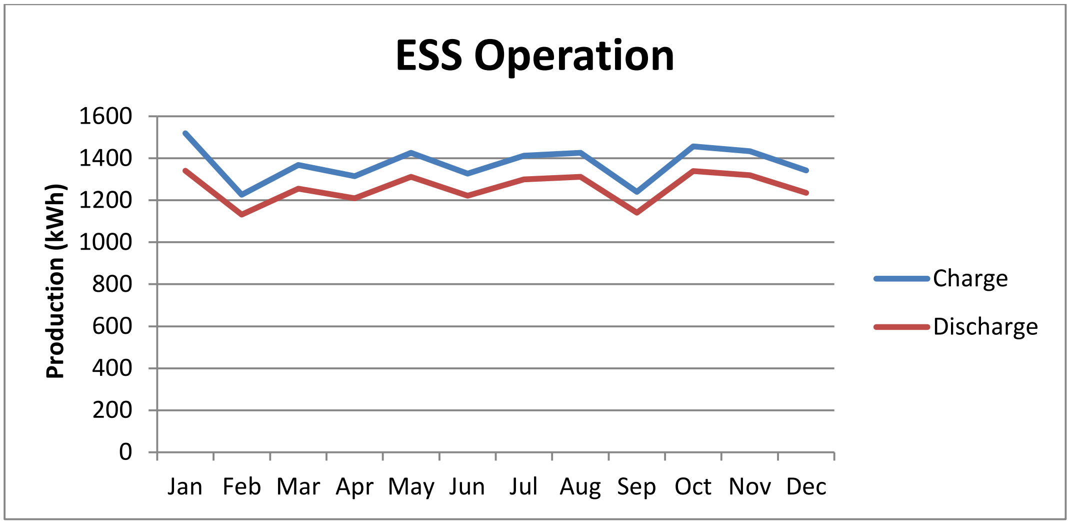
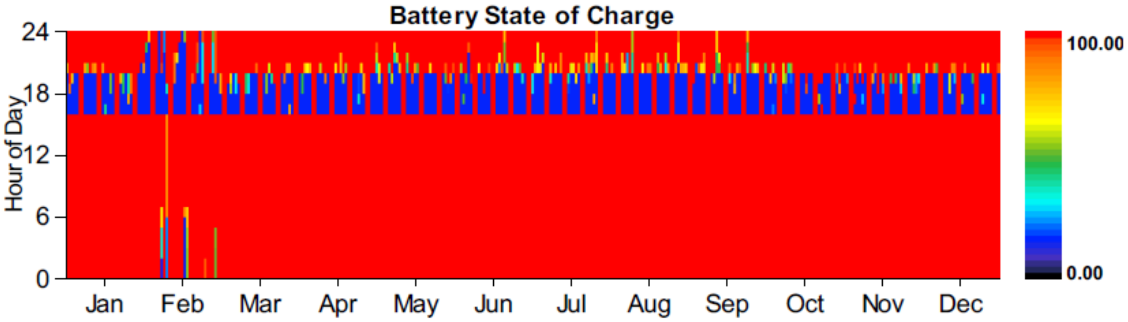


Figure 18 presents the hourly operation of the ESS in an example node in the form of a heat map. This representation demonstrates how the ESS units operate. Typically, the units are charged to a high SOC in the middle of the day. The operations represent PV intermittency support, PV load shifting, peak shaving (to manage utility imports), and supporting CHP loading.

Figure 18 – Example Node ESS Operational Summary



Island Mode Modeling Results

The resources included in the Port Washington Community Microgrid have been sized and operated to support island operation for a minimum period of seven days, with multi-week operation likely. During island mode operation, the microgrid control system will maintain system stability and ensure a balance of generation and load. The controller will forecast critical load and PV generation and then dispatch resources to match the load. We anticipate that the resources available to be controlled during island operations will include CHP, fossil fuel generators, PV systems, energy storage, and building load. We also expect that the utility will be able to provide an estimated time to restoration. This estimate will be used to help determine the remaining duration of island operation required, and will influence the dispatch of microgrid resources.

The design strategy for the Port Washington Community Microgrid is to supply the critical load at a level that enables the critical services that keep the community functioning at a sufficient level throughout the entire event duration. This provides full functionality for fire and emergency services while also providing some level of heat and power to other facilities and residents. Each node was modeled for operation during an extended outage (one week) to evaluate and optimize microgrid resources operating in island mode. Two outage events were modeled to represent an outage during the winter and an outage during the summer. Energy flows during the outages are presented as weekly averages in Table 13.

Table 13 –Microgrid Energy Overview: Island Mode Operation

Node	Season	Electric Demand		Electric Consumption	Thermal Load	Thermal Recovery
		Max (kW)	Avg (kW)	kWh/week	kBTU/week	kBTU/week
1	Winter	394	133	22,334	542,379	46,893
	Summer	371	162	27,249	23,858	23,858
2	Winter	808	384	64,464	689,519	355,660
	Summer	749	400	67,251	25,503	25,503
3	Winter	13	3	523	18,172	3,324
	Summer	13	3	587	0	0
4	Winter	38	10	1,621	19,055	3,676
	Summer	28	9	1,572	3,168	2,487
5	Winter	22	7	1,148	32,108	5,125
	Summer	41	9	1,470	1,255	1,249
Total	**Winter**	**1,275**	**536**	**90,091**	**1,301,233**	**414,678**
	Summer	**1,201**	**584**	**98,129**	**53,784**	**53,097**

FINANCIAL FEASIBILITY

The outputs of the technical modeling process described above were used to evaluate the financial viability of the proposed microgrid from two perspectives. First, the project team analyzed the financial strength of the project when deployed under a model in which the microgrid is owned by a special purpose entity (SPE) eligible to claim the federal investment tax credit. Under this model, the project is funded through external investment and debt which is recouped through a PPA with each facility. In addition, NYSERDA contracted with Industrial Economics, Incorporated (IEc) to perform a benefit-cost analysis. The focus of this analysis is to evaluate the societal benefit of the microgrid, including benefits from emissions reductions, cost reductions, and resilience improvements.

Installed Cost

At this feasibility stage of the project, a high-level project budget for the Port Washington Community Microgrid project was developed and incorporated into the technical model to ensure that the design meets both the technical and economic requirements of the project. This budget includes costs for engineering, permitting, capital equipment, site preparation, financing, construction, controls, start-up, commissioning, professional services and training. The budget also includes costs for a portion of the energy efficiency measures at facilities to be included in the microgrid. The cost for these efficiency measures is approximately $110,000. The cost associated with "site preparation" includes the addition and modification of electrical infrastructure, PCC controls, monitoring, and protection equipment. Some of these infrastructure costs may be paid to the electric utility. The estimated installed cost for this project is $4,347,000 with an accuracy of +/- 25% (within the +/- 30% set by NYSERDA). The net cost with the federal investment tax credit (ITC) that was recently extended by the US Congress is $3,596,000. This cost does not include other incentives that may be applicable to the project that will be applied during the detailed analysis in Stage 2.

The project team evaluated several available financial incentives when performing the financial analysis for the Port Washington Community Microgrid. The following programs[1] were evaluated:

- **Demand Response**: PSE&G LI's demand response programs pay customers who are able to temporarily reduce electric usage when requested. This capability will be improved by the existence of the microgrid.
- **Sales Tax Exemption**: Solar photovoltaic systems are 100% free from state and local taxes.
- **Business Energy Investment Tax Credit (ITC):** The ITC includes a 30% tax credit for solar or fuel cell systems on residential and commercial properties and 10% tax credit for CHP systems. If not renewed through legislative action, the ITC will expire in 2016.
- **NYSERDA PON 2568 CHP Acceleration Program**: This program provides financial incentives for the installation CHP systems at customer sites that pay the SBC surcharge on their electric bill, and will be fueled by natural gas that is subject to the SBC surcharge on the gas bill.
- **NY SUN initiative:** This program provides rebates and performance incentives for new residential and commercial solar PV installations. The program provides up to $0.34 per watt for new installed PV that displaces existing usage. An additional incentive of up to $50,000 applies if the project includes energy storage. An additional incentive of up to $50,000 applies if the project includes integrated energy efficiency. The program incentives are capped at 50% of the total installed system cost. NY Sun incentives will be available through 2023.
- **New York Power Authority – Energy Services Program for Public Utilities**: Provides various rebates on energy efficient equipment.

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[1] Identified from the DSIRE database as of December 2015.
http://programs.dsireusa.org/system/program?state=NY

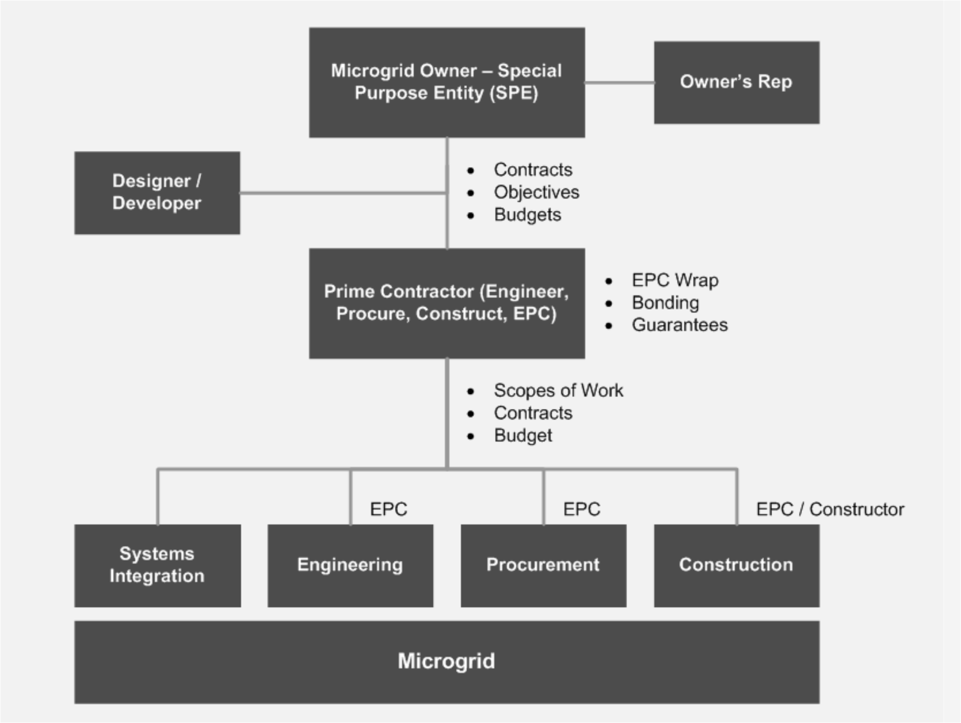
- **NYSERDA Sub Metering Program**: Will provide $250 incentive for each advanced sub meter and $1,500 for each master meter.
- **Federal Energy-Efficient Commercial Buildings Tax Deduction**: $0.30-$1.80 per square foot, depending on technology and amount of energy reduction for buildings that become certified as meeting specific energy reduction targets as a result of improvements in interior lighting; building envelope; or heating, cooling, ventilation, or hot water systems.

Ownership Model

Under the proposed third-party ownership business model, external parties would organize an SPE to fund all development and construction costs of the microgrid, own and operate the assets, and sell the energy generated from the microgrid to community customers through PPAs.

The SPE will engage the design team to finalize the construction drawings and utility interconnection agreements. The SPE will engage an engineering, procurement, and construction firm to build the microgrid, and will be financially responsible for all engineering, procurement, and construction for the system. The SPE will also be financially responsible for integrating the controls and communications systems. This process is presented in Figure 19 below.

Figure 19: Microgrid Development Relationships



To ensure proper operation of individual microgrid resources, an energy performance contractor (selected through a partnership or solicitation, and hired by the SPE) will conduct site acceptance tests that validate the operation and performance of the new equipment. Once the system construction and integration are complete, the SPE will engage a third party commissioning agent that will test the microgrid as a system to ensure that the controls, communication and sequence of operation function to meet the requirements as defined in the specified use cases and the final design. After the fully commissioned system is accepted and transferred to the SPE, the SPE will own and operate the microgrid for a period of 25 years.

Based on assumed project financing costs, and the 25 year contract term, the study supports a PPA electric rate equal to the current average blended rate paid by microgrid participants.

Benefit-Cost Analysis

NYSERDA contracted with IEc to conduct a benefit-cost analysis. The project team provided detailed information to IEc to support this analysis. IEc evaluated all costs against all potential benefits of the system. These benefits, when monetized, totaled $6,630,000, which fell short of the estimated system cost of $11.6 million. The evaluated benefits included:

- Reduction in Generating Costs
- Fuel Savings from CHP
- Generation Capacity Cost Savings
- Distribution Capacity Cost Savings
- Reliability Improvements
- Power Quality Improvements
- Avoided Emissions Allowance Costs
- Avoided Emissions Damages
- Major Power Outage Benefits

IEc ran two scenarios for this proposed microgrid. The first scenario modeled no power outages, and evaluated the grid connected mode of operation. The second scenario modeled the number of days (or partial days) outage at which the costs of the microgrid would be equal to its various benefits, thus yielding a cost benefit ratio of 1. For the Port Washington Community Microgrid, the breakeven outage case is 0.7 days of major power outage per year. The cost benefit results are presented in Table 14. The analyses indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to equal its costs, the average duration of major outages would need to equal or exceed 0.7 days per year (Scenario 2).

Table 14 – Cost Benefit Analysis Results

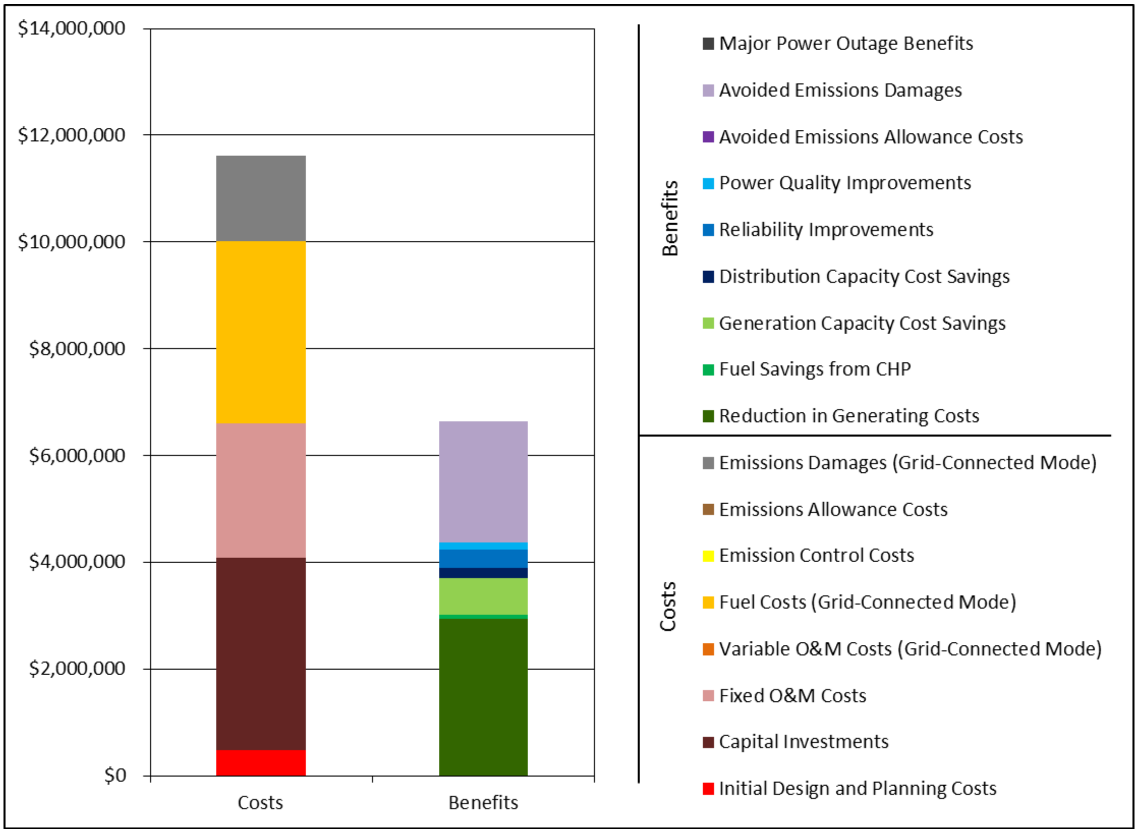
	Assumed average duration of major power outages	
Economic Measure	**Scenario 1: 0 DAYS/YEAR**	**Scenario 2: 0.7 DAYS/YEAR**
Net Benefits - Present Value	-$4,990,000	$361,000
Total Costs – Present Value	$11,600,000	$11,600,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	N/A	7.8%

The cost benefit analysis results for scenario 1 are presented in Table 15.

Table 15 – Cost Benefit Analysis Scenario 1
(No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$3,610,000	$293,000
Fixed O&M	$2,510,000	$221,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$3,410,000	$301,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,610,000	$105,000
Total Costs	**$11,600,000**	
Benefits		
Reduction in Generating Costs	$2,940,000	$260,000
Fuel Savings from CHP	$70,600	$6,230
Generation Capacity Cost Savings	$683,000	$60,300
Distribution Capacity Cost Savings	$188,000	$16,600
Reliability Improvements	$353,000	$31,100
Power Quality Improvements	$137,000	$12,100
Avoided Emissions Allowance Costs	$1,480	$130
Avoided Emissions Damages	$2,260,000	$147,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$6,630,000**	
Net Benefits	**-$4,990,000**	
Benefit/Cost Ratio	**0.6**	
Internal Rate of Return	**N/A**	

Figure 20 – Cost Benefit Analysis Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

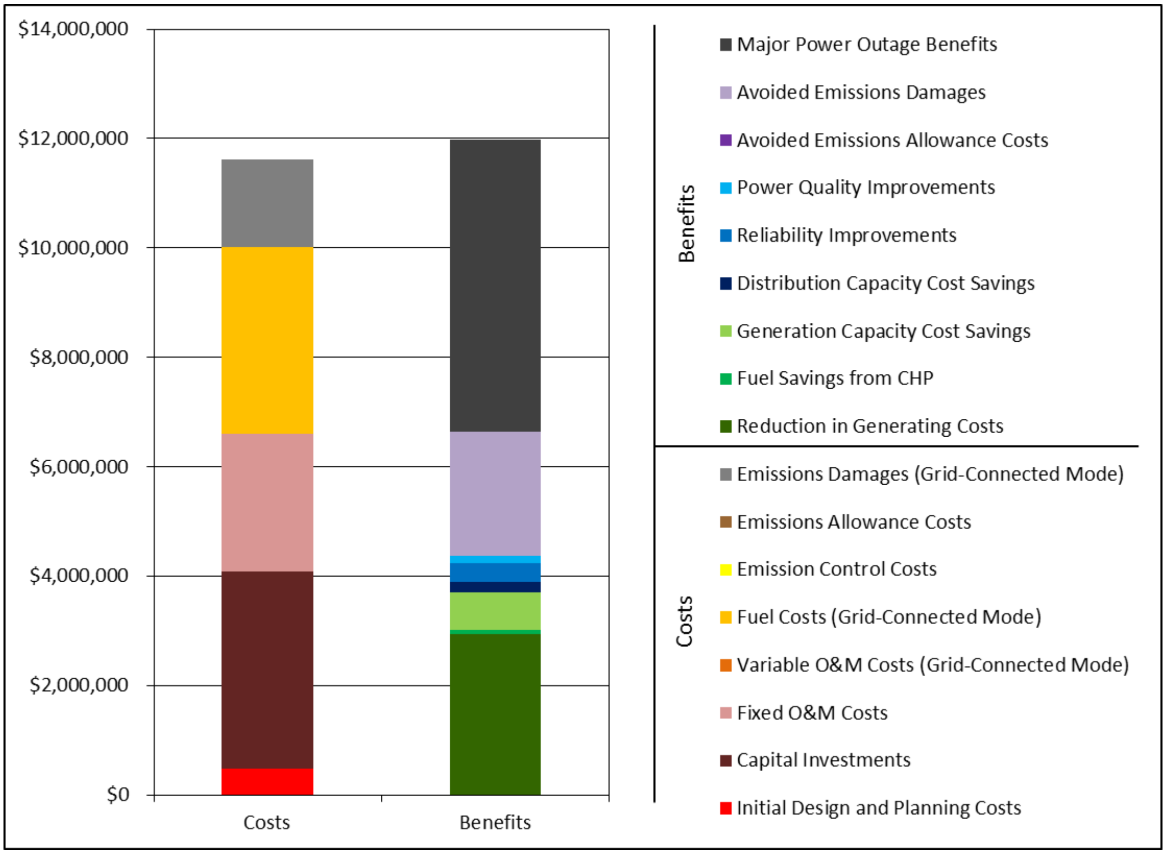


The major drivers of costs are the capital investments and fuel, where the major benefits are reduction in generation costs and avoided emissions damages.

Table 16 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 0.7 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$3,610,000	$293,000
Fixed O&M	$2,510,000	$221,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$3,410,000	$301,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,610,000	$105,000
Total Costs	**$11,600,000**	
Benefits		
Reduction in Generating Costs	$2,940,000	$260,000
Fuel Savings from CHP	$70,600	$6,230
Generation Capacity Cost Savings	$683,000	$60,300
Distribution Capacity Cost Savings	$188,000	$16,600
Reliability Improvements	$353,000	$31,100
Power Quality Improvements	$137,000	$12,100
Avoided Emissions Allowance Costs	$1,480	$130
Avoided Emissions Damages	$2,260,000	$147,000
Major Power Outage Benefits	$5,350,000	$472,000
Total Benefits	**$12,000,000**	
Net Benefits	**$361,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.8%**	

Figure 21 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 0.7 Days/Year; 7 Percent Discount Rate)



The benefits from the 0.7 days of outages result in $5,350,000 during the life of the microgrid. The entirety of the IEC analysis can be found in Appendix D of this report.

Model Comparisons

This benefit-cost analysis differs from the financial feasibility analysis performed by the project team in several ways. In addition to the differing objectives of these two analyses, the underlying assumptions used in each also differed. A few of these differences affected the results of these analyses in significant ways, including:

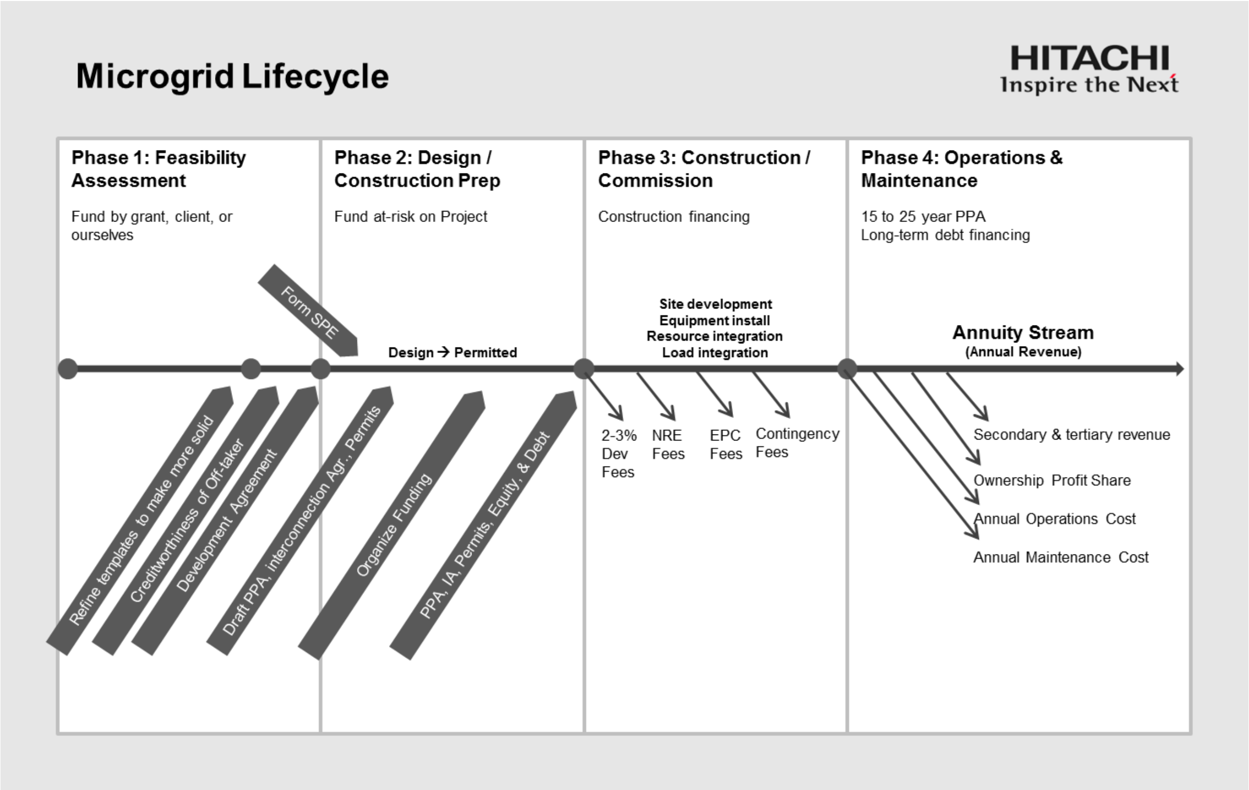
- Gas rates used in IEc's benefit-cost analysis were based on a state-wide average for commercial end-use customers. The rates used in Port Washington's financial feasibility analysis are based on available rate data from National Grid, and assumptions about likely discounts associated with CHP deployments (based on experience with other New York utilities). This resulted in year 1 gas rates of $6.34 and $4.30, for the benefit-cost analysis and the financial feasibility analysis, respectively. If National Grid's distributed generation rate were applied to the benefit-cost analysis, net benefits would be increased by $990,000.

- The financial feasibility assessment incorporates the tax benefits of the Federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit reduces the capital cost of the project by up to $751,000.
- Capital replacement costs used in the benefit-cost analysis BCA were calculated as a full replacement costs, whereas the project team assumed a 'rebuild' cost that is not equal to the full cost of replacement. The rebuild cost for the Port Washington Community Microgrid is $480,000 less than the full cost of replacement.
- The benefit-cost analysis derives a price for electricity based on average wholesale energy costs, whereas the financial feasibility assessment evaluates the savings to the community based on actual costs paid by community participants.
- The period of analysis in the benefit cost analysis is 20 years and the third party ownership model is based on a period of analysis of 25 years.

Development, Construction, and Operating Approach

Once the design phase of a microgrid project is complete, the project must be brought to life by a well-designed and effectively supported development approach. The Hitachi Microgrid Lifecycle process closely matches the NY Prize process shown in Figure 22:

Figure 22: Hitachi Microgrid Lifecycle



In addition to the elements included in NY Prize Stage 1, the Hitachi Microgrid Lifecycle includes an evaluation of the off-taker creditworthiness. In addition to the elements included in NY Prize Stage 2, the Hitachi Microgrid Lifecycle includes establishing a SPE early in the process to formulate the business model negotiation.

Prior to construction, it is important to clearly define the manner in which operations and maintenance (O&M) will be managed once the microgrid is operational. There are multiple options for handling microgrid O&M:

- System owner O&M – The system owner, or SPE, hires staff to operate and maintain the microgrid.
- O&M Contractor – The SPE hires an O&M contractor under a long term service-level agreement.
- Separate Operations and Maintenance Contractors – The SPE hires separate operations and maintenance contractors under long term service-level agreements because each has its own skills advantages and cost savings advantages.

For the long term benefit of all stakeholders, it is important to structure a deal in which all parties benefit from optimal operations of the microgrid. Therefore, the SPE revenue and profitability must be in balance with savings to the community off-takers. The appropriate O&M approach for the Port Washington Community Microgrid has not yet been determined.

System development will involve a complex permitting process. In Stage 2, the team should conduct an environmental assessment that includes CHP air emissions, PV and ESS recycle potential, inverter recycle potential, and visual pollution. The CHP systems will require air quality operating permits, but all proposed systems will qualify for permitting.

The local utility will need to approve of the design of the switching that provides disconnect, islanding, and restoration functions in case of power disruption. The utility will also need to approve plans to use sections of utility distribution equipment while in island mode.

The utility will coordinate protection and switching schemes for the points of common coupling and the distribution system. The project team should address these needs in the interconnection agreement and the studies that support it. The Hitachi approach to points of common coupling simplifies the interconnection agreement and studies for the utility. This is due to the straight-forward approach taken to isolate the microgrid from the distribution grid with control by the utility in accordance with the Institute of Electrical and Electronics Engineers 1547 interconnection standard. This gives the utility more control and makes the interconnection agreement easier to approve.

The project team will use only underground cabling to connect loads in the Port Washington Community Microgrid. Overhead distribution lines do not provide the resiliency or reliability required to meet the specified uptime requirements. Ownership of new purchased and installed underground cabling could be retained by the SPE or gifted to the utility, based on the objectives of community stakeholders. The Reforming the Energy Vision (REV) proceedings include a consideration of such arrangements.

If the utility owns the underground cable, then the utility may charge full delivery charges, or "freight," to the customers. This will likely not be the case if the microgrid project paid for the underground cable. A full freight policy, based on past practice and not true value, eliminates nearly all the community's financial benefit associated with the microgrid. This may become an issue for consideration under REV, and is policy recommendation that Hitachi supports.

Operation of the microgrid will include several key components:

Metering: The SPE will require the state of New York to allow sub-metering that can be applied to the microgrid. The project team will add new sub-metering as necessary.

Technical Operations: The microgrid controls and microgrid design are based on the ten Oak Ridge National Laboratory (ORNL) Microgrid Use Cases. The most important use cases address transition to an island mode (planned and unplanned) and return to grid-connected operations. If desired, the project team can provide a very detailed sequence of operations for transitioning to island and back to grid-connected mode.

Under normal conditions, the microgrid will operate under one of two regimes to accommodate its nodal structure. The first regime is local (within each node) where optimization is primarily focused on assurance of reliable and resilient operations. The second regime is global – across the entire microgrid – where optimization includes economic and emissions reduction objectives. At the global microgrid level, operations are focused on savings to the community and reduction of emissions.

Financial Operations: The SPE will bill system off-takers monthly for energy from system resources. Depending on how the SPE is established with the community, the customer may still be billed by the utility. To simplify bill management for the customers of the microgrid, the utility bill may become a pass-through within the microgrid billing.

Transactional: Any additional revenue to customers from shared utility program participation (demand response, ancillary services) will be accounted for in the monthly bill that the customer receives from the SPE.

PROJECT TEAM

The success of this project relies on a strong team to take it from a feasibility study to an operational system. This Port Washington Community Microgrid team has engaged with nearly all of the major community stakeholders. Local government representatives from North Hempstead have led this project from the beginning, and have signaled North Hempstead's clear interest in participating in a microgrid that can deliver resilient, cost effective energy. Though the local government is not likely to be the lead funder or developer of the microgrid, it is yet to be determined which entity or entities will play that role.

If the town government decides to move forward with the microgrid project, they will need to identify partners to assume, the following roles:

Potential Applicant – It has not been determined which entity would be the potential applicant for Stage 2. Their role, their qualifications, performance history, or financial strength are TBD pending the release of the Stage 2 RFP.

Microgrid Owner – It has not been determined which entity would be the Microgrid Owner. Their role, their qualifications, performance history, and financial strength are TBD.

Contractors – No contractors have been identified at this time, subject to further discussions around project leadership and definition of public procurement requirements.

Suppliers – No suppliers have been identified at this time. No information is available around what their role would be in the project, their qualifications, performance history, or financial strength.

Partners – No partners have been identified at this time. No information is available around what their role would be in the project, their qualifications, performance history, or financial strength.

Legal Advisors –Attorneys from Pace Energy and Climate Center performed in an advisory capacity for the Feasibility analysis, and their document will serve as a foundation for the remainder of the project. However, legal advisors for Phase 2 of this project have not been identified at this time. No information is available around what their role would be in the project, their qualifications, performance history, or financial strength.

Other stakeholders have been kept informed throughout the process and have assisted the study by supporting site audits, providing facility information, and participation in regular status calls. As this project enters the next phase, the project team should hold face-to-face meetings with participants to review the results of the feasibility study and touch base on their interest in participating in the microgrid once it becomes live.

Both PSE&G LI and National Grid are aware of this project and provided letters of support for the initial feasibility study. Throughout the process, the project team has engaged these utilities in design discussions. As of this date, neither utility has weighed in on the value of this project based on the results of the feasibility study.

LEGAL VIABILITY

The project team has developed a model for the legal organization of the Port Washington Community Microgrid based on ownership by a dedicated SPE. The project team has proven the legal viability of this model through numerous existing microgrid projects. This ownership structure maximizes opportunity for low-cost financing, and helps to ensure that final customer rates are kept as low as possible. The ultimate owner of the microgrid system has not been finalized at this point.

The SPE will not own the real estate or facilities in which microgrid systems and equipment will be installed. In each case these sites are owned by customers included in the microgrid. These customers have been included in the planning process throughout the feasibility study. Representatives for each accompanied the project team as they walked through the sites following the kick-off meeting, they have worked with the project team to gather data necessary to construct the model, and they will be included in the project close-out meeting. In each step of the process the project team has discussed plans for locating microgrid equipment at each site with the customers who own that site.

Market Barriers

There are a number of variables which could impact the viability of the project, even if the technical and economic fundamentals look strong. They include:

Financing: There may be aspects of the current market that make securing financing at a competitive cost of capital more difficult. The primary barrier is the education level and familiarity with microgrids within the finance sector. While solar PPA's are now a well-established financing opportunity, only ten years ago, they were little understood by financiers. Today, microgrids are not as well understood in the financial sector. The financial industry has not yet created standardized financing products for microgrids, and each new project has required a custom deal. This tends to drive up the cost of capital.

Stage 2 NY Prize Funding: Stage 1 funding was not sufficient to cover the costs of a comprehensive feasibility study. This was anticipated, and many organizations involved in the delivery engaged in cost sharing and were prepared to make significant investments to deliver a high quality and reliable study for the Port Washington feasibility study. However, given the levels of investment required of vendors in Stage 1, there will be little appetite or ability to incur additional cost share or risk in Stage 2. This is exacerbated by the inherent risks and known and unknown costs associated with the next phase of development, many of which are specific to community microgrids. Stage 2 funding may be critical to moving forward to the next stage of project development.

Customer Commitments: The project economics are highly sensitive to the microgrid design. The design is dependent on customer sites and loads, and the distributed energy resources planned for those locations. A major risk is posed by the possibility of customers withdrawing before final contracts are signed. This would affect the overall microgrid design and fundamental project economics.

Utility Cooperation: The negotiation of interconnection agreements with local utilities can cause significant delays and lead to new costs when the proposed microgrid concepts are unfamiliar to the utility's staff and engineering contractors. To date, PSE&G has demonstrated only moderate levels of support and cooperation with the feasibility study phase. Should this trend continue, North Hempstead can expect this risk to be somewhat significant in the next stage.

Regulatory Issues

The ownership model of the Port Washington Community Microgrid will influence the type of regulatory status it has under Public Service Law. This report assumes that the system will be owned by a third-party SPE. Privately-owned microgrids are legal in New York.

The system will not be considered an electric distribution company by the Public Services Commission because it utilizes qualifying forms of generation,[1] is under 80 MW,[2] serves a qualifying number of users, and its related facilities (including any private distribution infrastructure) are located "at or near" its generating facilities. This saves the system from a raft of burdensome regulatory requirements.

Placing distribution wires or leveraging the existing utility distribution system for energy sharing between facilities will be subject to state-wide electric utility regulations, local franchise and rights of way statutes, and the willingness of the local utility.

Privacy

Ensuring the privacy of the microgrid clients will be of paramount importance for both customer satisfaction and project replicability. The Project Team has taken steps to improve the privacy of all stakeholder data, including all utility data, plans, diagrams and site specific and sensitive information. The project team has done this by setting up a secure data site which allows our team to minimize access of this data to only those directly involved in the modeling and design process. This tightened data control will ensure the project stakeholder's data meets all privacy requirements.

CONCLUSIONS AND NEXT STEPS

The NY Prize feasibility assessment indicates that the Port Washington Community Microgrid is technically viable, and economically viable, assuming the willingness of microgrid participants to pay a rate for electricity at or slightly higher than their current rate. Economic viability strengthens further if future grants are awarded from NYSERDA in the NY Prize Stages 2 and 3. The microgrid will protect the operation of critical facilities in the two primary nodes, ensuring that many community services for vulnerable populations and the community at large can continue uninterrupted, while the schools can be used as emergency shelters. Additional microgrid nodes

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[1] Qualifying generation facilities are defined in PSL § 2 as those falling under the definitions of "Co-generation facilities," "Small hydro facilities," or "Alternate energy production facilities." A qualifying co-generation [1]
[2]Qualifying generation facilities are defined in PSL § 2 as those falling under the definitions of "Co-generation facilities," "Small hydro facilities," or "Alternate energy production facilities." A qualifying co-generation facility is defined as "Any facility with an electric generating capacity of up to eighty megawatts…. together with any related facilities located at the same project site, which is fueled by coal, gas, wood, alcohol, solid waste refuse-derived fuel, water or oil, …. and which simultaneously or sequentially produces either electricity or shaft horsepower and useful thermal energy that is used solely for industrial and/or commercial purposes." NY PSL § 2-a. A qualifying small hydro facility is defined as "Any hydroelectric facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts." NY PSL § 2-c. A qualifying "alternate energy production facility is defined as "Any solar, wind turbine, fuel cell, tidal, wave energy, waste management resource recovery, refuse-derived fuel or wood burning facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts, which produces electricity, gas or useful thermal energy." NY PSL Ser § 2-b.
[2] Id.

will protect other important facilities and functions including the hamlet's water district and animal shelter.

The Port Washington Community Microgrid is designed to directly address the vulnerabilities associated with the hamlet's location, hardening the hamlet's infrastructure and making services more resilient. This project should yield considerable lessons for other communities threatened by storms and flooding from their proximity to water and can serve as a model for similar microgrids around the state and across the country.

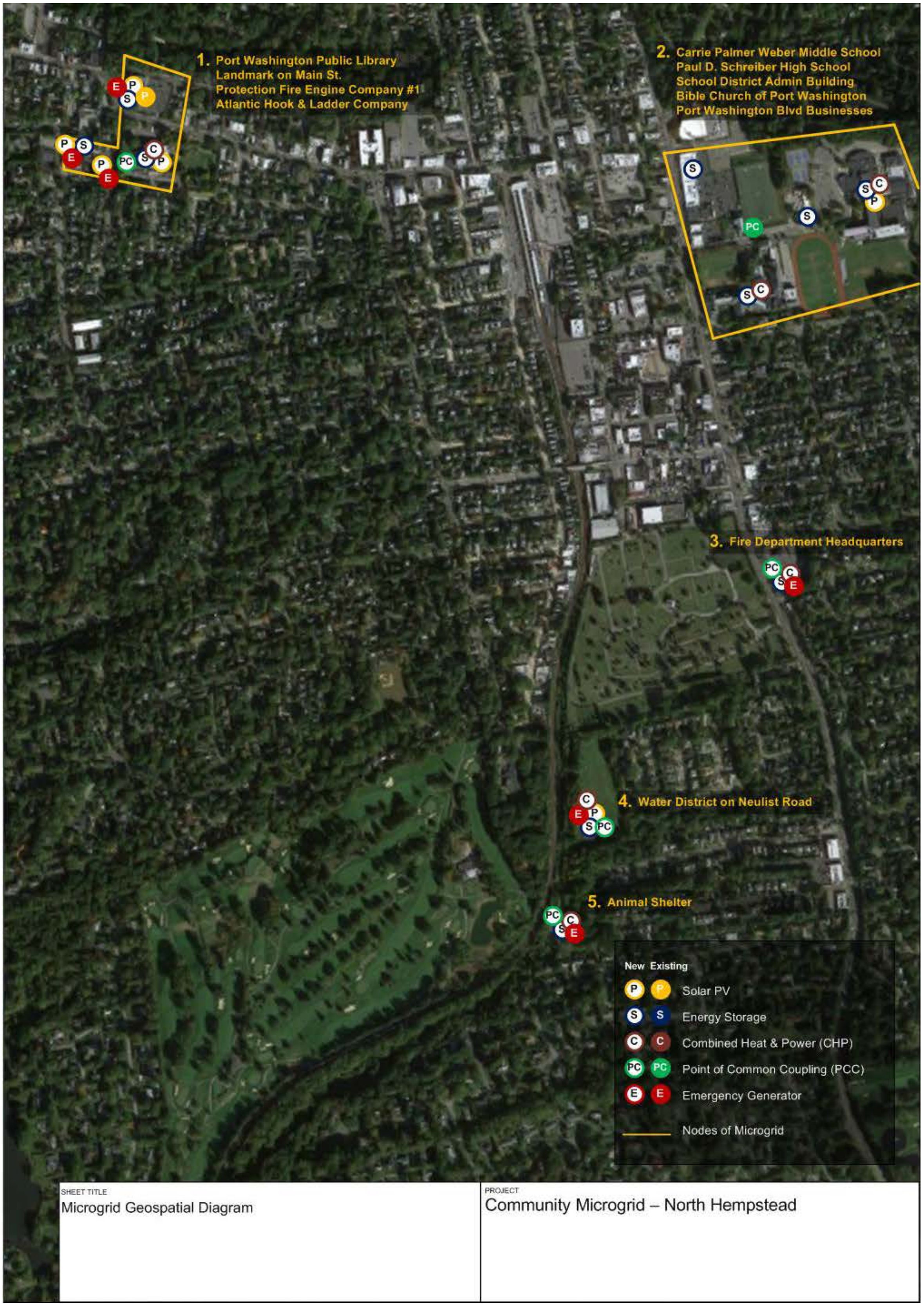
Key findings from the NY Prize feasibility assessment include:

1. ***Engaged Stakeholders***: The larger loads in the Port Washington Community Microgrid are all at facilities and institutions that are well established, and committed to the project, including many that are directly managed by municipal government agencies and service providers. This improves the prospects for the microgrid's adoption, unless final PPA rates exceed current energy costs. Many of the participants are unable or unlikely to purchase energy at a higher than assumed rates, without significant and clear benefits.
2. ***Many Small Distributed Systems***: The fact that the microgrid includes several nodes, and that several of them are quite small, contributes to a higher total installed cost.
3. ***Natural Gas Costs***: The cost of natural gas for CHP is not firm. The estimate that the project team used for the financial analysis was made using available data from National Grid and assumptions based on distributed generation discounts from other New York utilities. However, going forward, the project team will need to work closely with National Grid to establish a final, firm natural gas rate for the CHP installations included in the microgrid plan.
4. ***Community Microgrid Financing Costs***: The cost of project financing is high for community microgrids. This is due to the fact that there are numerous stakeholders and potential customers, and that each stakeholder has its own procurement requirements. The project team will need to seek out a financier that is knowledgeable about these projects, and can help keep transaction costs to a minimum.
5. ***Financial Prospects:*** As it stands, the Port Washington Community Microgrid project is likely to meet the financial requirements for third party financing and/or ownership only if microgrid participants are willing to pay a cost of electricity at or slightly higher than their current rate. In order to strengthen the case for financing, one or more of the following conditions would need to be met:
    a. The award of Stage 2 and Stage 3 NY Prize grants from NYSERDA
    b. The inclusion of additional commercial customers with higher electric costs
    c. Removal of smaller facilities and nodes
    d. The use of PPA rates above the current average cost of energy for prospective microgrid customers]

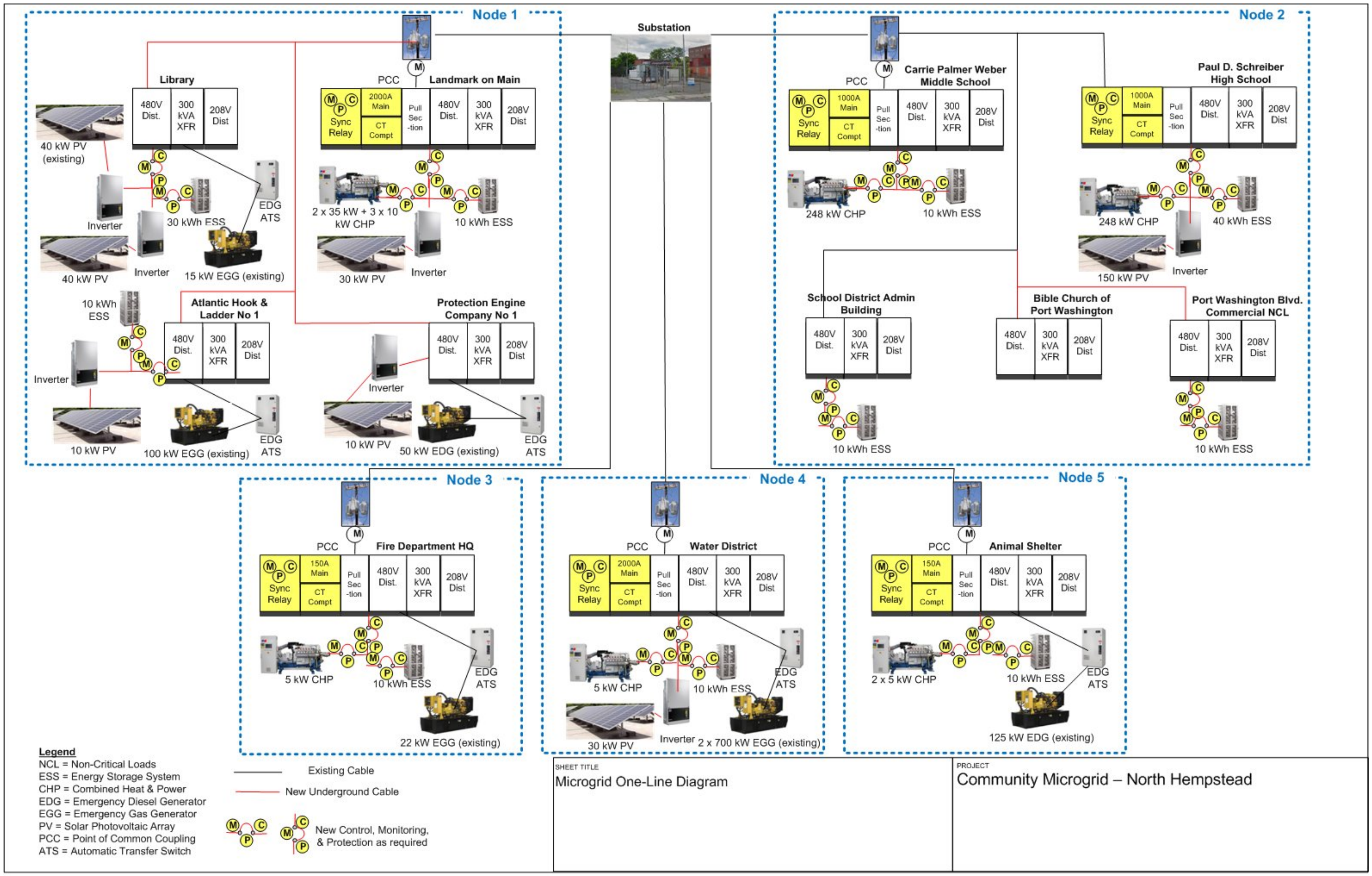
The next steps that the Port Washington community will need to undertake are to finalize the ownership structure to be proposed, and identify a team of partners to engage in the detailed design phase of the project.

[End of Report]

APPENDIX A: PORT WASHINGTON MICROGRID LAYOUT DIAGRAM



APPENDIX B: PORT WASHINGTON MICROGRID ONE-LINE DIAGRAM



Legend

NCL = Non-Critical Loads
ESS = Energy Storage System
CHP = Combined Heat & Power
EDG = Emergency Diesel Generator
EGG = Emergency Gas Generator
PV = Solar Photovoltaic Array
PCC = Point of Common Coupling
ATS = Automatic Transfer Switch

SHEET TITLE
Microgrid One-Line Diagram

PROJECT
Community Microgrid – North Hempstead

APPENDIX C: LEGAL AND REGULATORY REVIEW

Legal Issues Related to Ownership Structure

I. Ownership and Public Service Law Regulatory Treatment

The ownership model that the Port Washington microgrid undertakes will influence the type of regulatory status it has under Public Service Law. Three basic potential ownership models are identified below, with relevant regulatory implications noted.

1. Utility Ownership of Microgrid Assets, Inclusive

Utility ownership of microgrid assets can have the potential benefits of lowering the technical and administrative burdens on project participants, easing the interconnection process, and providing a ready source of capital, among others.

LIPA, a non-profit municipal electric provider, owns the retail electric Transmission and Distribution System on Long Island. It does not presently own any on-island generation. LIPA's enabling statute grants it the authority "to acquire, construct, improve, rehabilitate, maintain and operate such generating, transmission and related facilities as the authority deems necessary or desirable to maintain an adequate and dependable supply of gas and electric power within the service area."[3] If LIPA ownership of various microgrid assets is proposed, such as generation, storage, or advanced controls, further dialog with corporate counsel and LIPA's Board of Trustees would be necessary to determine LIPA's appetite and ability.

2. Utility Ownership of Non-Generation Microgrid Assets Only

Even if LIPA does not own any of the DER assets within the Port Washington microgrid, it may still be beneficial for the project to rely on existing distribution service to carry power between microgrid customers and avoid the investment and regulatory burden associated with private distribution. If LIPA ownership of only distribution microgrid assets is proposed, it will be necessary to address the method under which the microgrid will export to the utility grid. There are several potential regimes under which individual customers within the microgrid may export power onto the utility grid.

A) Net metering

New York's net metering law allows customers with eligible distributed generation sources to export power onto the utility grid. This mechanism may be relevant for facilities exporting power onto utility-owned wires for distribution to other microgrid customers. Net metering allows onsite generators to offset grid electricity purchases (when onsite demand exceeds onsite generation) with power exported to the grid (when onsite generation exceeds onsite demand). Under this mechanism, qualifying generators can effectively receive retail rates for their excess generation. Net metering is available in New York to residential and nonresidential solar, wind, fuel cells, microhydroelectric, agricultural biogas, and residential micro-CHP.

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[3] New York Public Authorities Law § 1020-g.

The size of the eligible generator is capped depending on the kind of generation (e.g., solar, wind, etc.) and customer type (e.g., residential, nonresidential, farm). The cap for residential solar, wind, and micro-hydroelectric is 25 kW. The cap for nonresidential solar, wind, and micro-hydroelectric is 2 MW. The cap for farm-based wind is 500 kW, and the cap for farm-based biogas is 1 MW. The cap for residential fuel cells and micro-CHP is 10 kW, while the cap for nonresidential fuel cells is 1.5 MW.[4]

In the Port Washington microgrid project, proposed PV generation assets may be eligible to receive net metering credit. LIPA's net metering tariff may be found at its tariffs under the Fifth Revised Leaf No. 34A.[5]

B) Buyback Tariffs

For generation that is not eligible for net metering, microgrid owners may also sell energy services through applicable "buy back" tariffs that require utilities to purchase excess generation from qualifying facilities. LIPA's buyback tariff can be found in its tariffs under the Third Revised Leaf No. 251.[6]

The buyback tariff will typically provide highly variable rates to the microgrid owner for energy services. The utility typically buys generation from the participating customer at the Locational Based Marginal Price (LBMP), which reflects the wholesale price of energy through NYISO's bulk power markets at the transmission level. From the standpoint of the nonutility microgrid owner, selling relatively large amounts of energy produced via a buy back tariff would likely not be a preferred arrangement due to the uncertainty of the revenue stream resulting from the fluctuating wholesale price of energy.

Selling energy back to the utility via a buy back tariff may be a viable option for North Hempstead if used as a secondary means of receiving compensation for energy services. This may be particularly salient if the system is designed to provide thermal energy through CHP operated to follow thermal demand. In these instances, there will be times where electric generation exceeds electric demand. When this occurs, the grid can serve as a destination for the surplus power produced.

The ability to sell surplus energy via the buyback tariff also provides the option for microgrids to export intentionally to the grid when the LBMP is at favorable rates. For example, while the Burrstone Microgrid has established a PPA with each microgrid user that covers most of the energy produced, the microgrid sells surplus power to National Grid at the LBMP. To operationalize the microgrid's interaction with the wholesale power market, Burrstone developed an algorithm that governs the microgrid control system. Using market prices fed into the algorithm, the microgrid control system provides signals to the units indicating when to run and when not to run. Burrstone's algorithm makes hourly operational decisions that are automatically implemented by the Energy Management System.

3. Privately-Owned Microgrid Distribution

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[4] NY PSL § 66-j.

[5] Available at http://www.lipower.org/pdfs/company/tariff/lipatariff.pdf.

[6] Id.

North Hempstead may pursue a privately-owned microgrid in a variety of flavors: a third-party energy services company, a special purpose entity or LLC owned and controlled by microgrid customers, or some combination of the two as relates to different assets. The important legal question across all varieties of this model will be whether the microgrid is an electric distribution company under Public Service Law, and if so, what level of regulation it will fall under at the Public Service Commission. Discussion of the State-level regulatory landscape, Section 2 of the Public Service Law, and various cases applying its standards will inform this discussion. New models of regulatory treatment, currently under discussion in the REV proceeding, may also apply if adopted in the future.

A) Currently Existing Regimes of Regulating Privately-Owned Microgrid Distribution Under Public Service Law

Under existing law and Commission guidance, the Port Washington microgrid will be treated as an electric corporation under Public Service Law unless it is deemed a qualifying facility under the terms of PSL §§ 2(2-d) or otherwise qualifies for lightened regulation.

If subject to the full spectrum of regulation that the Commission may exercise over an electric corporation, the microgrid may be regulated for general supervision[7] (investigating the manufacture, distribution, and transmission of electricity; ordering improvements; and performing audits), rates,[8] safe and adequate service,[9] all aspects of the billing process, financial, record-keeping, and accounting requirements,[10] corporate finance and structure,[11] and more. This expansive purview of regulation may prove too administratively onerous for a small project like the Port Washington microgrid to comply with. It is therefore important that, if the microgrid utilizes private distribution infrastructure, it be designated a qualifying facility, be subject to lightened regulation, or be granted some alternate regulatory status, as discussed in part (B) of this section.

i. Qualifying Facility

North Hempstead's microgrid may be exempted from much of the PSL regulation applying to electric distribution companies if it is deemed a qualifying facility under the terms of PSL §2. A microgrid will be deemed a qualifying facility if it utilizes qualifying forms of generation,[12] is under

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[7] PSL § 66.

[8] PSL § 65.

[9] PSL § 66.

[10] PSL § 66, 68(a).

[11] PSL § 69.

[12] Qualifying generation facilities are defined in PSL § 2 as those falling under the definitions of "Co-generation facilities," "Small hydro facilities," or "Alternate energy production facilities." A qualifying co-generation facility is defined as "any facility with an electric generating capacity of up to eighty megawatts…. together with any related facilities located at the same project site, which is fueled by coal, gas, wood, alcohol, solid waste refuse-derived fuel, water or oil, …. and which simultaneously or sequentially produces either electricity or shaft horsepower and useful thermal energy that is used solely for industrial and/or commercial purposes." NY PSL § 2-a. A qualifying small hydro facility is defined as "any hydroelectric facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts." NY PSL § 2-c. A qualifying "alternate

80 MW,[13] serves a qualifying number of users, and its related facilities (including any private distribution infrastructure) are located "at or near" its generating facilities.

Type of generation facilities: In the North Hempstead project, PV generation facilities have been proposed that will qualify. CHP facilities have also been proposed that will likely qualify if its electricity, shaft horsepower, or useful thermal energy is used solely for industrial and/or commercial purposes.

Size of generation facilities: In the North Hempstead project, generation facilities will likely fall under the statutorily imposed 80 MW limit.

Qualifying number of users: It is difficult to apply the requirement that a microgrid serve a qualifying number of users in the abstract. This requirement has not been explicitly spoken to by the Commission, but has been contested in Case 07-E-0802, regarding the Burrstone Energy Center.[14] There, petitioners raised the question of whether a qualifying facility may distribute power to three different institutional users – a hospital, college, and nursing home. The Commission found that "furnishing electric service to multiple users" is specifically contemplated in PSL §2(2-d) "by providing that electricity may be distributed to 'users,' in the plural."[15] The Burrstone Energy Project was held to qualify for regulatory exemption.

The *Burrstone* case is the only existing precedent of the Commission applying the "qualifying facility" standard to more than one user. One interpretation of this precedent might conclude that no upper bound exists on the number of users that may be served by a qualifying facility. This interpretation, however, may prove unwisely speculative. In the case of the Port Washington microgrid, it would be wise, as the petitioners in *Burrstone* did, to petition the Commission for a declaratory ruling that the multiple users anticipated in this microgrid do not run counter to the Commission's interpretation of PSL §2.

Distribution facilities at or near generation: The physical distance that distribution facilities may extend from generation facilities has been questioned in several Commission decisions applying the qualifying facility standard.[16] A limited review of prior cases interpreting the "at or near" requirement could suggest that a project will be deemed a qualifying facility if its distribution network is under two miles. However, this range might expand (or contract) depending on several types of variables, which the Commission has cited in previous precedent, including: whether the project site is in a densely or sparsely developed location; what type of technologies it uses (e.g., a

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energy production facility is defined as "any solar, wind turbine, fuel cell, tidal, wave energy, waste management resource recovery, refuse-derived fuel or wood burning facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts, which produces electricity, gas or useful thermal energy." NY PSL Ser § 2-b.

[13] Id.

[14] Case 07-E-0802 - Burrstone Energy Center LLC – Petition For a Declaratory Ruling That the Owner and Operator of a Proposed Cogeneration Facility Will Not Be Subject to Commission Jurisdiction (August 28, 2007).

[15] Id.

[16] See NYSERDA, "Microgrids for Critical Infrastructure Resiliency in New York," (Dec. 2014), at 31.

wind farm will naturally require a broader distribution network due to the acreage it takes up); and whether those facilities stay on private property or cross public rights of way.[17]

In the Port Washington microgrid, the geographic footprint of private distribution facilities may or may not satisfy the "at or near" test developed by the Commission, depending on the extent of private distribution facilities proposed. The maximum distance between properties proposed to be incorporated in the microgrid appears to be approximately 2 miles. Private distribution facilities would have to cross property lines and several rights of way. Declaratory rulings addressing facilities in comparable environments have approached this distance, such as *Burrstone* (approximately half a mile),[18] *Nissoquogue Cogen Partners* (1.5 miles),[19] and *Nassau District Energy Corporation* (1.7 miles).[20] Of these, the closest precedent may be the Burrstone case, because the Commission in Burrstone considered whether crossing multiple property lines complicated the "at or near" analysis (while Nissoquogue and NDEC involved distribution passing almost entirely over a single property). If the Port Washington microgrid opts to own private distribution over the total extent of both nodes, it would be pushing against the length for which positive precedent exists. If some lesser private distribution design were proposed, it might more easily satisfy this requirement.

In light of the above factors, the Port Washington microgrid project may satisfy the "at or near" requirement to achieve qualifying facility status. If the project wishes to secure its qualifying status, it must petition the Commission for a declaratory ruling to this effect.

ii. Lightened Regulation

If the North Hempstead project does not otherwise qualify for regulatory exemption, it may petition the Commission for a lightened regulatory burden. The Commission may consider a "realistic appraisal" of the need to regulate the microgrid based on a three-prong analysis: 1) whether a particular section of the PSL is inapplicable on its face; 2) if a provision is facially applicable, whether it is possible for an entity to comply with its requirements; and 3) whether imposing the requirements on an entity is necessary to protect the public interest, or whether doing so would adversely affect the public interest.[21] A realistic appraisal yields different results depending upon the microgrid's characteristics. The PSC recently applied the "realistic appraisal" test to the Eastman Park facility, which resembles a microgrid.[22] The precedent of microgrids receiving lightened regulatory burden under this standard is very thin, however, and it is difficult to prognosticate how this standard would be applied to the North Hempstead project.

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[17] Id.

[18] Case 07-E-0802 - Burrstone Energy Center LLC – Petition For a Declaratory Ruling That the Owner and Operator of a Proposed Cogeneration Facility Will Not Be Subject to Commission Jurisdiction (August 28, 2007).

[19] Case 93-M-0564, In re Nissoquogue Cogen Partners, Declaratory Ruling (1993)

[20] Case 89-E-148, Nassau District Energy Association, Petition for a Declaratory Ruling (Sept. 27, 1989).

[21] Case 98-E-1670, In re Carr St. generating Station, Order Providing for Lightened Regulation, at 4–5 (Apr. 23, 1999).

[22] Case 13-M-0028, RED-Rochester LLC and Eastman Kodak Company, Order Approving Transfer Subject to Conditions, Providing For Lightened Ratemaking Regulation, and Making Other Findings (issued May 30, 2013).

B) Future Regimes of Regulating Privately-Owned Microgrid Distribution Under Public Service Law

In its February 26th 2015 "Order Adopting Regulatory Framework and Implementation Plan,"[23] the Commission considered that a third model for regulating "community microgrids" with respect to the PSL might be appropriate. The Commission did not fully articulate how this model would function or make specific proposals. Parties were invited to comment on this matter on May 1st, 2015. The Port Washington microgrid project may be impacted by any future regulatory developments issued by the Commission pursuant to these comments or otherwise in REV.

II. Contractual Considerations for Various Ownership Models

The regulatory implications addressed in Section I make some distinction regarding who owns various types of microgrid infrastructure. As previously discussed, whether the utility or private parties own different types of microgrid assets may impact how they are treated by the Commission and under Public Service Law. However, setting aside State regulatory issues, there remain various contractual considerations that may impact how rights and responsibilities are aligned between microgrid parties. This section will consider those contractual questions.

North Hempstead's microgrid proposal has not yet addressed which parties may have the appetite for ownership, the access to capital, expertise, or what the preferred ownership structure would be for other participants. This section therefore addresses the potential ownership models introduced in Section I in the abstract and notes the areas of contractual tension that may arise for these parties.

1. Contracting between Utility and Customer/Project Developer in a Utility-Owned DER/Generation Model

Wholly utility-owned microgrids may have several advantages over privately-owned microgrids, including ease of the interconnection process, the utility's superior access to capital, and ease of customer solicitation, given the utility's existing relationship with its customers. Examples of microgrids where the utility owns at least some of the generation assets are the Consortium for Electric Reliability Technology Solutions (CERTS) demonstration project in Ohio, owned by American Electric Power,[24] and the Borrego Springs microgrid owned by San Diego Gas & Electric.[25]

From a contracting perspective, utilities may have broad latitude to develop unique contracting arrangements directly with customers in a pilot or demonstration project. There do not exist model contract templates for microgrid service. In Central Hudson's microgrid proposal, for example, it

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[23] Case 14-M-0101, Order Adopting Regulatory Framework and Implementation Plan, Feb. 26, 2015, at 110.

[24] See "CERTS Microgrid Test Bed with American Electric Power," CERTS, available at. http://energy.lbl.gov/ea/certs/certs-derkey-mgtb.html.

[25] See "Microgrids: Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts," DNV KEMA, at 6-3; and "Microgrids: An Assessment of Values, Opportunities, and Barriers to Deployment in New York State," NYSERDA, at A-2.

proposed developing "a service agreement for a specified term under which the cost for [microgrid] facilities would be recovered,"[26] but left open for collaborative discussions how this agreement would be structured. Customers will want to be concerned with the following aspects of contracting for microgrid service:

- Price of power
    - Potentially variable depending on customer class, demand level, and time of use
    - Potentially variable as linked to fluctuating operating costs, such as fuel prices
    - Value of tax credits, incentives, accelerated depreciation incorporated into rates or otherwise passed onto customers
- Customer obligation to take specific quantities of power or total system output over a given period
- Utility's obligation to produce certain quantities of project power over a given period
- Load shedding protocols
    - Price for varying levels of continued service in outage situation
- Penalties for non-performance or lateness in developing the project
- Ownership of RECs generated
- Any applicable terms relating to leasing customer land or facilities to microgrid owner
    - Insurance to cover damages to property
- Level of exit fees
- Allocation of interconnection costs
- Transferring service obligation to future property owners / encumbering property
- Potential joint-financing schemes (i.e., a municipal customer with a higher credit rating than utility may take lead on securing financing for some portion of project)

2. Contracting between Utility and Customer/Project Developer in a Privately-Owned DER/Generation Model

There does not presently exist a model tariff for utilities to provide islanding service to a group of customers served by privately-owned DERs. However, different microgrids have proposed to move forward under existing or novel tariffs with the incumbent utility to use utility distribution and rely on the utility to integrate with private microgrid controllers to support islanding functionality.[27]

In the North Hempstead project, existing utility distribution infrastructure may be employed, where the project exports power under a combination of standard net metering and buyback tariffs. In this case, key considerations would include:

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[26] Case 114-E-0318, Testimony of Reforming the Energy Vision Panel (July 25, 2014) at 14.

[27] See, e.g., discussion of the Parkville microgrid in NYSERDA's 2014 report, "Microgrids for Critical Infrastructure Resiliency in New York State," at 129, which states that "The Parkville Microgrid will also employ a buy/sell arrangement for the hybrid utility microgrid in addition to utilizing virtual net metering. The net excess energy produced by the reciprocating engine in the school that is not credited to another municipal account via virtual net metering will be purchased by the utility at applicable buy-back rates. The other microgrid users (i.e., the supermarket and gas station) will continue to buy their energy from the utility at their normal tariffs."

- Applicable tariff under which different levels of power export will occur
- Rights of utility to access or control equipment and facilities to ensure operational safety (easements, fee for access, etc.)

3. Contracting between Customer and Private Developer

Privately-owned microgrids are permissible in New York, subject to the regulatory concerns around PSL regulation discussed in the previous section. See the Burrstone Energy Center case study in NYSERDA's 2010 microgrid report.[28] A privately developed microgrid may be owned by a third-party developer with no pre-existing contractual relationship with the parties, or microgrid customers may collectively form a limited liability corporation for the purpose of owning and operating the microgrid on its customers' behalf. In either case, contractual concerns for customers may include:

- Price of power
    - Potentially variable depending on demand, time of use
    - Potentially variable as linked to fluctuating operating costs, such as fuel prices
    - Value of tax credits, incentives, accelerated depreciation incorporated into rates or otherwise passed onto customers
- Customer obligation to take specific quantities of power or total system output over a given period
- Developer's obligation to produce certain quantities of power over a given period
- Load shedding protocols
    - Price for varying levels of continued service in outage situation
- Penalties for non-performance or lateness in developing the project
- Ownership of RECs generated
- Any applicable terms relating to leasing customer land or facilities to microgrid owner
    - Insurance to cover damages to property
- Fair exit fees
- Allocation of interconnection costs
- Transferring obligation to future property owners / encumbering property
- Potential joint-financing schemes (i.e., a municipal customer with a higher credit rating than developer may take lead on securing financing for some portion of project)
- Privacy of customer usage data
- Division of operational responsibilities
- Allocation of potential liabilities / indemnification of customers or developer
- Access rights to equipment/facilities (easements, fee for access, etc.)
- Purchase option at end of service term
- Division of interconnection costs between developer and customers

It is premature at this time to make a recommendation on ownership structure for the North Hempstead project.

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[28] NYSERDA, "Microgrids: An Assessment of the Value, Opportunities, and Barriers to Deployment in New York State," (Sept. 2010) at A-45.

III. Franchises and Rights-Of-Way

All entities that require the use of public ways (i.e., for transmission or distribution facilities) must be granted permission by the presiding municipal authority in the form of a franchise or some lesser consent, depending on the scope of the usage. The cities, towns, and villages of New York have specific statutory authority to grant franchises: as provided by N.Y. Twn. Law § 64, every city is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city.[29] "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.[30]

In the town of North Hempstead, the process for granting a franchise for electric distribution wires is not specified, nor is any other franchising procedure provided for guidance. Under N.Y. Twn. Law, the Town Board will have discretion in determining the application process to obtain a franchise or lesser consent, subject to a public hearing preceded by proper notice.[31] Comparable jurisdictions have adopted specific franchise requirements that North Hempstead may look to.[32]

IV. Application of Other Local Codes

1. Zoning

The candidates to receive microgrid service in North Hempstead are zoned as follows:

- The Landmark at Main, 232 Main Street #1, Port Washington NY 11050: C-F Community Facility District
- Protection Engine Company No. 1, 14 South Washington Street, Port Washington NY 11050: R-C Residence C District
- Atlantic Hook & Ladder Company No. 1, 25 Carlton Avenue, Port Washington NY 11050: R-C Residence C District
- Port Washington Library, 1 Library Drive, Port Washington NY 11050:
- Paul D. Schreiber High School, 101 Campus Drive, Port Washington NY 11050: R-A Residence A District
- Carrie Palmer Weber Middle School, 52 Campus Drive, Port Washington NY 11050: B-A Business A District
- Port Washington Union Free School District Administration Building, 100 Campus Drive, Port Washington NY 11050: B-A Business A District

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[29] N.Y. Twn. Law § 64.

[30] See, e.g., "Contract of April 7, 1887 between Hess et al. Commissioners & Consolidated Telegraph & Electrical Subway Co." (Con Tel and Electrical Subway Company Agreements 1886-1891.pdf)

[31] N.Y. Twn. Law § 64.

[32] See, e.g., Chapter 292 of New Rochelle Code, available at http://ecode360.com/6737770.

- Port Washington Police Department Headquarters, 500 Port Washington Boulevard, Port Washington NY 11050: R-B Residence B District
- Port Washington Fire Department Headquarters, 423 Port Washington Boulevard, Port Washington NY 11050: R-B Residence B District
- Port Washington Water District, 20 Neulist Avenue, Port Washington NY 11050: R-C Residence C District
- Town of North Hempstead Animal Shelter, 75 Marino Avenue, Port Washington NY 11050: R-C Residence C District

Generation as Permitted Use

Electric generation is expressly listed as a permitted use in the Hospital District of North Hempstead; however, electric generation is not expressly permitted in any district where candidate properties for microgrid service in North Hempstead are located. Power generated in the Hospital District may only be used to service the needs of the hospital's campus and may not be generated for commercial uses or offsite uses, and thus, cannot be extended to any of the relevant residential or business districts.[33] The Code is clear that in the community facility, residential, and business districts, "lots or premises may be used for any of the purposes set forth in [the governing Article] and no other."[34] Generation must be sited pursuant to some other permitted use, as an accessory use, a special permit use, or a variance. For these purposes, the relevant zoning implications will be identical across all zones.

Accessory Use: Like many jurisdictions, permitted accessory uses are not listed exhaustively in the Zoning Code. Rather, zoning restrictions for each district include a section on accessory uses that is often linked by reference to permissible uses in other districts. Generators are expressly permissible accessory uses in residential districts where they comply with all requirements for accessory buildings and structures.[35] Generation may be a permissible accessory use in business districts and community facility districts if they meet the definition of being "subordinate or …customarily incidental to and located on the same lot."[36] Emergency generation is not expressly listed as a permitted accessory use anywhere in the Code.

While in some jurisdictions, backup electric generation is considered an accessory use, it is uncertain that electric generation of a scale to be sold back to the grid or a microgrid operator in large quantities would be considered accessory to the principal uses of the districts in question. Whether power export is "customarily incidental" to other permitted uses of the properties in question poses, at least, some regulatory uncertainty.

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[33] North Hempstead Zoning Code § 70-96.4.

[34] See North Hempstead Zoning Code § 70-105.2 for C-F District, § 70-24 for R-A District, § 70-34 for R-B District, § 70-44 for R-C District, and § 70-125 for B-A District.

[35] North Hempstead Zoning Code § 70-100.2(K), as enabled by § 70-99.

[36] North Hempstead Zoning Code § 70-231. See also North Hempstead Zoning Code § 70-125(S) for B-A District. See also § 70-105.2(B) for C-F District.

Special Permit Use for "Public Utility": All residential zones include "Public Utility" as a conditional use subject to Zoning Board of Appeals approval.[37] "Utilities" are regulated in respect to each zone; however, "Public Utility" is not defined in the Zoning Code itself.[38]

If public utility use is of the same general character as any permitted use in the business district, it may be a special use if approved by the Zoning Board of Appeals.[39]

Special permits and conditional use permits are granted following an application to the Zoning Board of Appeals and a public hearing process.[40] The approving agency will have wide discretion in evaluating the application, subject to the following standards:

> 225(B)(1)(a) The purposes of zoning as laid out in the NY Town Law as well as permitted uses in the district where the property is located.[41]
>
> 225(B)(1)(b) The character, use, size, location, design, and site layout on the site are such that the special permit or conditional use is "appropriate to and in harmony with the surrounding properties."[42]
>
> 225(B)(1)(c) The proposed use will provide "a desirable service, facility or convenience to the area or otherwise contribute to the proper growth and development of the community and to its general welfare."[43]
>
> 225(B)(1)(d) The proposed use will not be "hazardous, conflicting or incongruous to the immediate neighborhood" due to excessive traffic, gather of individuals or vehicles, "proximity to travel routes or congregations of children or pedestrians."[44]
>
> 225(B)(1)(e) The proposed use will not be of the kind objectionable to nearby residential dwellings due to noise, light, vibration, or other impacts.[45]

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[37] North Hempstead Zoning Code § 70-25(B) for R-A District; by reference in § 70-35(A) for R-B District, by reference in § 70-45(A) for R-C District. Zoning Board of Appeal approval required by Article XXIV of the Zoning Code.

[38] "Public Utility" is defined in the Telecommunications Code at § 75-2 as "any company authorized by the NY PSC, a municipality, or other such authority) to provide water, electric, gas or telephone services to the public" but the code does not indicate that the definitions in this section are applicable to the terms in the zoning code.

[39] North Hempstead Zoning Code § 70-127.

[40] North Hempstead Zoning Code § 70-225(A).

[41] North Hempstead Zoning Code § 70-225(B)(1)(a).

[42] North Hempstead Zoning Code § 70-225(B)(1)(b).

[43] North Hempstead Zoning Code § 70-225(B)(1)(c).

[44] North Hempstead Zoning Code § 70-225(B)(1)(d).

[45] North Hempstead Zoning Code § 70-225(B)(1)(e).

> 225(B)(1)(f) The proposed use will be harmonious in the district where it is located, will not hinder the use or development of adjacent uses, and will not hinder nor degrade the value of adjacent uses.[46]
>
> 225(B)(1)(g) In a business or industrial district, the Zoning Board of Appeals must also consider the nature and intensity of the proposed use, the site layout, and access to streets.[47]

Variances: The Zoning Board of Appeals is empowered to hear applications for variances from the use restrictions of the Zoning Code. The Code specifies application requirements but does not require satisfaction of specific criteria.[48] However, NY Town law requires that applicants for use variances meet four criteria:

(a) The applicant cannot realize a reasonable return, provided that lack of return is substantial as demonstrated by competent financial evidence;
(b) That the alleged hardship relating to the property in question is unique and does not apply to a substantial portion of the district;
(c) That the requested variance, if granted, will not alter the essential character of the neighborhood; and
(d) That the alleged hardship has not been self-created.[49]

These requirements are unlikely to be satisfied for microgrid facilities, which may add value to the properties in question, but are not indispensable to the value of the properties in general.

Zoning Solutions: If electric generation were added as a specially permitted use in each of the districts in which microgrid customers have been proposed, it would create a regulatory path forward while allowing the Zoning Board of Appeals to maintain some essential controls over the character and uses of affected neighborhoods. Some relevant considerations for policymakers and model language have been attached in Appendix A.

2. Building Code

The North Hempstead Building Construction Code incorporates the New York Uniform Fire Prevention and Building Code.[50] It does not make any other substantive requirements impacting generation or electrical distribution.

3. Electric Code

The North Hempstead Electrical Code incorporates by reference “the National Electrical Code and the statutes of the State of New York.”[51] It does not make any substantive additions impacting generation or electric distribution.

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[46] North Hempstead Zoning Code § 70-225(B)(1)(f).

[47] North Hempstead Zoning Code § 70-225(B)(1)(g).

[48] North Hempstead Zoning Code § 70-227.

[49] NY Town Law §267.

[50] North Hempstead Code, §2-23.

[51] North Hempstead Code, §2-70.

V. Applicable Tariffs

Distributed generation may be eligible for new tariffs for each of the customers at which DG is sited. This section outlines the various tariff structures one or several customers within the microgrid may fall under. This section builds on the discussion in Section I(2), which discussed tariffs under which power could be exported onto the utility grid, including net metering, buyback, offset, and potential future microgrid regimes.

1. Standby Tariff

Customers operating private generating facilities to cover part of their load while receiving backup or supplementary power from the utility will be subject to LIPA's standby tariff.[52] Under current standby rate design, LIPA recovers the cost of supplying supplemental power through three distinct charges: customer charges, contract demand charges, and daily as used demand charges. The customer charge is designed to recover certain fixed costs, such as metering expenses and administrative costs that do not vary with energy use. The customer charge shows up on the customer's bill as a fixed monthly charge.

The standby contract demand charge is intended to recover variable costs associated with distribution infrastructure dedicated to the customer (e.g. nearby infrastructure that only serves the single customer). The contract demand charge is based on the customer's maximum metered demand during some previous 12 month period of time. The charge is levied regardless of whether the customer's actual maximum peak demand approaches the level at which the charge is set.

The actual level at which the contract demand charge is set can be established by the customer or LIPA. If the customer opts to set their own contract demand charge, penalties can be levied if the charge is exceeded, while a charge set by the utility is not subject to penalties. Exceedance penalties will result in a surcharge equal to 12 times (depending on the level of exceedance) the sum of the monthly demand charges for the demand in excess of the contract demand.

2. Residential/Non-Residential DG Gas Rate

The North Hempstead project is in National Grid's territory for gas service. A distributed generation rate is established in National Grid's territory, applying to customers who "demonstrate the ability to operate at a minimum load factor of 50%, within the first year of service, and have Distributed Generation units with capacity of less than 50 MW."[53] This rate may be economically advantageous for CHP components of the microgrid, although customers should compare costs against a Transportation Rate or the price offered by a third-party gas marketer, as these may also propose a cost-effective solution.

2.1 Cost of Gas Service Upgrades

Microgrids that incorporate new natural gas-fired generators or CHP systems may require the delivery of substantially more natural gas to the site than was previously provided by the utility. If

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[52] Long Island Power Authority's Fifth Revised Leaf No. 262.

[53] *See* National Grid Gas Tariff 215.

the additional natural gas demand exceeds the current infrastructure's capacity, the relevant natural gas mains, service piping, and related facilities will need to be upgraded for the project to succeed. The requirements of utilities and gas upgrade applicants regarding gas service upgrades are governed by 16 NYCRR §230. Prior to any upgrades, the applicant must sign an agreement to assure the utility that he/she will be a reasonably permanent customer, pay the utility for any installation and materials costs beyond the costs the utility is required to bear, and pay a rate for future gas delivery charged to similarly situated customers.[54] Section §230.2 outlines the "100 foot rule," which requires gas utilities to install up to 100 feet of main and service line extensions and related facilities at no cost to the applicants.[55] Utilities can bear the cost of extensions and additional facilities beyond 100 feet if the utility deems the expansion to be cost justified.[56] This situation, however, is relatively rare, and utilities will often require the applicant to pay for any installation and material costs beyond 100 feet.

Distributed generation that is designed to receive gas at high inlet pressures may be more economical in cases where it can receive gas service directly from the utility company's high pressure transmission lines, rather than the comparatively lower pressure distribution lines that service most customers.[57] This might save a customer-generator the cost of buying and maintaining gas compressors that raise the gas pressure to appropriate inlet levels. In such a case, the customer must typically apply to the utility company for a dedicated service line at high pressure connecting to the transmission line, which would be built and paid for under the same set of rules that govern gas service upgrades, described above.

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[54] 16 NYCRR § 230.2(b).

[55] 16 NYCRR § 230.2 (c), (d), and (e).

[56] 16 NYCRR § 230.2 (f). Methods for determining cost-justified upgrades are set forth in each utility's tariff.

[57] Different types of natural-gas powered DG may or may not require higher pressure gas service. e.g., small scale reciprocating engines do not require high pressure gas lines to operate. A sub 500 kwe unit may require 0.3(min)-0.8(max) PSIG input pressure. Small scale microturbines may require higher gas input pressure of about 75-80PSIG.

APPENDIX D: IEC BENEFIT-COST ANALYSIS

Benefit-Cost Analysis Summary Report

Site 10 – Town of North Hempstead

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Town of North Hempstead has proposed development of a microgrid that would enhance the resiliency of electric service for the following 13 facilities:

- Two fire stations and the fire department headquarters, which also all provide emergency medical services;
- Landmark on Main, a large multi-purpose mixed residential and commercial use facility;
- Paul D. Schreiber High School and Weber Middle School, both of which are designated as community shelters in the event of an emergency;
- The Water District facility on Neulist Road, a municipal water pumping station serving 30,000 residents;
- The School Administration Building;
- The Port Washington Public Library;
- An animal shelter;
- Bible Church of Port Washington; and
- The Port Washington Boulevard retail strip.[58]

The microgrid would incorporate combined heat and power (CHP) and solar capabilities to provide base load power. Eleven natural gas-fired CHP units would be distributed among the participating facilities; these would range in capacity from 0.005 MW to 0.248 MW. Three photovoltaic (PV) arrays would also be distributed among the participating facilities, ranging in capacity from 0.03 MW to 0.15 MW; total PV nameplate capacity would be 0.31 MW. A battery storage system and energy efficiency measures would also be incorporated into the microgrid.[59] The operating scenario submitted by the project's consultants indicates that these new resources together would produce approximately 4,130 MWh of electricity per year, roughly 75 percent of the amount required to meet the average annual demand of the facilities listed above. During a major outage, the project's consultants indicate that the microgrid system would supply

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[58] The project's consultants indicate that the Bible Church of Port Washington and the Port Washington Blvd. retail strip facilities are "potential participants" in the microgrid; while the project team has not yet solicited these facilities to confirm their participation, they have been included in the team's Stage 1 feasibility study.

[59] In addition to these resources, the microgrid would incorporate the emergency generators that currently serve the facilities listed above. These units, however, would only be relied upon in extreme circumstances and would not operate on a regular basis.

100 percent of average electricity use at the facilities served by the microgrid.[60] They also indicate that the system would be capable of providing ancillary services to the grid.

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

METHODOLOGY AND ASSUMPTIONS

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

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

This analysis relies on an Excel-based spreadsheet model developed for NYSERDA to analyze the 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.[61] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of

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[60] As noted previously, the capacity of the new resources appears sufficient to supply approximately 75 percent of average daily electricity use at facilities within the microgrid's island; the remainder would come from the emergency generators the system would incorporate.

[61] 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.]

the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[62]

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.7 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.7 DAYS/YEAR
Net Benefits - Present Value	-$4,990,000	$361,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	N/A	7.8%

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

Scenario 1

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

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

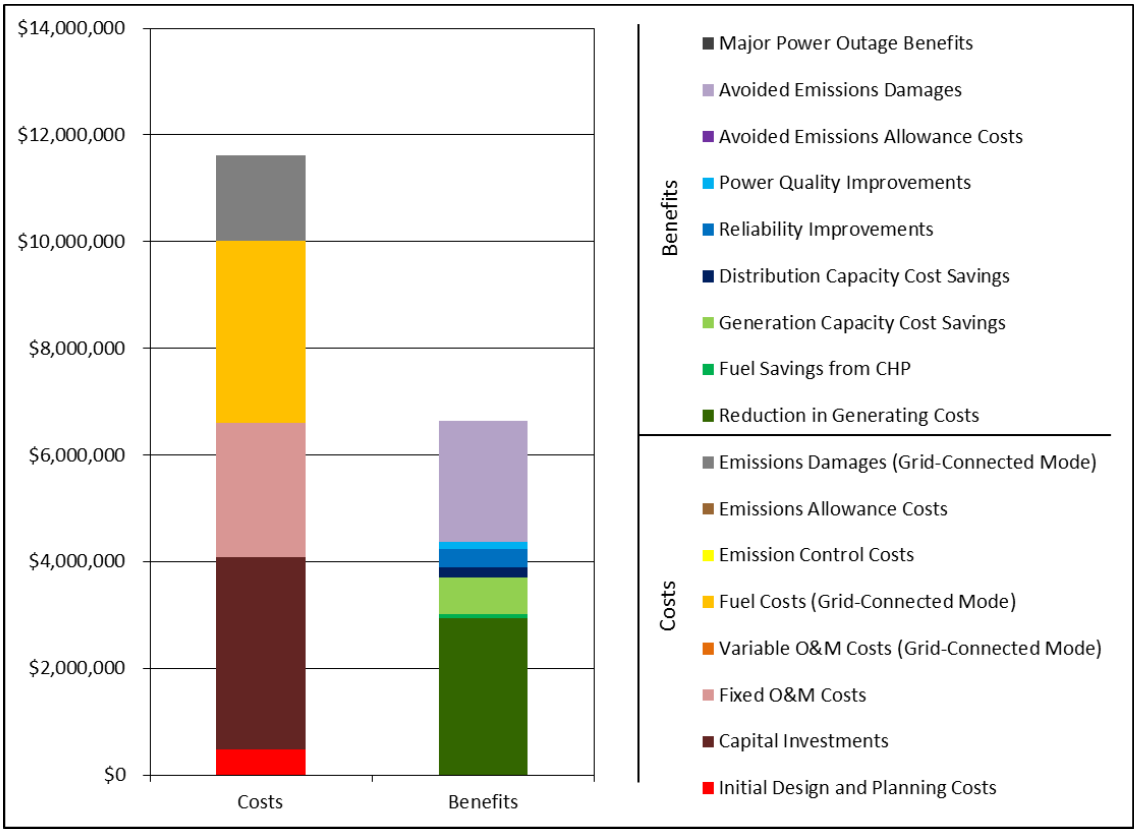

Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$3,610,000	$293,000
Fixed O&M	$2,510,000	$221,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$3,410,000	$301,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,610,000	$105,000
Total Costs	**$11,600,000**	
Benefits		
Reduction in Generating Costs	$2,940,000	$260,000
Fuel Savings from CHP	$70,600	$6,230
Generation Capacity Cost Savings	$683,000	$60,300
Distribution Capacity Cost Savings	$188,000	$16,600
Reliability Improvements	$353,000	$31,100
Power Quality Improvements	$137,000	$12,100
Avoided Emissions Allowance Costs	$1,480	$130
Avoided Emissions Damages	$2,260,000	$147,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$6,630,000**	
Net Benefits	**-$4,990,000**	
Benefit/Cost Ratio	**0.6**	
Internal Rate of Return	**N/A**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $475,000.[63] The present value of the project's capital costs is estimated at approximately $3.61 million, including costs associated with installing the new CHP units, PV arrays, battery storage, and associated microgrid infrastructure (controls, communication systems, information technology, etc.). The present

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[63] The project consultants note that this estimate is based on the costs of developing the power purchase agreement (PPA), negotiating other contracts, and arranging financing and insurance. It represents an average cost estimate; the actual costs ultimately incurred may be higher or lower, depending on the complexity of the site.

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 $2.51 million, based on an annual cost of $221,000.

Variable Costs

A significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's CHP units. 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.[64] Based on these figures, the present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $3.41 million.

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 CHP units are estimated at approximately $105,000 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 $1.61 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. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $2.94 million; this estimate takes into account both the electricity that the microgrid's CHP units and PV arrays would produce and an anticipated reduction in annual electricity use at the facilities the microgrid would serve.[65] In addition, the new CHP systems would cut consumption of natural gas for heating purposes; the present value of these savings over the 20-year period analyzed is approximately $70,600. The reduction in demand for electricity from bulk energy suppliers would also reduce the emissions of air pollutants from these facilities, yielding emissions allowance cost savings with a present value of approximately $1,480 and avoided emissions damages with a present value of approximately $2.26 million.[66]

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[64] 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.

[65] The project's consultants anticipate an annual reduction in electricity consumption of four percent due to energy efficiency upgrades included with the microgrid.

[66] 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.

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.[67] Based on application of standard capacity factors for the CHP units, as well as the capacity of the battery storage systems, the analysis estimates the present value of the project's generating capacity benefits to be approximately $683,000 over a 20-year operating period. Similarly, the project team estimates that the microgrid project would reduce the need for local distribution capacity by approximately 0.45 MW/year, yielding annual benefits of approximately $16,600. Over a 20-year period, the present value of these benefits is approximately $188,000.

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

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 $31,100 per year, with a present value of $353,000 over a 20-year operating period. This estimate was developed using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[68]

- System Average Interruption Frequency Index (SAIFI) – 0.72 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 81.6 minutes.[69]

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

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[67] 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.

[68] www.icecalculator.com.

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

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

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. The project team estimates that the facilities served by the microgrid would avoid an average of 1.08 such events annually. The model estimates the present value of this benefit to be approximately $137,000 over a 20-year operating period.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.6; i.e., the estimate of project benefits is approximately 60 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

The estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[71,72]

As noted above, the Town of North Hempstead's proposed microgrid project would serve 13 facilities during an extended outage. In the BCA model, several factors influence the costs that facilities would incur during an outage, including the following:

- Whether the facility is equipped with a backup generator;
- Whether the facility would rent a backup generator to supply power during an outage;
- The ability of the facility to operate when using backup power;
- The ability of the facility to operate during a complete loss of power;

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[71] The methodology used to estimate the value of lost services was developed by the Federal Emergency Management Agency (FEMA) for use in administering its Hazard Mitigation Grant Program. See: FEMA Benefit-Cost Analysis Re-Engineering (BCAR): Development of Standard Economic Values, Version 4.0. May 2011.

[72] As with the analysis of reliability benefits, the analysis of major power outage benefits assumes that development of a microgrid would insulate the facilities the project would serve from all outages. The distribution network within the microgrid is unlikely to be wholly invulnerable to service interruptions. All else equal, this will lead the BCA to overstate the benefits the project would provide.

- The cost of operating backup generators;
- The extent to which the facility would incur costs for emergency measures (e.g., evacuation of patients or staff); and
- The economic value of the services that the facility would cease to provide during an outage.

Table 3 summarizes these parameters for the facilities included in the microgrid. As shown in Table 3, facilities are grouped as follows for purposes of analyzing the effects of a major power outage:

- **Emergency Shelters**: The project's consultants indicate that the middle school and high school would be used as places of refuge in the event of a major outage. Considered together, these facilities are capable of providing shelter for 2,950 individuals. The total value of services per day is based on the capacity of the shelter facilities multiplied by the American Red Cross estimate of the cost of providing overnight shelter ($50/person/day). A backup generator would be rented to power the facilities in the event of an outage.
- **Fire and EMS facilities**: In the event of an outage, the fire stations (which each provide emergency response services as well) would be powered by existing backup generators. Protection Engine Co. No. 1 and the Fire Dept. Headquarters would maintain full service, while Atlantic Hook and Ladder No. 1 would maintain 80 percent of service in the event of an outage. In addition, these three facilities would each incur a cost of $2,500 per day to provide heat or air conditioning while housing members during an outage. The analysis calculates the impact of an outage on these facilities using standard FEMA methodologies.
- **Water Services.** The Water District facility on Neulist Road would be fully functional with its existing backup generator. The analysis calculates the impact of an outage on the 30,000 residents served by this pumping station using standard FEMA methodologies.
- **Residential Electric Services**: The Landmark on Main senior housing facility would rent a backup generator to maintain 50 percent of its operational capabilities during a major power outage. The analysis calculates the impact of an outage on this residential senior housing facility using standard FEMA methodologies.
- **Port Washington Library:** In the event of a major power outage, the library would maintain 50 percent of its operational capabilities with its existing backup generator. In addition, the library would incur one-time costs of $2,000 to shut down its IT network and drain its heating system (to avoid freezing pipes). The value of service provided by the library, estimated by the ICE Calculator, is approximately $76,100 per day.
- **Port Washington Blvd. Retail Strip:** The analysis assumes that the facilities in this retail center would rent a backup generator to maintain 50 percent of their operations during a power outage. Backup for these facilities would only be required five days per week. The collective value of service for this complex, as estimated by the ICE Calculator, is approximately $90,000 per day.
- **Other Commercial Facilities Equipped with Backup Generators**: The School Administration Building and the Animal Shelter are equipped with backup generators and are capable of operating at half capacity while on backup power. The collective value of service for these facilities, as estimated by the ICE Calculator, is approximately $69,500 per day.

- **Other Commercial Facilities without Existing Backup**: This subset of commercial facilities would rent backup generators to maintain half of their operations during a power outage. The collective value of service, as estimated by the ICE Calculator, is $68,500.

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

Based on the estimated value of service as well as the backup power capabilities and operational features of the facilities, the analysis estimates that in the absence of a microgrid, the average cost of an outage is approximately $5.3 million per day. The greatest benefit of the microgrid in the event of an outage would be its ability to maintain water service to the surrounding community.

Table 3. Summary of Major Power Outage Parameters, Scenario 2

		VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
CATEGORY	FACILITIES INCLUDED	VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY
Emergency Shelters	Paul D. Schreiber High School and Weber Middle School	$147,500	Red Cross	0%[1]	100%	$500	$1,500	$0	$0
Fire and Emergency Services	Protection Engine Co. No 1, Atlantic Hook and Ladder No. 1, Fire Dept. Headquarters	FEMA methodologies		0%	Various	$0	$60	$0	$7,500
Water Services	Water District on Neulist Road	FEMA methodologies		0%	100%	$0	$49	$0	$0
Residential Electric Services	Landmark on Main senior housing (65 residents)	FEMA methodologies		50%	100%	$0[2]	$0[2]	$0	$0
Public Library	Port Washington Library	$76,133	ICE	50%	100%	$0	$72	$2,000	$0
Retail Strip	Port Washington Blvd. retail strip	$90,025	ICE	50%	100%	$500	$1,000	$0	$0
Other Commercial Facilities Equipped with Backup Generators	School Administration Building and Animal Shelter	$69,451	ICE	50%	100%	$0	$47	$0	$0
Other Commercial Facilities without Existing Backup	Landmark on Main (Community Center & Playhouse) and Bible Church of Port Washington	$68,480	ICE	50%	100%	$1,000	$2,000	$0	$0

Notes:

CATEGORY	FACILITIES INCLUDED	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
		VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY

[1] These facilities are assumed to operate as emergency shelters during a major power outage. The project team indicated that these facilities would experience a 98 percent loss in service capabilities in their capacity as schools.

[2] The cost of hooking up and operating a rental generator is included in the figure provided for Other Commercial Facilities without Existing Generators -- one generator would be used for the entire Landmark on Main facility, including both the senior housing residential portion and the community center and playhouse.

Summary

Figure 2 and Table 4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.7 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 0.7 Days/Year; 7 Percent Discount Rate)

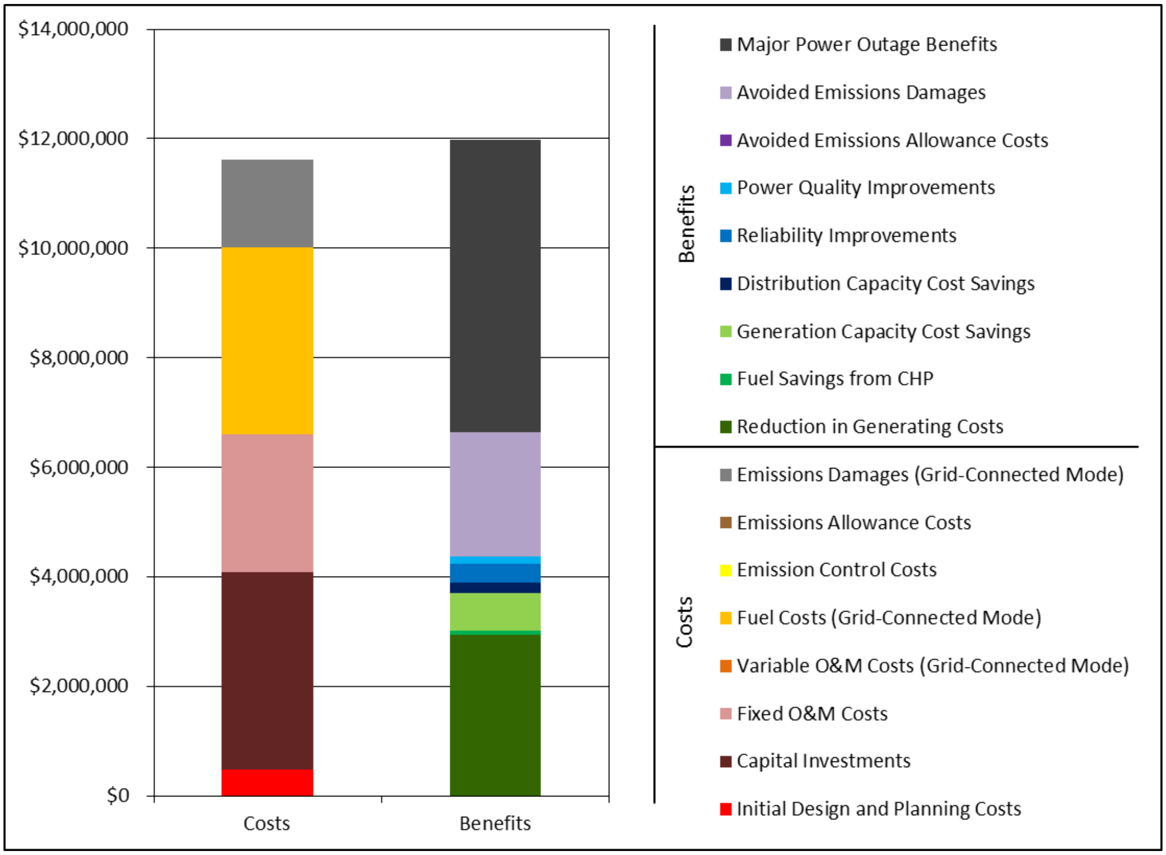

Table 4. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.7 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$3,610,000	$293,000
Fixed O&M	$2,510,000	$221,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$3,410,000	$301,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,610,000	$105,000
Total Costs	**$11,600,000**	
Benefits		
Reduction in Generating Costs	$2,940,000	$260,000
Fuel Savings from CHP	$70,600	$6,230
Generation Capacity Cost Savings	$683,000	$60,300
Distribution Capacity Cost Savings	$188,000	$16,600
Reliability Improvements	$353,000	$31,100
Power Quality Improvements	$137,000	$12,100
Avoided Emissions Allowance Costs	$1,480	$130
Avoided Emissions Damages	$2,260,000	$147,000
Major Power Outage Benefits	$5,350,000	$472,000
Total Benefits	**$12,000,000**	
Net Benefits	**$361,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.8%**	

APPENDIX E: NREL RENEWABLE ENERGY FEASIBILITY AND MICROGRID CONSIDERATIONS

NATIONAL RENEWABLE ENERGY LABORATORY

North Hempstead Renewable Energy Feasibility and Microgrid Considerations: Report Excerpt

Report for Port Washington Community Microgrid Feasibility Study[1]

April 2016

This report is not an official NREL publication and is not publically available. The report did not go through the NREL publications and review process at the request of the client.

1 Microgrid Impacts on Renewable Energy Development Potential

Having a microgrid could impact future renewable energy project development both positively and negatively depending on final design and use of the microgrid. This section discusses a number of potential considerations and implications.

1.1 Combined Heat and Power Systems Could Discourage Renewables

Each of the microgrid nodes for North Hempstead has been designed to have a combined heat and power (CHP) system as part of a preliminary design. These CHP systems will be fueled with natural gas and be the primary power source for the microgrid. CHP systems are typically designed to meet the majority of a site's heat load with electric generation as a valuable secondary byproduct. CHP systems are most economical if they are operated at high capacity factors e.g. 80%-100% of rated output. In order to present the most compelling financial return the planned CHP systems for North Hempstead are being designed to meet a majority of building and node electrical loads during normal grid connected operation. If these buildings or nodes have CHP systems meeting a significant fraction of their electrical and heat loads the presence and economics of these systems would significantly reduce the potential for renewable energy systems. Any installed systems would need to be much smaller than the sizes recommended in the NREL analysis. Under this scenario the renewable energy systems would be sized to meet the fraction of the electrical load that the CHP system is not meeting. This has two key impacts; first it limits the amount of renewable energy that can be produced so as to not compete with the CHP system. Also, it likely makes the financial return of the renewable energy systems worse as they would need to be smaller and thus less economical than if they could be sized to meet the entire electrical load of a building or node.

1.2 Microgrid Controls Improve Economics of Renewable Energy

The microgrids designed for North Hempstead will likely contain a considerable ability to control generation to optimize the economics of future and planned renewable energy systems. There are a number of ways microgrid controls could potentially do this, several as discussed below.

The central microgrid controller could utilize economic dispatch algorithms to optimize energy savings for the microgrid owners by utilizing the combination of CHP generation, energy storage and solar PV planned for the microgrid to reduce peak demand charges by limiting overall site demand. This economic optimization is often not possible with just PV because of the impacts of weather and clouds on PV production, however the CHP and storage in the microgrid could be used to solve this issue.

The microgrid could also be utilized to capitalize on new and novel economic value streams for potential renewable energy systems that might not otherwise be possible. For example, the controller and the presence of an economic optimization control layer may allow for bidding of generation into power markets and/or renewable energy systems to be utilized and controlled to provide ancillary services such as voltage regulation.

The presence of the microgrid and networked microgrid nodes may allow for the sharing of renewable energy generation between nodes either physically or virtually. New York has policies that allow for remote aggregated net-metering of PV or wind systems for owners with nonresidential accounts. Energy produced on a “host account” can be credited to other accounts or meters that are owned by the same customer and North Hempstead could likely take advantage of this opportunity. This would be advantageous to improve the economics of the renewable energy systems. For example, if the town could build a large PV system in an area with available land and use the power generated by this system to offset loads in other areas as well as power a local microgrid that is physically connected to the system with the energy generated, the microgrid this would improve the development potential of these PV systems as well as their economics.

Having a microgrid that is capable of operating during grid outages would increase the average annual operating hours of potential and future renewable energy systems as opposed to having these valuable resources stranded during an outage as would happen now. Increasing the number of hours that the renewable energy systems are able to operate over the course of the year improves their overall economics as they are able to generate more energy.

1.3 Microgrid Infrastructure Expands Renewable Energy Integration Potential and Lowers Costs

The electrical equipment and controls put in place for the microgrid in North Hempstead will improve the ability of the distribution system to manage variable distributed generation and could lower interconnection costs.

The microgrid may be able to lower the interconnection costs of planned and future renewable energy systems by sharing or deferring the cost of necessary improvements to electrical infrastructure. For example, by combining RE with energy storage on a feeder, utility construction costs can be deferred, i.e., if a feeder is approaching its capacity limits due to new residential/commercial development projects, the load can be reduced and give the utility some breathing room to plan upgrades or even stay with existing infrastructure. Also, often when a renewable energy system is interconnected, upgrades to switches, transformers, lines, or other electrical distribution equipment are required. The planned microgrid project could also require a number of similar electrical system improvements in order to function properly. Planned and future renewable energy systems would not be required to make these investments in part or in total (because they were already done) thus reducing the capital improvement costs of the systems and improving their economics.

Typically electrical distribution systems are limited in the amount of variable renewable energy such as solar PV that they are safely able to accommodate before system upgrades are required to maintain power quality and reliability. Having a microgrid that is able to help regulate power quality by controlling CHP systems to stabilize voltage and frequency will allow for more renewable energy to be added to the distribution system than would have otherwise been possible with the same equipment and infrastructure. Thus the town will be able to reach higher levels of renewable energy penetration on the distribution system without potentially expensive system upgrades. This will lower the overall integration costs of the renewable energy systems and defer necessary investments in infrastructure.

1.4 Renewable Energy Benefits to the Microgrid

The presence of renewable energy systems in the microgrid provides a number of potential benefits, including lowering costs and improving reliability that are worth noting. These are summarized below:

- Renewable energy systems increase the reliability of the microgrid by providing a generation resource that is not dependent on a fuel source that is outside the control of the microgrid operator.
- Renewable energy systems lower the operating and maintenance costs of the microgrid as they produce electricity at nearly zero marginal cost; this reduces overall costs for system operations, maintenance, and fuel.
- [Large CHP systems require air pollution permits to build and operate. In many jurisdictions these permits are becoming increasingly difficult and expensive to obtain. Additionally, these permits can reduce the number of potential operating hours of a microgrid. Including renewable energy generation into the microgrid reduces the amount of fossil fuel consumed and thus the amount of air pollutants emitted. This can help ease permitting burdens and requirements for equipment to improve emissions.]
- Energy storage systems are planned for the Port Washington microgrid. These are available for a federal tax credit to reduce their capital costs by 30% if they are primarily charged (75% or above) by renewable energy. Thus the presence of the solar PV systems in the microgrid will help improve the economics of the energy storage systems.[73]
- RE systems now have the capability to improve the power quality of a microgrid, for example controllable inverters can be used to provide reactive power, even at night.

2 Microgrid Ready PV Design Considerations

Designing new solar projects to be ‘microgrid-ready’ enables the users to plan future microgrid initiatives to utilize solar PV as an energy resource under emergency conditions. This section provides background information with suggested language for several up-front considerations that can be added to a solar project procurement or request for proposal (RFP) that will help ensure that PV systems are built with microgrid resource functionality. [74]

2.1 Microgrid Ready Upfront Planning

The PV system may be a resource in a future microgrid that can operate when utility disturbances or outages occur. The planned microgrids for North Hempstead will include conventional (engine) generators, solar PV, and energy storage. Suggested RFP language and functionality includes:

- The inverters and their functionality as distributed resources in planned electrical islands shall comply with applicable provisions described in IEEE Std 1547.4-2011.
- Selected PV inverters [typically the larger inverters] shall be multi-mode DC to AC inverters capable of switching between grid-interactive mode and microgrid (intentional island) mode. These inverters, in conjunction with a system supervisory controller, shall be capable of bi-directional real and reactive power flow. The use of 3 port inverters that can include both PV and energy storage DC inputs should be considered.

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[73] Additional details can be found here, http://www.renewableenergyworld.com/articles/2016/02/when-is-energy-storage-eligible-for-the-30-percent-itc.html

[74] The text and information in this section is adapted from the NREL Fact Sheet Microgrid Ready PV. http://www.nrel.gov/docs/fy15osti/64582.pdf

- Spare communications raceways shall be installed that can be used to route communications cabling to the point of common coupling, central controller, or other pertinent equipment.

2.2 Inverters for Grid Support

The core job of a PV inverter is to convert the DC from solar cells into AC, but other inverter functions can be useful to both the PV system and microgrid. For example, if PV generation needs to be reduced to balance generation and load in a microgrid, the inverter can curtail its power output via control set-point(s).

Inverters also have the capability to “ride through” frequent minor electrical disturbances, as in the case of weak grids or microgrids. Current standards require that inverters disconnect the PV system when grid frequency or voltage falls outside a specified range. Adjustments to inverter trip levels and clearing times, with mutual agreement with the electric utility, can allow the PV system to stay online and respond accordingly to relatively short-term, minor events. In some cases, this function can actually help the grid to self-heal from a disturbance. Suggested RFP language and inverter functionality include:

- The inverter shall be capable of curtailing its output in logical steps, with controllable ramp rates, in response to commands from a microgrid controller or other source.
- The inverter shall have adjustable trip limit and clearing capabilities as determined by electrical studies, and as permitted by IEEE Std 1547a-2014. Important capabilities include fault ride-through to stay on-line during transient grid disturbances, such as sags and swells, and extended operating voltage and frequency ranges to avoid nuisance tripping.
- The inverter shall be capable of real-time data logging, alarm reporting, and responding to control signals from a remote power system controller.

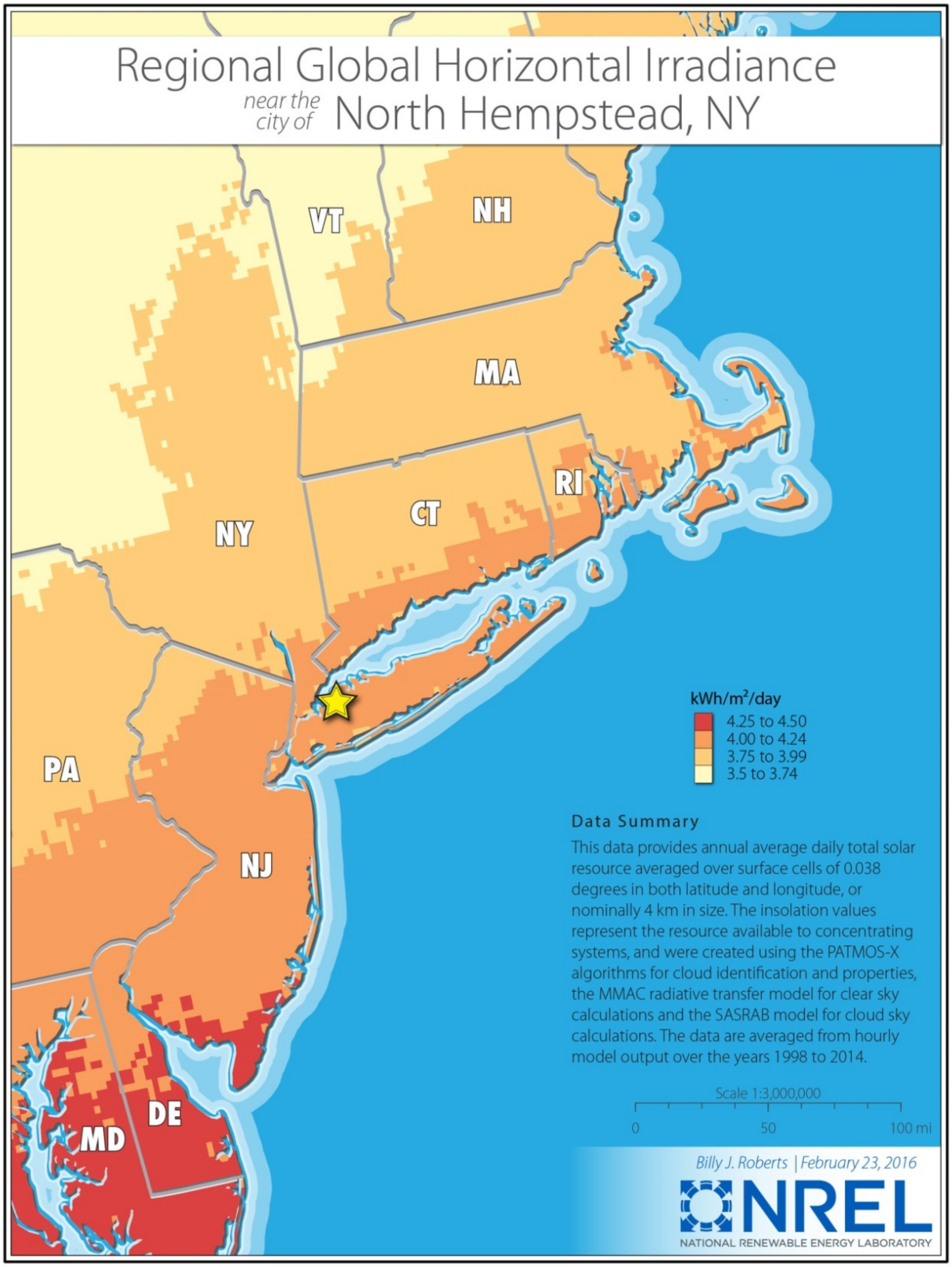
2.3 Power Factor Considerations

PV systems can affect the power factor (PF) in an electrical system. The solar PV project should be analyzed for its impact on power factor from a technical and economic perspective in both grid connected and microgrid modes. If it is determined that site load PF will be affected, inverters, dedicated power electronics, or traditional capacitor banks can provide PF and reactive power (VAR) support. The full cost of all the options should be considered, such as operations and maintenance, controller costs, and upsizing the inverter to be able to maintain the same kW and source VARs. Suggested RFP language and functionality includes:

- Inverters shall be capable of sourcing or sinking reactive power for the purpose of improving power factor and mitigating or eliminating monthly power factor charges. Reactive power levels (absorption or supply) shall be either programmed locally (autonomous control) or be implemented upon receipt of a set-point command provided by a remote controller. The control system shall adjust inverter reactive power need based on actual system conditions. Inverter reactive power capacity shall be determined by the system integrator following evaluation of load data, PV system size, and utility rate schedule. The inverter shall be capable of sourcing VARs even when daylight is not present. Oversizing the inverter to allow for both reactive power and planned real power requirements may be necessary.

- If power purchase agreement or other contract with private ownership is involved, include the following: The system owner shall propose how they should be compensated for any lost real power kWh in exchange for sourcing VARs. (For example, use the inverters to record potential kWh vs. actual kWh.)

Solar Resource Map



Data Summary

This data provides annual average daily total solar resource averaged over surface cells of 0.038 degrees in both latitude and longitude, or nominally 4 km in size. The insolation values represent the resource available to concentrating systems, and were created using the PATMOS-X algorithms for cloud identification and properties, the MMAC radiative transfer model for clear sky calculations and the SASRAB model for cloud sky calculations. The data are averaged from hourly model output over the years 1998 to 2014.

APPENDIX F: ACRONYM GLOSSARY

- ATS- automatic transfer switch
- BCA – benefit-cost analysis
- BTU – British thermal unit
- CCA- community choice aggregation
- CHP- combined heat and power plants
- DER- distributed energy resources
- DHW- domestic hot water
- DMS- distribution management system
- EDG- emergency diesel generator
- EEM- energy efficiency measures
- EGG- emergency gas generator
- EPC- engineering procurement contractor
- EPRI- Electric Power Research Institute
- ESS- energy storage systems
- GHG- greenhouse gases
- Hr - hour
- IEEE- Institute of Electrical and Electronics Engineers
- ISO- independent system operators
- IT – information technology
- ITC- Investment Tax Credit
- kBTU – 1,000 BTU
- kV - kilovolt
- kW – kilowatt
- kWh – kilowatt-hour
- LAN- local area network
- Li-ion- lithium ion
- MW - megawatt
- NOC - Network Operations Center
- NREL- National Renewable Energy Laboratory
- NYSERDA- New York State Energy Research and Development Authority
- O&M- operations and maintenance
- ORNL- Oak Ridge National Laboratory
- PCC - point of common coupling
- PLC- programmable logic controller
- PPA- power purchase agreement
- PSE&G LI- Public Service Electric and Gas Long Island
- PV- Solar photovoltaic
- REV- Reforming the Energy Vision
- RFI- request for information
- RFP- request for proposals
- RTO- Regional Transmission Organizations
- SGIP- Smart Grid Interoperability Panel
- SOC- state of charge
- SPE- special purpose entity