3 - Town of East Hampton

September 2016

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East Hampton Community Microgrid

Final Report – NY Prize Stage 1: Feasibility Assessment

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April 2016

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PROJECT TEAM

East Hampton

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- Alan Houghton
- Derek Price

National Renewable Energy Laboratory

- Samuel Booth

Pace University

- Jordan Gerow

PROJECT STAKEHOLDERS

- East Hampton Government
- East Hampton Airport
- East Hampton Healthcare Center
- East Hampton Emergency Services
- East Hampton Union Free School District
- Various commercial businesses

EAST HAMPTON COMMUNITY MICROGRID - KEY OVERVIEW METRICS

Team

Project Lead:	Town of East Hampton
Technical Lead:	Hitachi Microgrids
Additional Consultants:	National Renewable Energy Laboratory, Johnson Controls, Inc.

Utilities

Electric:	PSE&G Long Island
Gas:	National Grid

Microgrid System Design

Size:	1720	kW
Load Served:	9,257,316	kWh/yr

DER*	Qty	Capacity
Combined Heat & Power (CHP):	23	710 kW
Existing CHP:	*1*	*75 kW*
Photovoltaic:	21	1,010 kW
Existing Photovoltaic:	*1*	*10 kW*
Energy Storage Systems:	16	260 kWh
Existing Emergency Gen:	*12*	*1845 kW*

Microgrid Financials

Total Installed Cost:	$ 9,266,000
Net Cost (after ITC deduction):	$ 7,715,000
Resiliency Savings:	$ 362,000/yr
GHG Offset:	$ 119,000/yr
Current Avg. Energy Cost:	$ 0.181/kWh

** Estimates based on financial modeling*

Supporting Organizations

- Town of East Hampton
- East Hampton Union Free School District
- East Hampton Emergency Services
- East Hampton Airport
- East Hampton Healthcare Center

Customer Types

Gov't Administrative:	9
Emergency Services:	4
Municipal Services:	1
Education	3
Health Care:	2
Small Commercial:	11
Multi-Unit Residential:	2
Total:	**32**

Electric Demand & Consumption with Microgrid

	Max kW	Avg kW	kWh / yr
Node 1	577	191	1,672,459
Node 2	77	23	204,486
Node 3	307	105	919,078
Node 4	458	168	1,469,818
Node 5	243	92	802,800
Node 6	1,188	301	2,638,637
Node 7	230	72	633,526
Node 8	438	105	916,512
Total	**3,518**	**1,057**	**9,257,316**

Benefit Cost Analysis Outputs

	Scenario 1	Scenario 2
Days of Major Outage	0 days/yr	1.4 days/yr
Total Benefits**	$ 10,000,000	$ 18,200,000
Total Costs**	$ 18,200,000	$ 18,200,000
Net Benefits**	-$ 8,190,000	$ 26,100
Benefit-Cost Ratio	0.6	1.0

***Net Present Value*

**Distributed Energy Resources*

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 the feasibility assessment (Stage 1 of the NY Prize Program) for the East Hampton Community Microgrid. Hitachi Consulting worked with Johnson Controls and the National Renewable Energy Laboratory (NREL) to develop the microgrid design based both on NYSERDA's requirements and the needs and priorities of the Town of East Hampton. The design was developed using an iterative process that allowed the design team to optimize the design against cost, emissions, and resilience goals. Hitachi Consulting also led the feasibility assessment, in collaboration with the East Hampton government. Various community organizations and partners, including the future customers of the East Hampton Community Microgrid, lent additional support.

Community Overview

East Hampton is a town on the south fork of Long Island and is home to over 21,000 residents. Like most of coastal New York, East Hampton was hit hard by Tropical Storm Irene in 2011, Superstorm Sandy in 2012, and several recent severe snow events (Nor'Easters) that have left the town or portions of the town without power for days. In addition, PSE&G LI estimates that the current local distribution capacity will no longer be able to serve peak demand beginning in 2017. This shortfall is estimated at 6MW in 2017, 9 MW in 2018 and 84MW in 2030.

The East Hampton Community Microgrid is comprised of a series of nodes, addressing energy resilience needs across the community. The largest node includes the community government facilities, police facility, and medical facilities. Several other nodes pick up additional mission critical facilities such as the airport, schools, and affordable housing.

The microgrid design is based on an overall energy strategy that incorporates both demand-side management and new distributed generation resources. Microgrid operational objectives are to simultaneously improve resiliency, increase energy efficiency, lower emissions, and lower cost to energy users.

Community Requirements and Microgrid Capabilities

The East Hampton Community Microgrid is designed to meet specific needs within the community. These include the need to harden critical infrastructure, and to secure transportation capabilities into and out of the community.

First, the microgrid is designed to harden infrastructure against damage, particularly that caused by increasingly frequent severe weather events. The East Hampton microgrid provides reliable power to critical first responders while also powering schools to allow these facilities to be used as public shelters or simply to get students back in the classroom faster after a grid-loss event.

The microgrid is also designed to protect the ability of residents and visitors to evacuate the area if need be or receive additional supplies. As the community is on the South fork, there are very few roads in and out of East Hampton, making transportation in an emergency a considerable challenge. The microgrid includes the East Hampton Airport – a critical infrastructure element that can support evacuation or the delivery of additional supplies in an emergency. It also powers the local train station, ensuring lighting and computer operations to facilitate train service.

The East Hampton 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 and may reduce energy costs for microgrid customers.

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 East Hampton 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 East Hampton 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.* 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 equipment. 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. 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 East Hampton community. In order to include non-adjacent facilities, the design is based on eight 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 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	577	-	-	-	-	-	-	6	805
	Microgrid	340	7	300	7	50/100	6	110	6	805
2	Business as Usual	77	-	-	-	-	-	-	-	-
	Microgrid	47	1	50	1	5/10	2	20	-	-
3	Business as Usual	307	-	-	-	-	-	-	1	50
	Microgrid	187	4	130	2	20/40	3	80	1	50
4	Business as Usual	458	-	-	-	-	-	-	2	275
	Microgrid	190	5	120	2	10/20	2	140	2	275
5	Business as Usual	243	1	10	-	-	-	-	-	-
	Microgrid	235	1	10	1	5/10	2	70	-	-
6	Business as Usual	1188	-	-	-	-	1	75	1	450
	Microgrid	940	1	200	1	20/40	2	165	1	450
7	Business as Usual	230	-	-	-	-	-	-	1	115
	Microgrid	150	1	100	1	10/20	3	50	1	115
8	Business as Usual	438	-	-	-	-	-	-	1	150
	Microgrid	410	1	100	1	10/20	3	75	1	150

Executive Summary Table 2, which also appears in Section 2 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 heat 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	577	191	1,672,459	139,372	5,510,045	459,170	1,939,520	161,627
2	77	23	204,486	17,041	172,909	14,409	123,400	10,283
3	307	105	919,078	76,590	2,615,793	217,983	1,084,338	90,361
4	458	168	1,469,818	122,485	7,514,615	626,218	2,975,163	247,930
5	243	92	802,800	66,900	1,007,998	84,000	742,166	61,847
6	1,188	301	2,638,637	219,886	20,361,912	1,696,826	2,933,319	244,443
7	230	72	633,526	52,794	1,234,734	102,894	622,421	51,868
8	438	105	916,512	76,376	1,417,192	118,099	876,456	73,038
Total	**3,518**	**1,057**	**9,257,316**	**771,443**	**39,835,196**	**3,319,600**	**11,296,782**	**941,399**

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. It 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 East Hampton 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. This transition is facilitated by the technology at the PCC between the microgrid and the utility grid.

The process of islanding a microgrid can create instability (in the form of an electrical transient) and added risk to operations. The structure of the PCCs in the East Hampton Community Microgrid is specifically designed to minimize this effect and protect the microgrid from danger. This structure enables the utility-controlled breaker or switch to immediately open on loss of the grid. The microgrid controller will adjust all microgrid resources for island mode operational and performance objectives. The microgrid design ensures a seamless transition back to the grid when power is restored. The microgrid controller (and/or operator) will connect with the utility distribution management according to all appropriate protocols, safety mechanisms, and switching plans.

Financial Feasibility

The project team developed a budget estimate for the East Hampton 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, construction, controls, start-up, commissioning, and training. 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 $9,266,000 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 $7,715,000. 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 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 using the proposed third-party ownership business model. Under this model, the project is funded through outside 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 proposed business model, the system owner 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. This owner could be the local government, one of the other off-takers, or a third party. The system 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 $0.181/kWh. Based on estimated project financing costs and the 25 year contract term, the study supports a PPA electric rate with an electric cost that is higher than the average cost of electricity currently paid by potential microgrid customers. This analysis does not include Stage 2 or Stage 3 NY Prize funding, which would have the potential to significantly lower the PPA rate.

Benefit-Cost Analysis (BCA) 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 East Hampton Community Microgrid, the breakeven outage case is an average of 1.4 days of outage per year. PSEG Long Island estimates that it will soon experience peak power deficiencies in this area. The cost benefit results are presented in Executive Summary Table 3.

Executive Summary Table 3 – Benefit-Cost Analysis Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 1.4 DAYS/YEAR
Net Benefits - Present Value	-$8,190,000	$26,100
Total Costs – Present Value	$18,200,000	$18,200,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-12.1%	6.2%

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 East Hampton'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 $4.42, 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 $670,000

- 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 $1,551,000.
- Capital replacement costs used in the BCA were calculated as 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 East Hampton Community Microgrid is $302,000 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 East Hampton Community Microgrid is technically viable and is potentially economically viable with additional NY Prize grants. East Hampton's location at the eastern end of the south shore makes it one of the communities in the state most susceptible to storm damage. The resilience strategies employed by the microgrid will yield lessons for similarly vulnerable communities in New York and across the country.

Based on the findings of this feasibility analysis, there are several next steps for the project team to undertake. First, the project team should solicit confirmation from each stakeholder that they are interested in continuing to participate in this effort to build a community microgrid. Based on the final customer list, the project should be remodeled project to estimate the technical and economic impact of any additions or subtractions.

Once the model is final the project team will need to make a go/no go decision about moving forward. If a decision is made to move forward, a project team will need to be finalized. This team will draft a proposal to NYSERDA to compete in Stage 2 of NY Prize. This Stage 2 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. A Stage 2 will require cost-share, and a determination should be made about who which parties will take this on.

East Hampton 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, medical needs, an airport, and low-income and student populations of East Hampton. 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.

The proposed microgrid will include an airport, a police station, municipal buildings, medical centers, several schools, as well as some residential and commercial spaces. Collectively, there are a total of 8 “nodes” that make up the East Hampton Community Microgrid.

The eight East Hampton nodes and included facilities and functions are listed in the table below.

Table 1 – Overview of Microgrid Nodes

Microgrid Node #	Facilities	Functions
1	• Police Garage • Police Substation • Town Hall Annex (Future Site) • Animal Control/Land Acquisition • Justice Court • New Town Hall • New Parking Structure (Future Site) • Emergency Services • 200 Pantigo (Health Center) • 300 Pantigo (Office Building) • Emergency Room Annex (Future Site) • Commercial Non-Critical Load (Montauk Hwy Retail)	• Municipal services • Police • Medical • Parking • Housing • Retail • Recreation
2	• Airport Terminal & Tower	• Airport
3	• Police Station • Police Back Parking Lot • Wainscott Industrial Center (39 & 41 Industrial Rd)	• Police • Commercial
4	• Montauk Fire Station • Montauk Playhouse • Montauk Manor • Train Station • East Hampton Housing Authority (Affordable Housing) • Pumping Station	• Fire station • Community center • Hotel • Transportation • Residential • Restaurant • Pump • Municipal Services
5	• East Hampton Emergency Services Building	• Emergency services
6	• East Hampton High School	• Education • Shelter
7	• East Hampton Middle School	• Education • Shelter
8	• John M. Marshall Elementary School	• Education • 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 as described above.

The design team met with PSE&G LI Distribution Engineering and Power Asset Management Teams to review utility infrastructure that impacts the microgrid design. In general, they understand the proposed design and did not identify any major issues.

Table 2 - Microgrid Electrical and Thermal Infrastructure Plan

Infrastructure	Class	Associated Device	Comment / Description
13.8 kV, 3 phase, Underground Cabling	New	Nodes 1, 3 & 4	Added for microgrid nodes that have multiple electric accounts
SCADA Switch	New	All Nodes	Enables sectionalizing of PSE&G LI circuit to support microgrid operations
PCC (All Nodes)	New	13.8 kV line to distribution transformers	Transition from overhead to underground
13.8 kV Transformers	Updated	Critical Facilities	Conversion from pole-top to pad mount
Synchronizing Switches	New	CHP	Each CHP at a critical facility will require a synchronizing switch with protection to enable remote synchronization with the microgrid bus
M, C, P	New	All resources	Monitoring (sensing), Control, and Protection relays for proper management of resources in all modes
Automatic Transfer Switch	Existing	Emergency Generators	All emergency generation (diesel or gas) have automatic transfer switches installed in critical facilities. This will remain unchanged.
HW Supply Connection	New	CHP & heating	Tie-in from CHP to facility thermal loop for each facility with new CHP
HW Return Connection	New	CHP & heating	Tie-in from CHP to facility thermal loop for each facility with new CHP

The area covered by the proposed East Hampton microgrid will positively impact 21,000 residents and will generate benefits to local businesses.

Table 3 – Community Stakeholders to Benefit from the Microgrid

Facility	Current Condition in Grid-Loss Scenario	Future Condition with Microgrid in Grid-Loss
Police Garage	The facility is served by a 90 kW emergency diesel generator (EDG) in times of grid outage.	The microgrid will allow the police station to continue to operate for an extended period of time during a grid outage. The police force that is housed in this facility serves all of the town's 21,400 residents.
Police Substation	The facility is served by a 150 kW emergency gas generator (EGG) in times of grid outage.	
Town Hall Annex (Future Site)	The town hall is not currently planned to be served by backup generation, and would have to close during a power outage.	The Town Hall will serve as a command center during an emergency in East Hampton. The microgrid will allow the village's government to continue to operate at a high level during a grid outage.
Animal Control/Land Acquisition	The facility is served by a 65 kW EGG in times of grid outage.	The microgrid will allow this facility to continue 24/7 operation without the need to operate backup generators.
Justice Court	The facility is served by a 200 kW EDG in times of grid outage.	The microgrid will allow this facility to continue 24/7 operation without the need to operate backup generators or concerns about running out to diesel fuel.
New Town Hall	The Town Hall is not currently served by backup generation, and must close during a power outage.	The Town Hall will serve as a command center during an emergency in East Hampton. The microgrid will allow the village's government to continue to operate during a grid outage.
New Parking Structure (Future Site)	The parking structure is not currently served by backup generation, and must close during a power outage.	
Emergency Services	The facility is served by a 200 kW EGG in times of grid outage.	The emergency services housed in this facility serve 21,000 residents in the East Hampton area, and provide frequent mutual aid to surrounding communities. The microgrid would allow this facility to operate at a high level during a power outage, protecting the safety of all area residents.
200 Pantigo (Health Center)	The facility is served by a 100 kW EDG in times of grid outage.	The microgrid will allow this facility to continue 24/7 operation without the need to operate backup generators or concerns about running out to diesel fuel.
300 Pantigo (Office Building)	300 Pantiogo is not currently served by backup generation, and must close during a power outage.	A microgrid would allow this facility to remain open and continue operations for businesses there.
Medical Center (Future Site)	It is unclear as to whether any backup generation is planned for the medical center.	A microgrid would ensure continued operation of the medical center – providing critical health services for local residents.

Facility	Current Condition in Grid-Loss Scenario	Future Condition with Microgrid in Grid-Loss
Commercial Non-Critical Load (Montauk Hwy Retail)	These facilities are not currently served by backup generation, and must close during a power outage. This results in a loss of revenue for store owners as well as reduced services for residents during power outage.	A microgrid would allow these businesses to remain open, providing services to community members.
Airport Terminal & Tower	The airport is not currently served by backup generation, and must close during a power outage. This will prevent use of the airport to provide supplies and transportation for the local community.	The microgrid will allow the airport to stay open; creating a safe transportation option out of the region should evacuation become necessary.
Police Station	The facility is served by a 50 kW EDG in times of grid outage.	The microgrid will allow the police station to continue to operate at for an extended duration during a grid outage. The police force that is housed in this facility serves all of the town's 21,400 residents.
Police Back Parking Lot	The parking lot is not currently served by backup generation. The lack of night time lighting in a service outage would create a hazard for law enforcement.	
Wainscott Industrial Center (39 & 41 Industrial Rd)	The Wainscott Center is not currently served by backup generation, and must close during a power outage. This could result in a loss of productivity and even product for tenant businesses.	A microgrid would allow this facility to remain open and continue operations for businesses there.
Montauk Fire Station	The facility is served by a 75 kW EDG in times of grid outage.	The microgrid will allow this facility to operate for an extended period of and at a higher level of service than with it current emergency backup generator.
Montauk Playhouse	The facility is served by a 200 kW EDG in times of grid outage.	The microgrid will allow this facility to operate for an extended period of and at a higher level of service than with it current emergency backup generator. This facility could serve as a shelter during an extended power outage.
Montauk Manor	The Manor is not currently served by backup generation, and must close during a power outage. All 140 apartments would be without power.	A microgrid will provide continuous power for the residents of Montauk Manor.
Train Station	The train station is not currently served by backup generation, and must close during a power outage. This would cut off another vital transportation option for local residents.	The microgrid will allow the train station to stay open, creating a safe transportation option out of the region should evacuation become necessary.
East Hampton Housing Authority	The Avallone apartments are not currently served by backup generation, and must close during a power outage. All apartments would be without power.	A microgrid will provide continuous power for the residents of this East Hampton Housing Authority facility.
Rough Riders Landing Office	The office is not currently served by backup generation, and must close during a power outage.	A microgrid will provide continuous power for the Office, allowing employees to provide support and coordination to residents and visitors.
Ciao by the Beach	Ciao by the Beach is not currently served by backup generation, and must close during a power outage. This would result in a loss of revenue and reduce eating options for local residents.	The microgrid will allow this restaurant to stay open during a power outage.

Facility	Current Condition in Grid-Loss Scenario	Future Condition with Microgrid in Grid-Loss
Pumping Station	The pumping station is not currently served by backup generation, and must close during a power outage. This would reduce the efficacy of the local water system and potentially cause a loss of water service.	The presence of a microgrid will keep this pumping station online, dramatically reducing the risk of loss of water service to the local population.
East Hampton Emergency Services Building	The Emergency Services Building is not currently served by backup generation, and must close during a power outage. This would dramatically reduce the community's ability to respond to emergencies and increase the public risk.	The emergency services housed in this facility serve 21,000 residents in the East Hampton area, and provide frequent mutual aid to surrounding communities. The microgrid would allow this facility to remain operational during a power outage, protecting the safety of all area residents.
East Hampton High School	The facility is served by a 450 kW EDG in times of grid outage.	The microgrid will allow the schools to draw on the entire portfolio of microgrid resources to remain powered and open during an outage. This will ensure that students can attend school and allow parents of students to attend work as usual. This facility may also serve as a temporary shelter for community members in an emergency.
East Hampton Middle School	The facility is served by a 115 kW EDG in times of grid outage.	
John M. Marshall Elementary School	The facility is served by a 150 kW EDG in times of grid outage.	

The existing thermal infrastructure consists mainly of hot water systems. If there is a steam system, we will not attach to it because the output temperatures of the natural gas engines do not meet the quality standards for a steam system. The CHP connections to the hot water systems are installed in parallel with the existing boiler(s), and fed into the supply and return headers.

Key Features of the Microgrid

Community Microgrid Controller

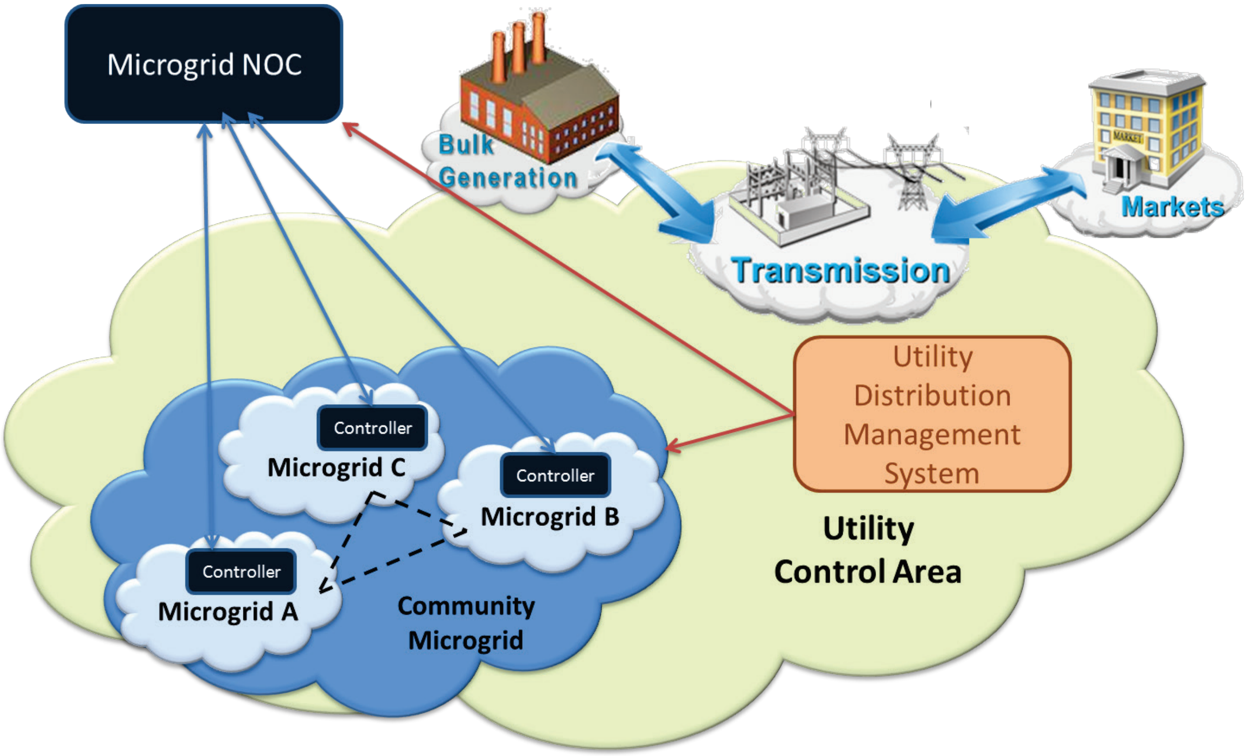
One of the challenges of community microgrids is that the facilities and the microgrid resources are distributed. To maximize the economics, reliability, and emissions reduction potential of the community microgrid, the microgrid controller architecture must have the capability to coordinate and control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

Our 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 operations 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 our 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.

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.

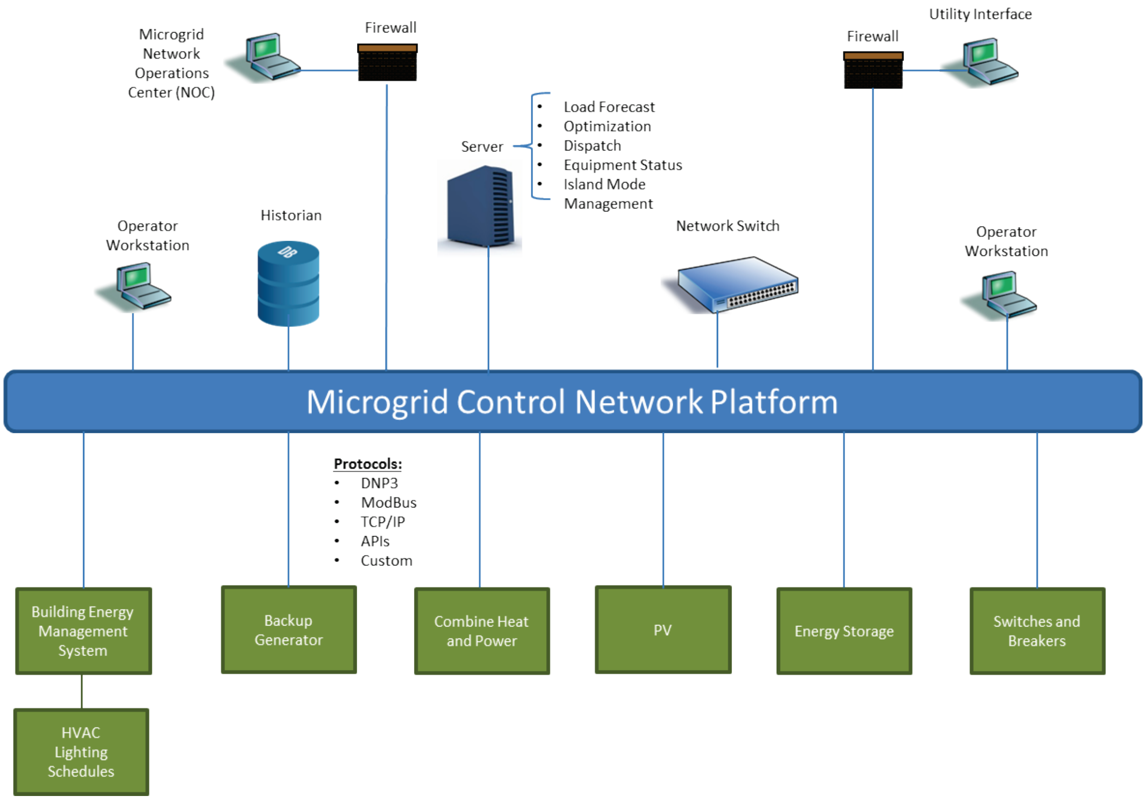
In addition, the microgrid controller will:

- Forecast variable aspects: load, wind, 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 programming logic controller (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 the 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 smart grid interoperability panel (SGIP) and generally accepted communications protocols, such as ModBus (TCP/IP), DNP3 (TCP/IP), and IEC61850, 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 distribution management system (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 the following:

- CHP
- PV
- ESS
- Building Load Control
- Energy Efficiency Measures (EEMs)

- Utility Grid
- Backup Generators

The East Hampton Community 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).

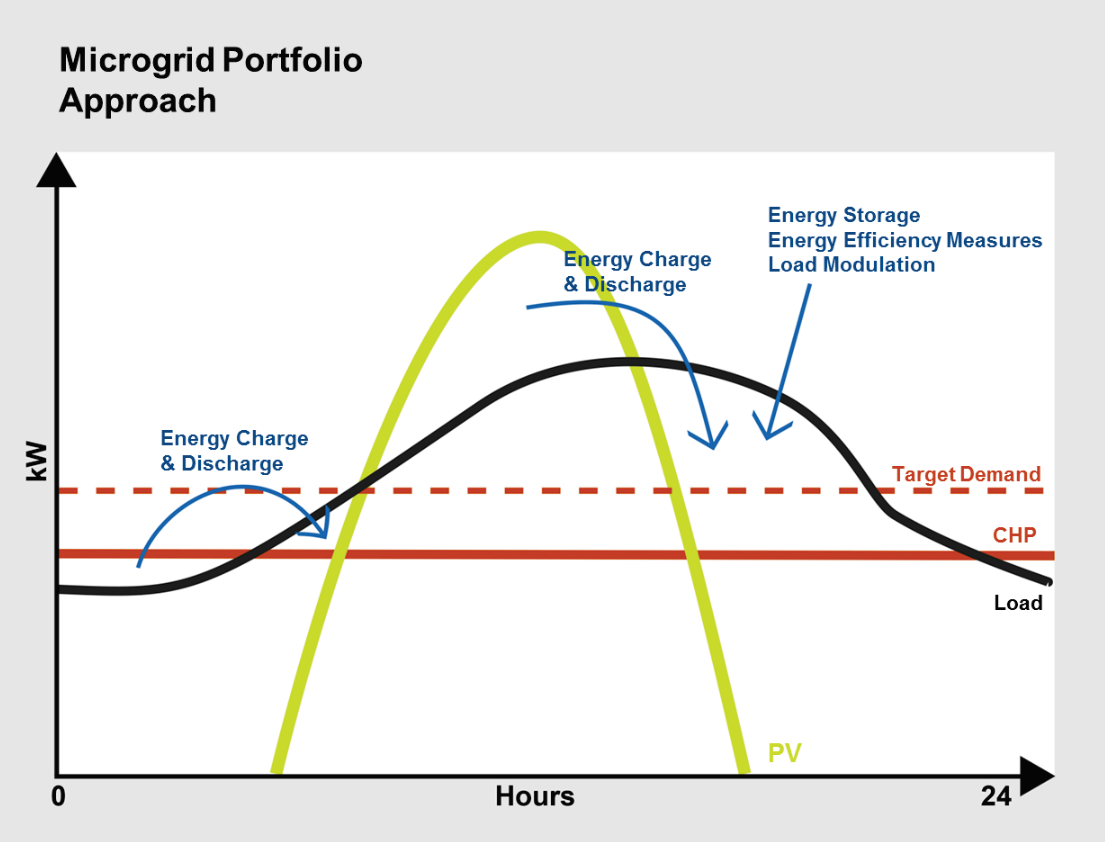
To support steady-state frequency requirements, as well as the ANSI 84.1-2006 standard voltage requirements and to support the customer power quality requirements at PCC, the microgrid controller will actively manage the dispatch of generation resources; actively manage the charge and discharge of energy 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 run at design output while PV and ESS will be integrated into the system to meet the load that varies above the base load. 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.

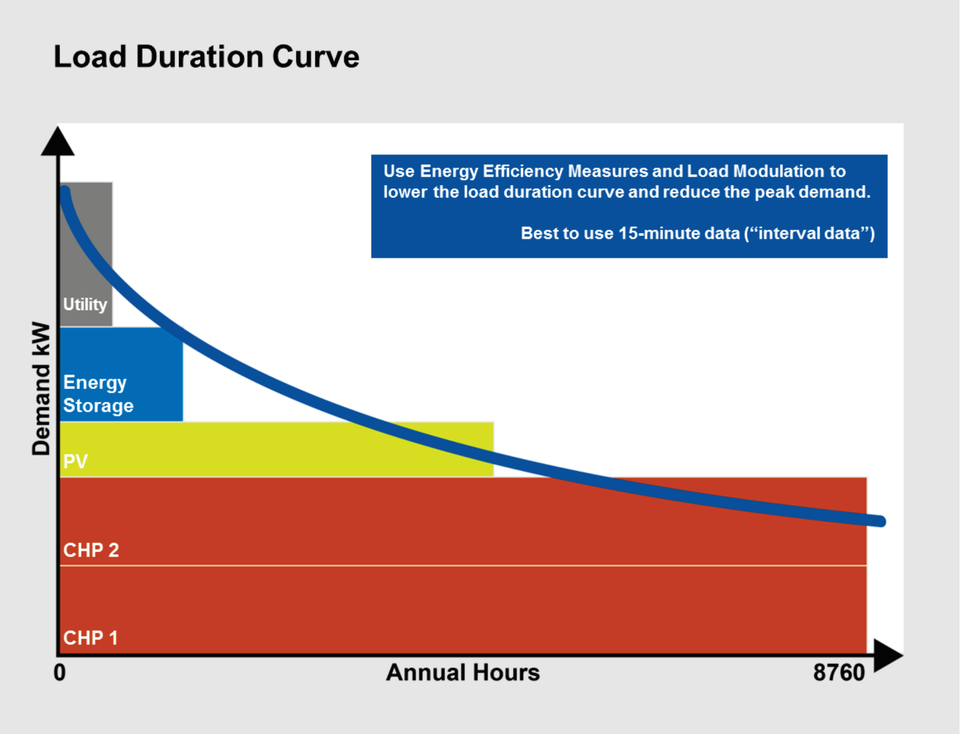
Figure 3 – Microgrid Portfolio Approach



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 East Hampton 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 East Hampton 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.

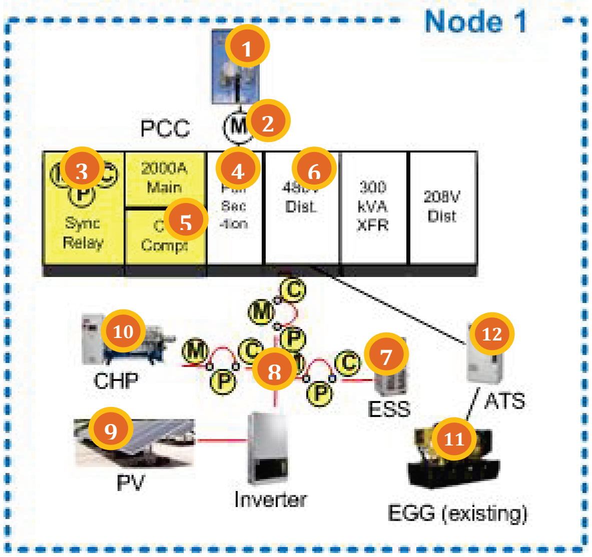
- Unplanned Transition*:* In an unplanned transition, an unanticipated outage takes place such as the loss of a transformer or a car hitting a distribution power pole. Depending on the microgrid resources operating at the time, an outage may take place that requires the microgrid to establish itself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

A complete layout of the design showing all microgrid nodes is presented in Appendix A. This geospatial image shows the facilities and location of electrical infrastructure and major new microgrid resources. More details about each individual node are presented on the following pages.

In addition, a microgrid one-line diagram is presented in Appendix B. The diagram includes the substation, major electrical equipment, and the rated capacity for each microgrid distributed energy resource. The PCCs are shown with associated monitoring (M), control (C), and protection (P) devices.

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

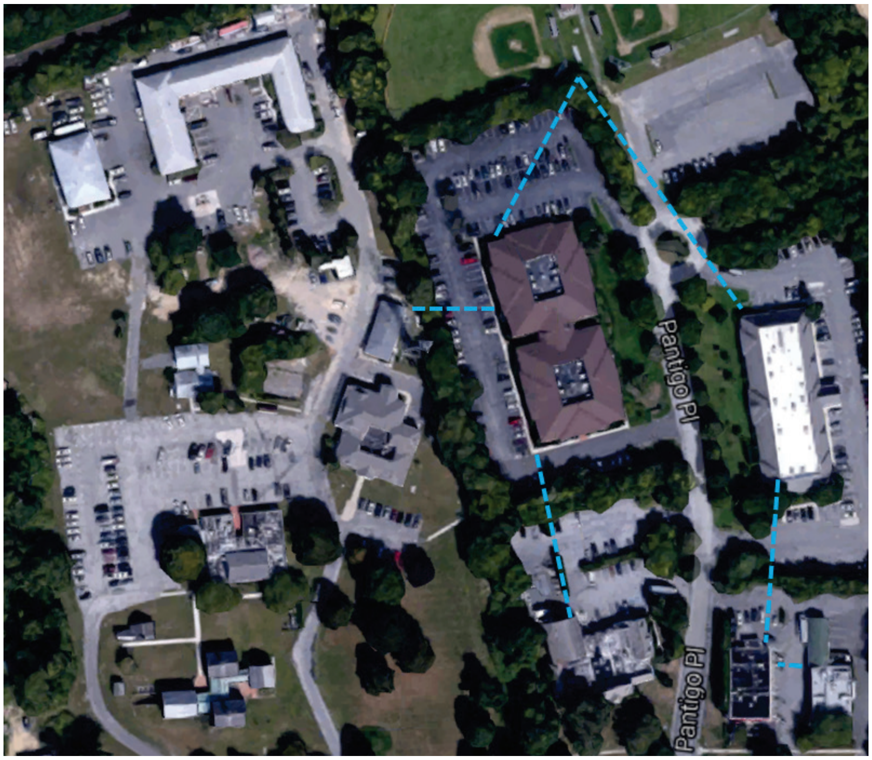
Figure 5 – One-Line Diagram Explanation



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 480 Volt 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. Emergency generators: Emergency Gas Generator (EGG) or Emergency Diesel Generator (EDG)
12. Automatic Transfer Switch (ATS)

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

Node 1 System Configuration



Facilities

- Police Garage
- Police Substation
- Town Hall Annex (Future Site)
- Animal Control/Land Acquisition
- Justice Court
- New Town Hall
- New Parking Structure (Future Site)
- Emergency Services
- 200 Pantigo (Health Center)
- 300 Pantigo (Office Building)
- Emergency Room Annex Emergency Room Annex(Future Site)
- Commercial Non-Critical Load (Montauk Hwy Retail)
- Baker House (Future Site)

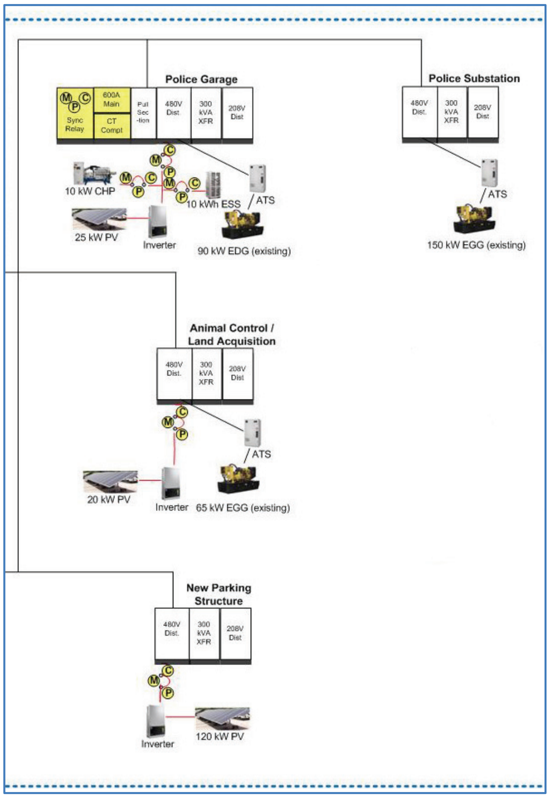
Node 1 consists of several facilities grouped around Pantigo Place and Montauk Highway. It includes 2,952 feet of new underground infrastructure to connect the facilities at 159 Pantigo with those at 200 Pantigo, 300 Pantigo, and several commercial buildings along Montauk highway.

Additional detail on the facilities included in this node is provided on the following pages.

Node 1 System Configuration (Continued)

Geospatial Diagram

One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facilities

- Police Garage
- Police Substation
- Animal Control & Land Acquisition
- New Parking Structure (Future Site)

Description

The following infrastructure will be included in the microgrid:

Police Garage:

- Rooftop PV (25 kW)
- CHP (10 kW)
- ESS (10 kWh)
- Existing EDG (90 kW)

Police Substation:

- Existing EGG (150 kW)

Animal Control/Land Acquisition:

- Rooftop PV (20 kW)
- Existing EGG (65 kW)

New Parking Structure (Future Site):

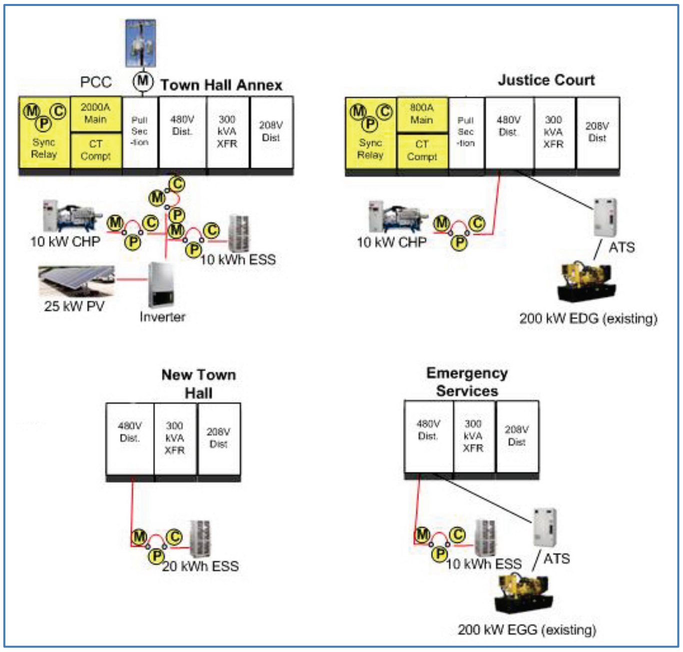
A proposed parking structure west of the Animal Control/Land Acquisition building will include the following:

- Covered parking PV (120 kW)

Node 1 System Configuration (Continued)

Geospatial Diagram

One-Line Diagram Excerpt



*See appendix B for full one-line diagram

Facilities

- Town Hall Annex (Future Site)
- New Town Hall
- Justice Court
- Emergency Services

Description

The point of common coupling (PCC) for Node 1 will be located between the New Town Hall and the future Town Hall Annex site. In addition to the following facilities, Node 1 was also optimized to support a proposed facility at the site of the Baker House. The following infrastructure will be included in the microgrid:

Town Hall Annex (Future Site):

The proposed Town Hall Annex located at the site of the Old Town Hall will include:

- Covered Parking & Rooftop PV (25 kW)
- CHP (10 kW)
- ESS (10 kWh)

New Town Hall:

- ESS (20 kWh)

Justice Court:

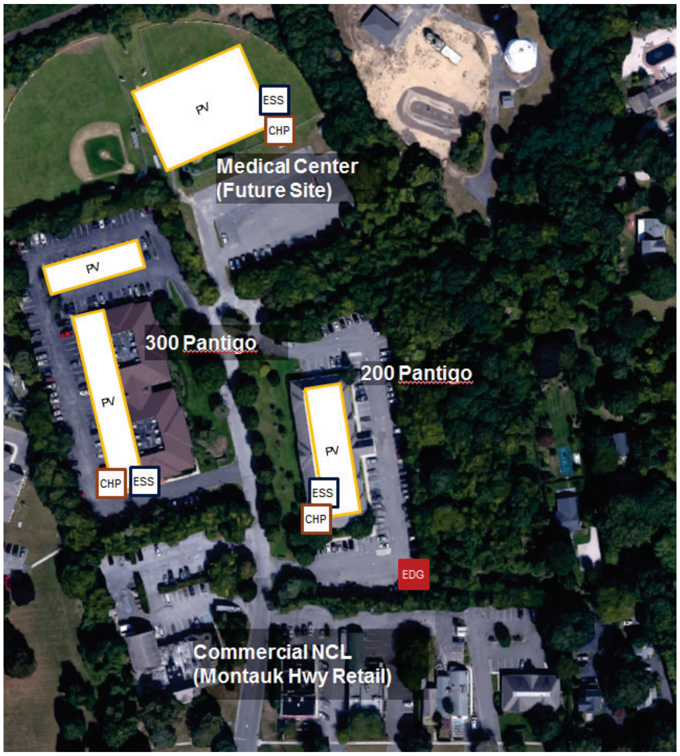
- CHP (10 kW)
- Existing EDG (200 kW)

Emergency Services

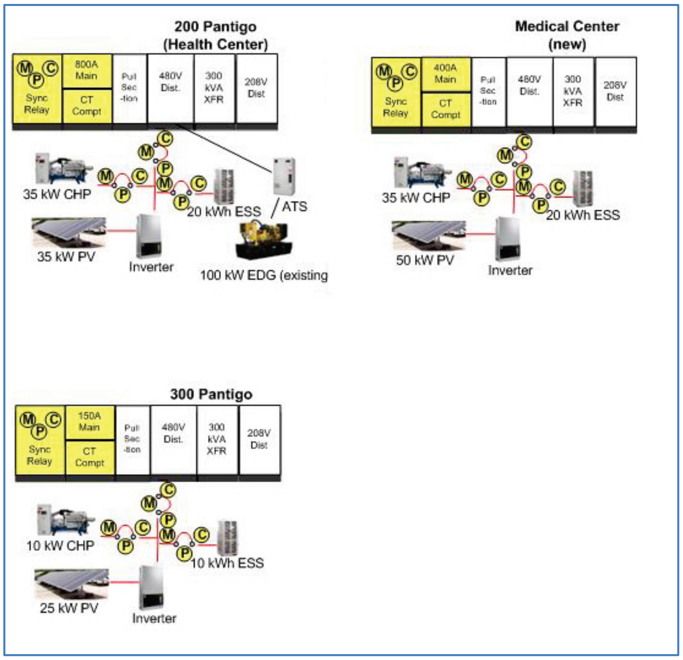
- ESS (10 kWh)
- Existing EGG (200 kW)

Node 1 System Configuration (Continued)

Geospatial Diagram



One-Line Diagram Excerpt



*See appendix B for full one-line diagram

Facilities

- Town Hall Annex (Future Site)
- New Town Hall
- Justice Court
- Emergency Services

Description

In addition to the facilities listed below, Node 1 also leverages infrastructure across several commercial properties along Montauk Highway. The following infrastructure will be included in the microgrid:

Emergency Room Annex(Future Site):

The proposed Emergency Room Annex located at the site of the Baseball Field will include:

- Rooftop PV (50 kW)
- CHP (35 kW)
- ESS (20 kWh)

200 Pantigo (Health Center):

- Rooftop PV (35 kW)
- CHP (35 kW)
- ESS (20 kWh)
- Existing EDG (100 kW)

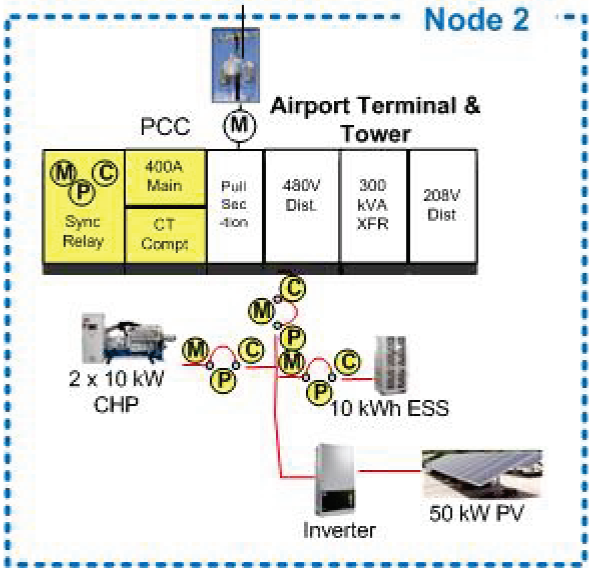
300 Pantigo (Offices):

- Rooftop PV (25 kW)
- CHP (10 kW)
- ESS (10 kWh)

Node 2 System Configuration

Geospatial Diagram

One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facility

- Airport Terminal & Tower

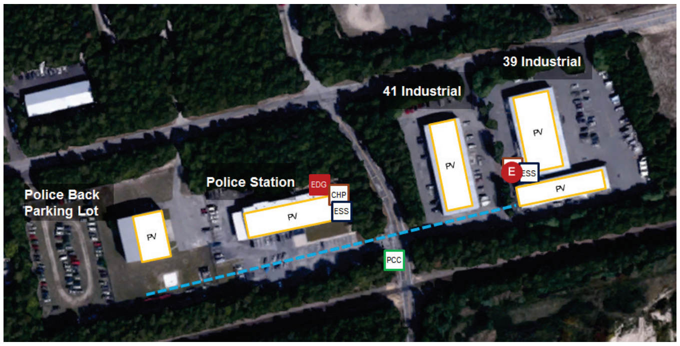
Description

Node 2 is a single-facility node consisting of the airport. The Point of Common Coupling (PCC) is located along Daniels Hole Road near the entrance. The following new infrastructure will be included in the microgrid:

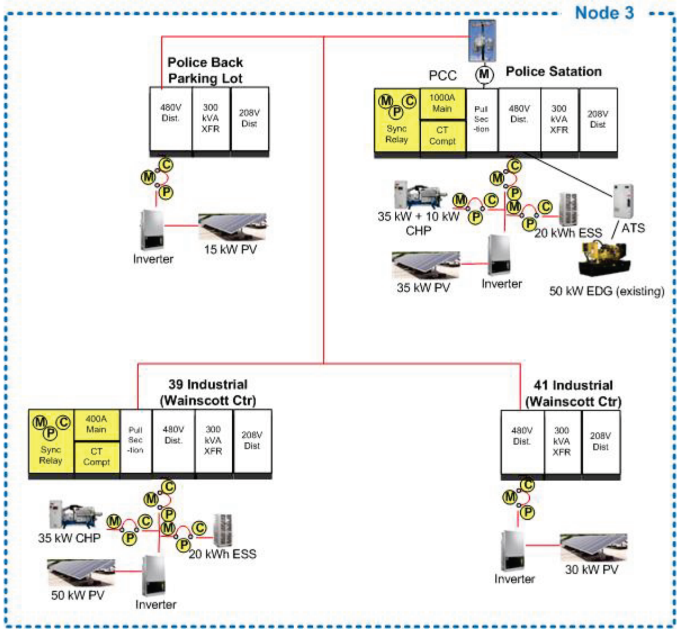
- Covered Parking & Rooftop PV (50 kW)
- CHP (20 kW)
- ESS (10 kWh)

Node 3 System Configuration

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facilities

- Police Back Parking Lot
- Police Station
- Wainscott Industrial Center
    - 39 & 41 Industrial Rd.

Description

Node 3 contains multiple facilities along Industrial Road. The Point of Common Coupling (PCC) is located along Wainscott NW Road behind the Police Station, and the facilities are connected with 750 feet of new underground infrastructure. The following new infrastructure will be included in the microgrid:

Police Back Parking Log

- Rooftop PV (15 kW)

Police Station

- Rooftop PV (35 kW)
- CHP (45 kW)
- ESS (20 kWh)
- Existing EDG (50 kW)

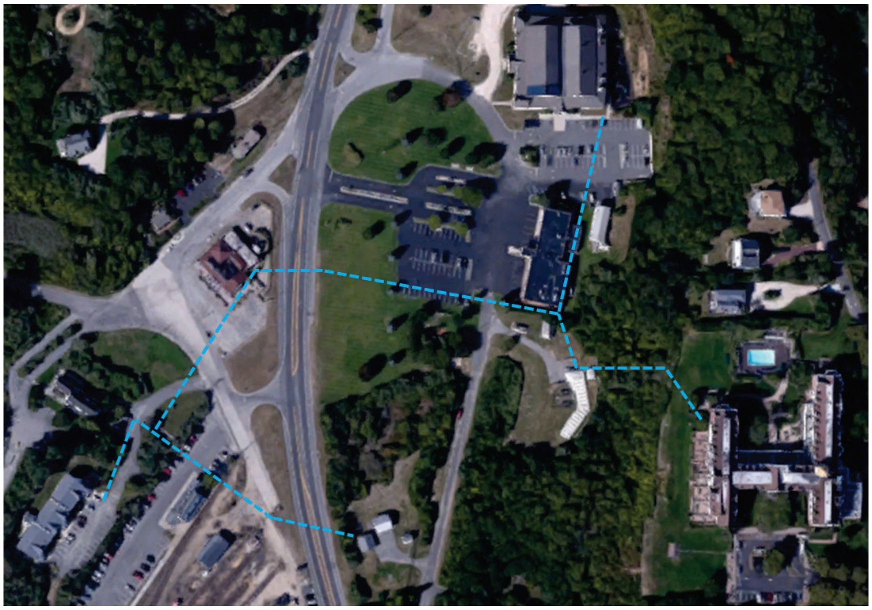
39 Industrial Rd.

- Rooftop PV (50 kW)
- CHP (35 kW)
- ESS (20 kWh)

41 Industrial Rd.

- Rooftop PV (30 kW)

Node 4 System Configuration



Facilities

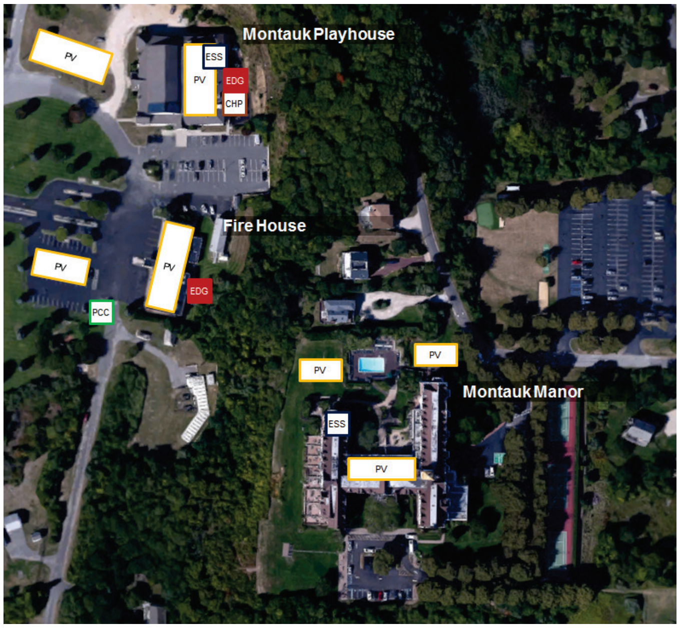
- Montauk Fire Station
- Montauk Playhouse
- Montauk Manor
- Train Station
- East Hampton Housing Authority (Affordable Housing)
- Pumping Station

Node 4 consists of several facilities grouped around Flamingo Avenue in Montauk. It includes 2,450 feet of new underground infrastructure to connect the facilities.

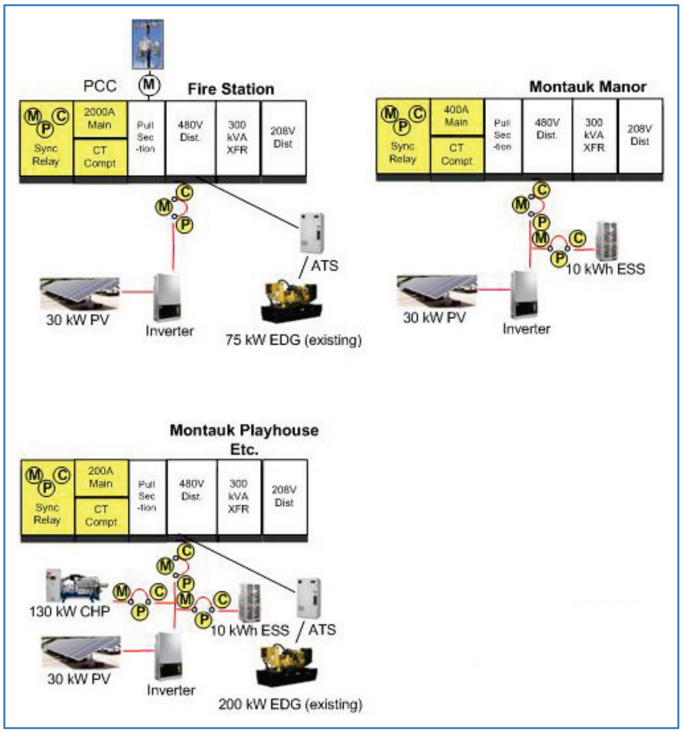
Additional detail on the facilities included in this node is provided on the following pages.

Node 4 System Configuration (Continued)

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facilities

- Montauk Playhouse
- Montauk Fire Station
- Montauk Manor

Description

The Point of Common Coupling (PCC) for Node 4 is located along Edgemere Street near the Fire Station. The following new infrastructure will be included in the microgrid:

Montauk Playhouse

- Ground-Mounted & Rooftop PV (30 kW)
- CHP (130 kW)
- ESS (10 kWh)
- Existing EDG (200 kW)

Montauk Fire Station

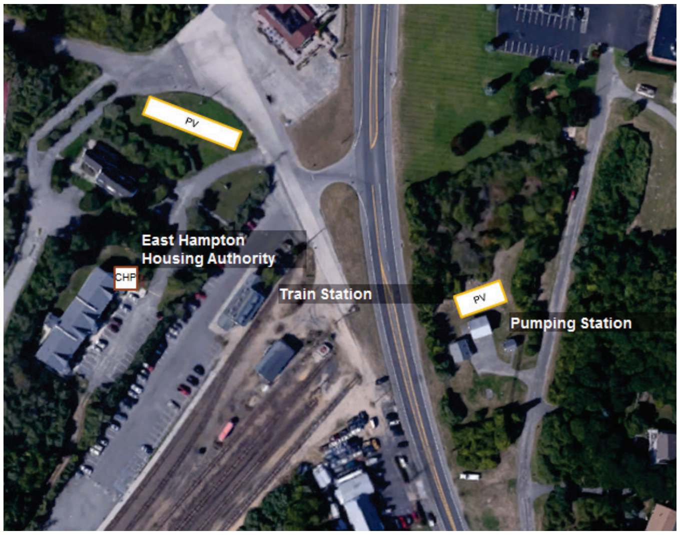
- Covered Parking & Rooftop PV (30 kW)
- Existing EDG (75 kW)

Montauk Manor

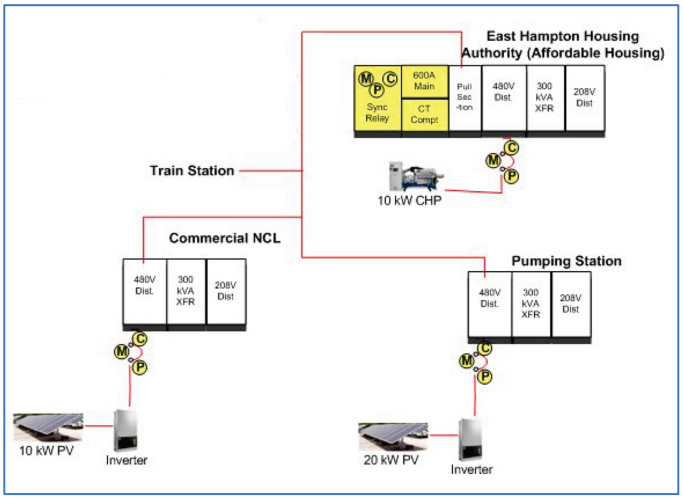
- Ground-Mounted & Rooftop PV (30 kW)
- ESS (10 kWh)

Node 4 System Configuration (Continued)

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facilities

- East Hampton Housing Authority (Affordable Housing)
- Pumping Station
- Train Station

Description

In addition to the facilities listed below, Node 4 was also optimized to support the Train Station. The following infrastructure will be included in the microgrid:

East Hampton Housing Authority (Affordable Housing)

- CHP (10 kW)

Pumping Station

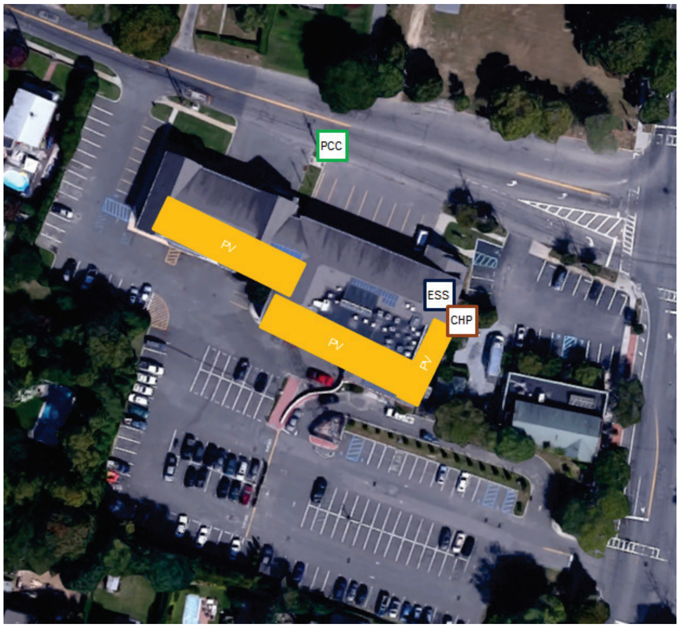
- Ground-Mounted PV (20 kW)

Locates at Commercial Non-Critical Load Facilities

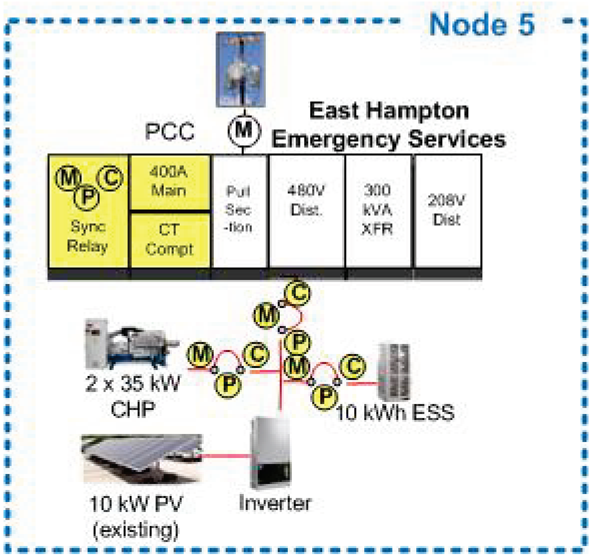
- Ground-Mounted PV (10 kW)

Node 5 System Configuration

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facility

- East Hampton Emergency Services

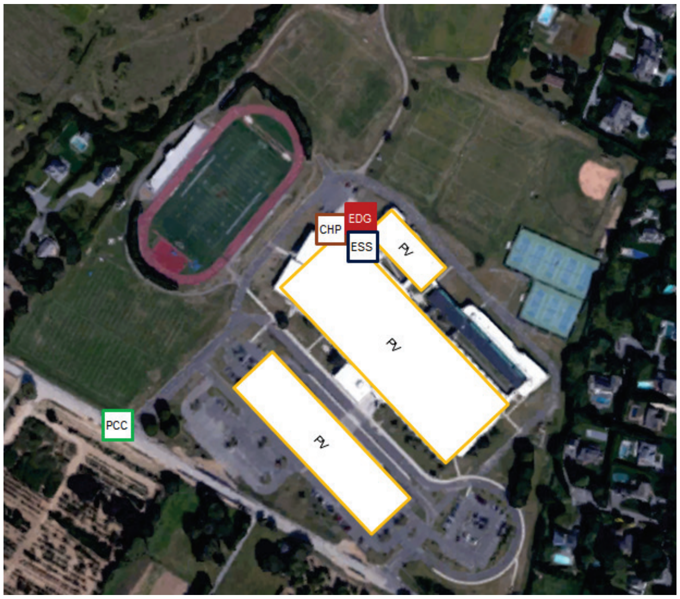
Description

The PCC is located along Cedar Street north of the facility. The facility has an existing PV system (10 kW). The following resources will be included in the microgrid:

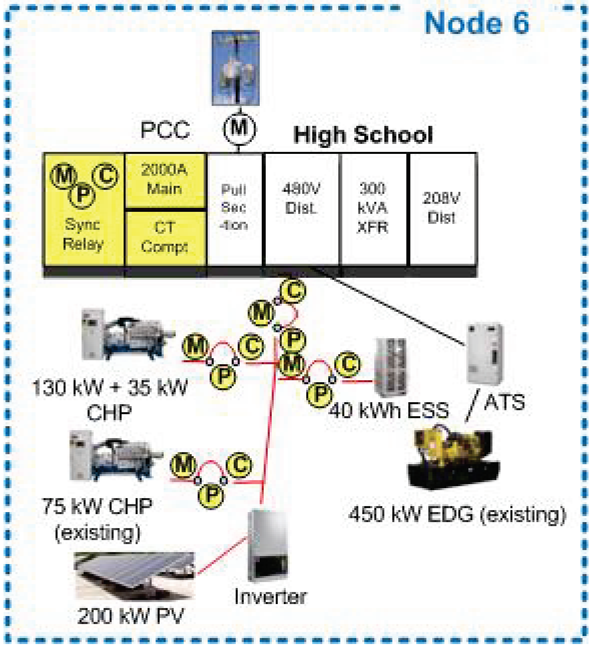
- Existing PV (10 kW)
- CHP (70 kW)
- ESS (10 kWh)

Node 6 System Configuration

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facility

- East Hampton High School

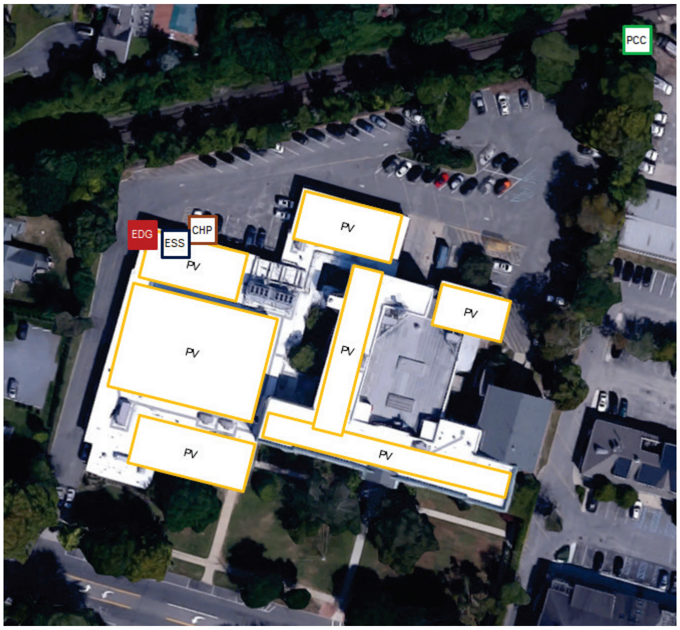
Description

The PCC is located along Long Lane. south of the facility. The facility has an existing CHP system (75 kW) and diesel backup generator (450 kW). The following resources will be included in the microgrid:

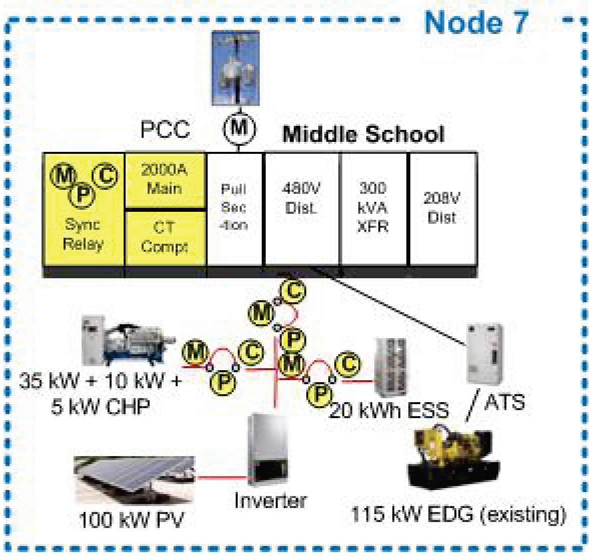
- Ground-Mounted & Rooftop PV (200 kW)
- CHP (165 kW)
- Existing CHP (75 kW)
- ESS (40 kWh)
- Existing EDG (450 kW)

Node 7 System Configuration

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facility

- East Hampton Middle School

Description

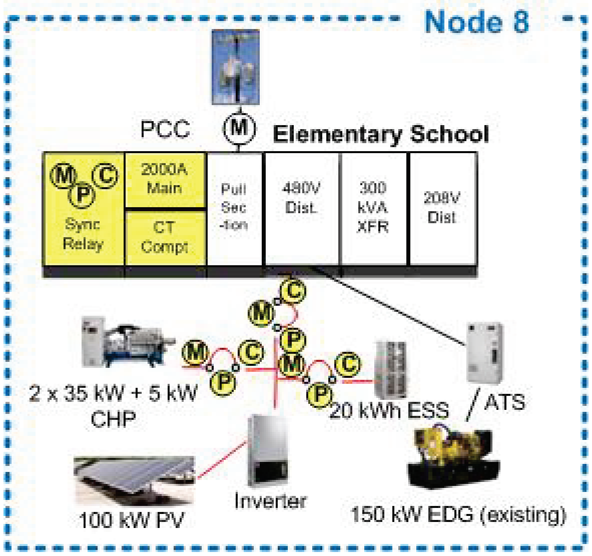
The PCC is located northeast of the facility near the train tracks. The facility has an existing diesel backup generator (115 kW). The following resources will be included in the microgrid:

- Rooftop PV (100 kW)
- CHP (50 kW)
- ESS (20 kWh)
- Existing EDG (115 kW)

Node 8 System Configuration

Geospatial Diagram

One-Line Diagram Excerpt*



*See appendix B for full one-line diagram

Facility

- John M. Marshall Elementary School

Description

The PCC is located along Church Street west of the facility. The facility has an existing diesel backup generator (150 kW). The following resources will be included in the microgrid:

- Covered Parking & Rooftop PV (100 kW)
- CHP (75 kW)
- ESS (20 kWh)
- Existing EDG (150 kW)

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.
- **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 eight nodes separately. Table 5 presents an overview of the annual energy operations of the microgrid by node. The microgrid will have a maximum demand of 3,518 kW and an average demand of 1,057 kW. The microgrid will deliver approximately 9,300,000 kWh per year. The thermal loads in the microgrid will be approximately 39,800,000 kBTU per year, of which approximately 11,300,000 kBTU will be recovered from the CHP systems and reused to support on-site thermal loads.

Table 4 – Microgrid Energy Overview: Grid Connected Operation

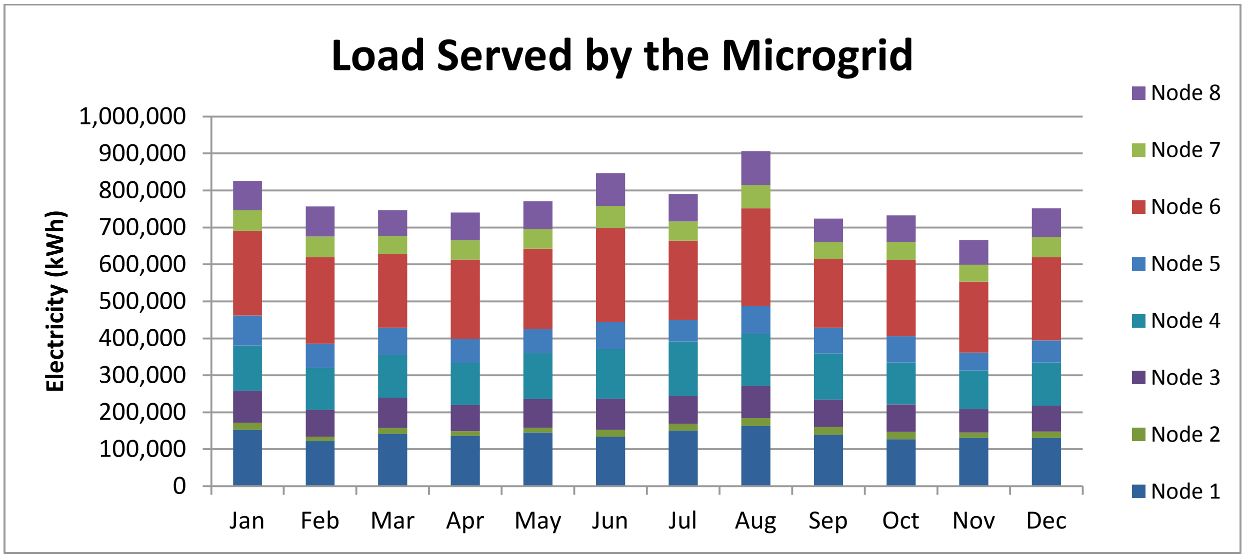
	Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
Node	Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
1	577	191	1,672,459	139,372	5,510,045	459,170	1,939,520	161,627
2	77	23	204,486	17,041	172,909	14,409	123,400	10,283
3	307	105	919,078	76,590	2,615,793	217,983	1,084,338	90,361
4	458	168	1,469,818	122,485	7,514,615	626,218	2,975,163	247,930
5	243	92	802,800	66,900	1,007,998	84,000	742,166	61,847
6	1,188	301	2,638,637	219,886	20,361,912	1,696,826	2,933,319	244,443
7	230	72	633,526	52,794	1,234,734	102,894	622,421	51,868
8	438	105	916,512	76,376	1,417,192	118,099	876,456	73,038
Total	**3,518**	**1,057**	**9,257,316**	**771,443**	**39,835,196**	**3,319,600**	**11,296,782**	**941,399**

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

Table 5 –Monthly Grid Connected Operation by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Total
	(kWh)								
Jan	152,125	19,434	86,774	122,125	81,552	229,246	55,168	79,698	826,121
Feb	121,917	12,252	72,777	113,150	65,514	233,612	56,060	81,192	756,473
Mar	141,673	15,853	82,068	115,556	73,478	200,123	48,130	69,444	746,325
Apr	135,999	13,000	70,775	113,348	65,198	215,013	51,781	74,789	739,903
May	144,973	13,330	77,687	124,194	64,331	217,976	52,400	75,623	770,514
Jun	134,243	18,435	84,151	134,247	72,191	254,283	60,946	88,335	846,831
Jul	150,944	17,876	76,161	146,813	57,580	214,872	51,536	74,633	790,414
Aug	162,412	21,760	86,983	140,667	74,854	264,573	63,428	91,803	906,480
Sep	139,162	20,554	74,912	124,680	69,851	185,875	44,498	64,462	723,993
Oct	127,392	20,024	74,288	113,427	70,097	206,235	49,503	71,792	732,757
Nov	131,005	14,719	62,629	104,952	48,558	191,340	45,972	66,512	665,687
Dec	130,615	17,249	69,873	116,661	59,596	225,490	54,105	78,229	751,818
Total	**1,672,459**	**204,486**	**919,078**	**1,469,818**	**802,800**	**2,638,637**	**633,526**	**916,512**	**9,257,316**

Figure 6 - Monthly Grid Connected Operation by Node



The East Hampton microgrid is designed for the majority of 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 East Hampton 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 East Hampton 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 6 - Microgrid Resources Comparison

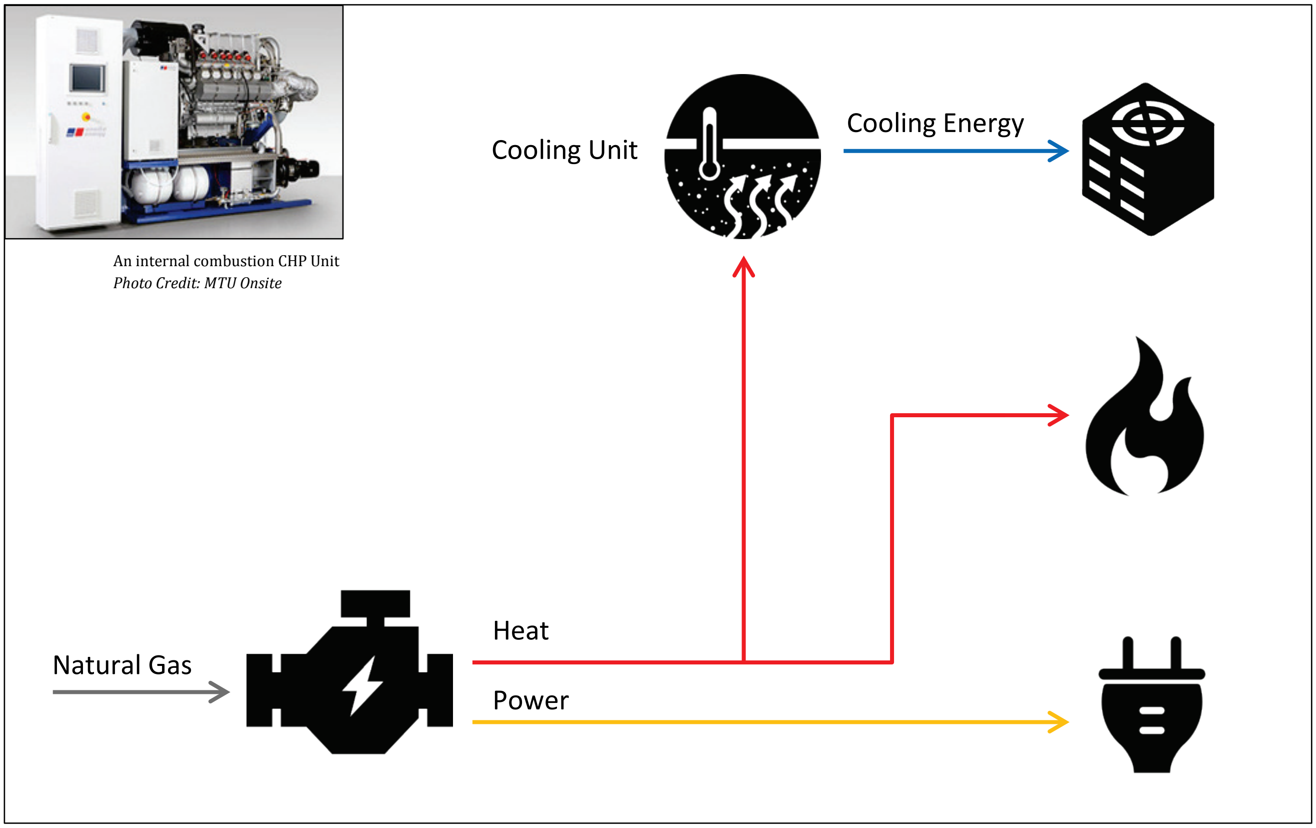
Node	Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW
1	Business as Usual	577	-	-	-	-	-	-	6	805
	Microgrid	340	7	300	7	50/100	6	110	6	805
2	Business as Usual	77	-	-	-	-	-	-	-	-
	Microgrid	47	1	50	1	5/10	2	20	-	-
3	Business as Usual	307	-	-	-	-	-	-	1	50
	Microgrid	187	4	130	2	20/40	3	80	1	50
4	Business as Usual	458	-	-	-	-	-	-	2	275
	Microgrid	190	5	120	2	10/20	2	140	2	275
5	Business as Usual	243	1	10	-	-	-	-	-	-
	Microgrid	235	1	10	1	5/10	2	70	-	-
6	Business as Usual	1188	-	-	-	-	1	75	1	450
	Microgrid	940	1	200	1	20/40	2	165	1	450
7	Business as Usual	230	-	-	-	-	-	-	1	115
	Microgrid	150	1	100	1	10/20	3	50	1	115
8	Business as Usual	438	-	-	-	-	-	-	1	150
	Microgrid	410	1	100	1	10/20	3	75	1	150

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 7.

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
- The federal investment tax credit may apply to eligible customers

CHP Approach

- Co-locate generators near thermal loads on the customer-side of the meter
- Design for base load operation 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, DHW, and pool heating
- Design to serve specific summer Heat Recovery Loads, including space cooling, domestic hot water (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 7 - Microgrid CHP Resources by Node

Node	Natural Gas Engine or CHP	
	Qty	Total kW
1	6	110
2	2	20
3	3	80
4	2	140
5	2	70
6	2	165
7	3	50
8	3	75
Total	**23**	**710**

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

Table 8 - Microgrid CHP Electric Production by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Total
	Electric Production (kWh)								
Jan	75,739	12,489	54,748	87,954	51,298	82,991	28,061	42,331	435,611
Feb	60,174	7,454	47,154	79,498	45,251	101,160	29,851	45,428	415,969
Mar	68,007	8,990	51,903	79,680	49,432	69,896	25,000	38,712	391,620
Apr	69,145	7,026	47,434	81,436	47,000	72,277	26,003	38,857	389,178
May	69,468	7,164	48,682	83,886	46,659	66,368	23,034	37,593	382,855
Jun	64,365	10,466	51,221	84,169	47,945	83,400	27,181	40,604	409,351
Jul	73,230	9,527	46,772	87,928	39,542	69,848	25,188	39,301	391,337
Aug	73,658	12,572	51,495	87,955	47,478	77,839	27,460	40,795	419,252
Sep	67,309	12,038	48,154	80,676	44,878	66,169	21,122	35,719	376,065
Oct	66,199	12,397	51,044	82,095	50,655	67,743	24,792	38,784	393,709
Nov	68,468	8,898	41,340	79,324	36,292	67,437	24,804	37,666	364,228
Dec	70,367	11,402	48,843	83,321	47,596	69,871	26,370	39,901	397,672
Total	**826,129**	**120,424**	**588,789**	**997,920**	**554,025**	**895,000**	**308,865**	**475,693**	**4,766,845**

Figure 8 – Microgrid CHP Electric Production

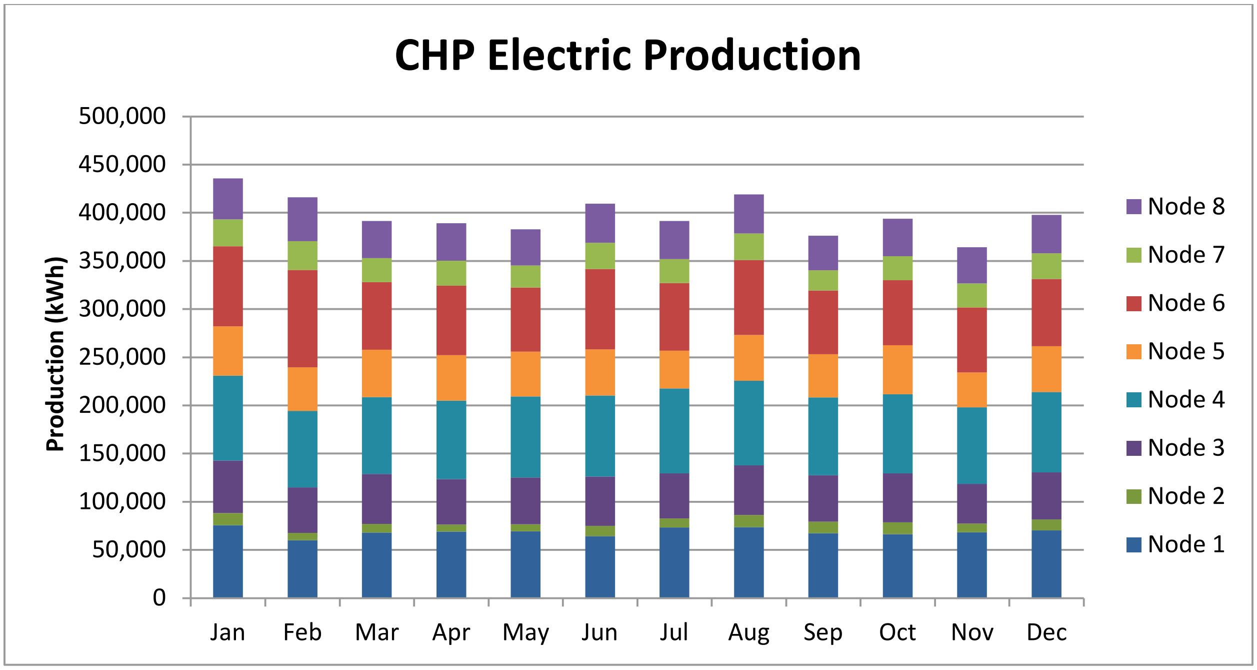


Table 9 - Microgrid CHP Heat Recovery by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Total
	Heat Recovery (kBTU)								
Jan	266,039	27,722	181,487	436,387	119,097	383,869	86,631	121,754	1,622,987
Feb	214,036	22,345	160,118	393,795	112,892	475,123	82,731	116,992	1,578,031
Mar	237,113	17,950	149,569	396,399	129,791	320,344	86,115	126,965	1,464,245
Apr	186,774	2,714	60,098	332,972	117,248	331,852	75,650	100,930	1,208,238
May	120,849	0	26,012	79,783	61,703	30,287	2,116	2,689	323,440
Jun	52,975	0	20,614	39,178	28,266	66,911	4,115	4,864	216,923
Jul	43,068	0	20,628	28,015	7,983	56,580	3,609	4,280	164,162
Aug	46,484	0	23,738	40,692	7,606	66,613	4,113	4,652	193,899
Sep	108,371	0	27,920	79,217	8,324	259,839	19,067	21,746	524,485
Oct	188,864	5,351	108,395	342,423	16,430	311,238	72,161	94,579	1,139,440
Nov	224,739	21,145	140,881	393,399	45,829	309,838	89,912	133,519	1,359,262
Dec	250,207	26,173	164,879	412,902	86,996	320,825	96,202	143,486	1,501,670
Total	**1,939,520**	**123,400**	**1,084,338**	**2,975,163**	**742,166**	**2,933,319**	**622,421**	**876,456**	**11,296,782**

Figure 9 – Microgrid CHP Heat Recovery

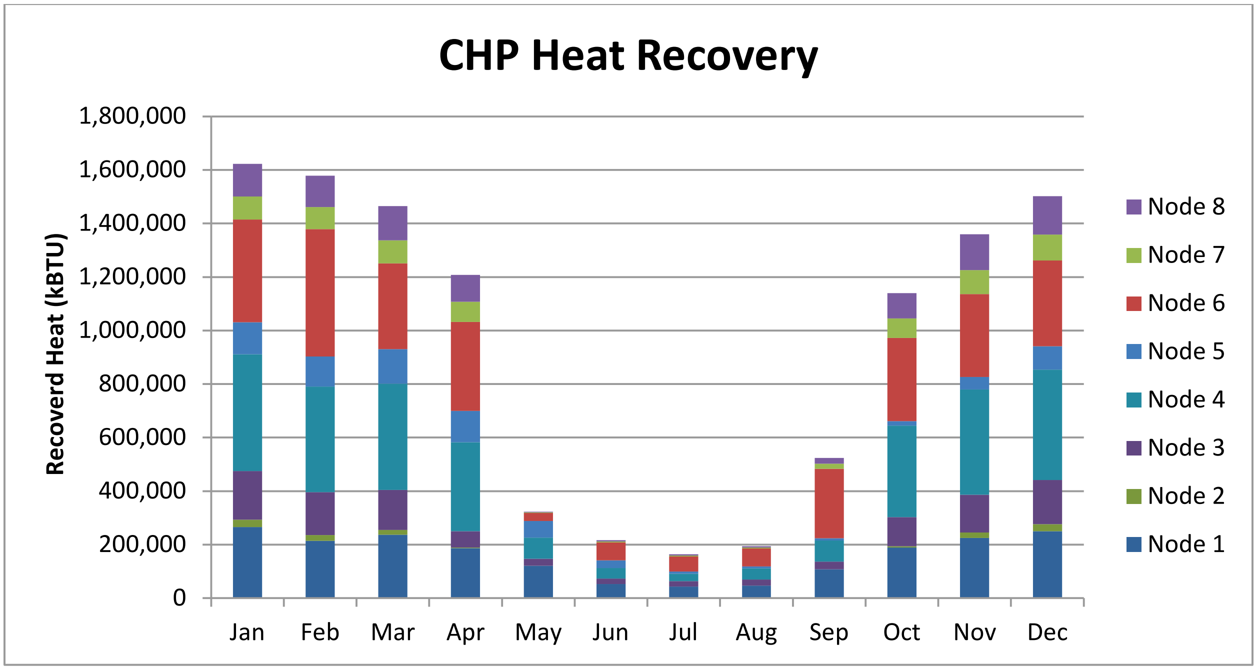
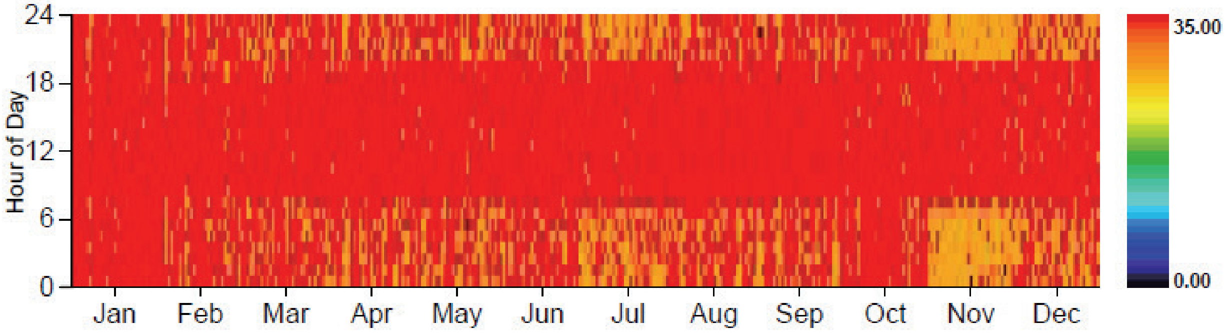


Figure 10 presents the hourly operation of the CHP in an example node in the form of a heat map. This representation demonstrates that the CHP unit is operating near full capacity for a majority of hours (red), then does some electric load following during the other hours (orange) but is loaded at an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

Figure 10 – Example Node CHP Operational Summary

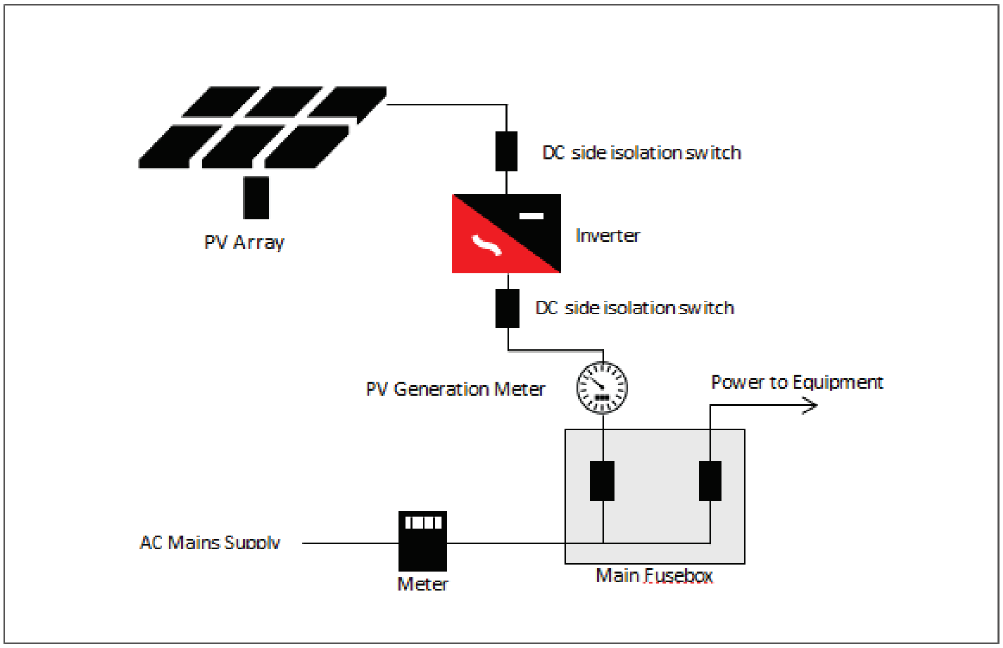
CHP Output



Solar Photovoltaics

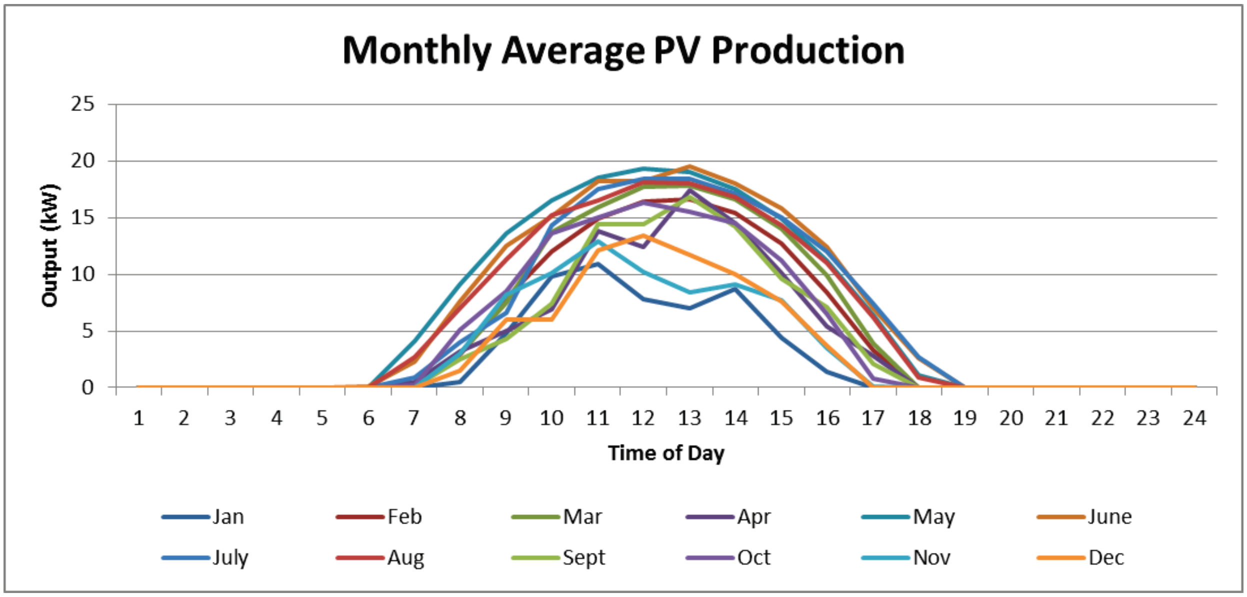
The solar PV will be rooftop, parking lot, or ground mounted using hail-rated solar panels. PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by photons and 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. Total production is based on a capacity factor specific to solar production in East Hampton (15.5%).

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

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 10 - Microgrid PV Resources by Node

Node	PV	
	# of Inverters	Total kW
1	7	300
2	1	50
3	4	130
4	5	120
5	1	10
6	1	200
7	1	100
8	1	100
Total	**21**	**1,010**

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

Table 11 – Microgrid PV Fleet Electric Production

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Total
Electric Production (kWh)									
Jan	26,729	4,455	11,582	10,692	912	18,238	9,119	9,119	90,845
Feb	29,367	4,894	12,726	11,747	994	19,880	9,940	9,940	99,487
Mar	40,015	6,669	17,340	16,006	1,368	27,361	13,680	13,680	136,120
Apr	37,400	6,233	16,207	14,960	1,237	24,748	12,374	12,374	125,534
May	39,500	6,583	17,117	15,800	1,300	26,007	13,003	13,003	132,314
Jun	38,271	6,378	16,584	15,308	1,247	24,935	12,468	12,468	127,659
Jul	37,411	6,235	16,212	14,965	1,215	24,293	12,146	12,146	124,623
Aug	37,660	6,277	16,319	15,064	1,211	24,228	12,114	12,114	124,988
Sep	36,428	6,071	15,786	14,571	1,206	24,110	12,055	12,055	122,282
Oct	33,657	5,610	14,585	13,463	1,108	22,164	11,082	11,082	112,750
Nov	25,946	4,324	11,243	10,378	855	17,109	8,554	8,554	86,964
Dec	25,278	4,213	10,954	10,111	833	16,664	8,332	8,332	84,718
Total	**407,962**	**67,944**	**176,653**	**163,065**	**13,487**	**269,736**	**134,868**	**134,868**	**1,368,583**

* Note: Total production is based on a capacity factor specific to solar production in East Hampton (15.5%).

Figure 14 – Microgrid PV Fleet Electric Production

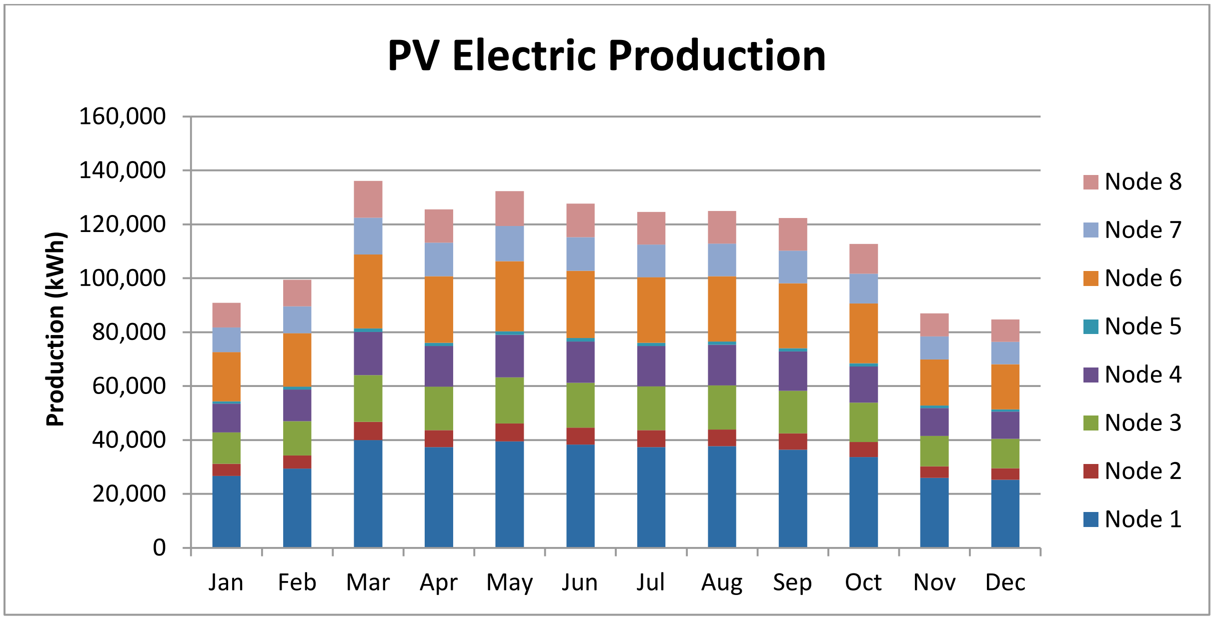
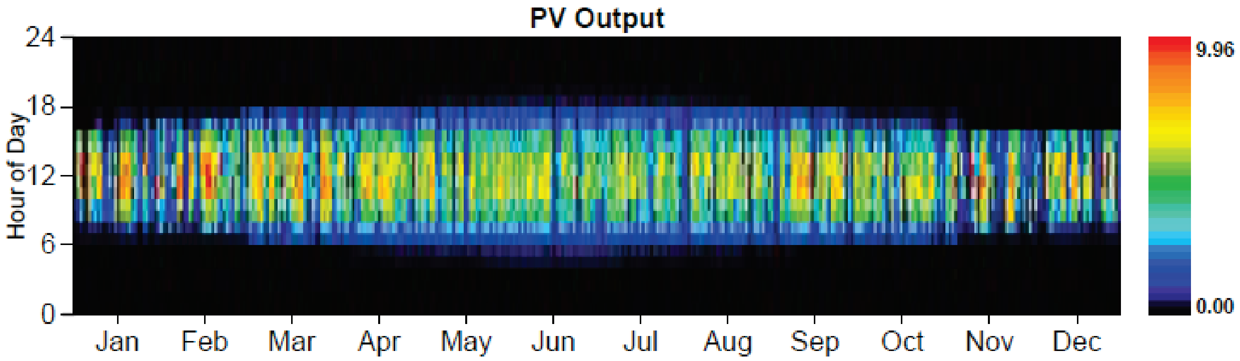


Figure 15 presents the hourly operation of the PV in an example node in the form of a heat map. This representation demonstrates how the PV units operate during hours of sunshine with maximum production in the middle of the day, ramping up in the mornings and ramping down in the afternoon hours. This 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 East Hampton microgrid is 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

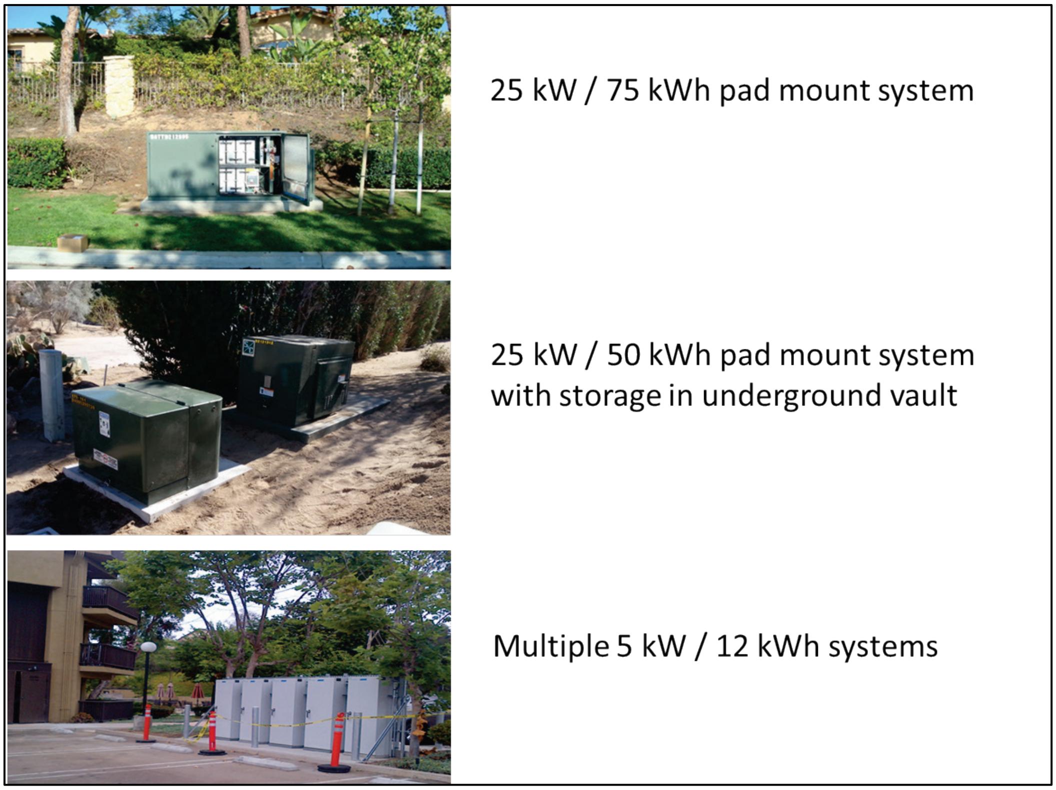
- Most Li-ion systems have accurate methods of determining the system SOC
- Typical power electronic systems provide multiple modes of operation
- Systems are typically capable of four quadrant operation

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
    - Load Shifting
    - Frequency Regulation
    - Reactive Power Support
    - PV Support
    - Demand Response
    - Energy Arbitrage
    - Backup Power

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

Figure 16 – Example ESS Installations



25 kW / 75 kWh pad mount system

25 kW / 50 kWh pad mount system with storage in underground vault

Multiple 5 kW / 12 kWh systems

Energy Storage Approach

- Co-locate 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 12 - Microgrid ESS Resources by Node

Node	Battery Energy Storage		
	Qty	kW	kWh
1	7	50	100
2	1	5	10
3	2	20	40
4	2	10	20
5	1	5	10
6	1	20	40
7	1	10	20
8	1	10	20
Total	**16**	**130**	**260**

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 13 – Microgrid ESS Operation Example Node

Month	Charge	Discharge	Net
	(kWh)		
Jan	34	32	3
Feb	64	59	5
Mar	144	124	20
Apr	116	113	4
May	153	139	14
Jun	131	117	14
Jul	175	169	6
Aug	153	140	12
Sep	136	117	19
Oct	103	100	3
Nov	207	186	21
Dec	170	163	7
Total	**1,586**	**1,458**	**128**

Figure 17 – Microgrid ESS Operation

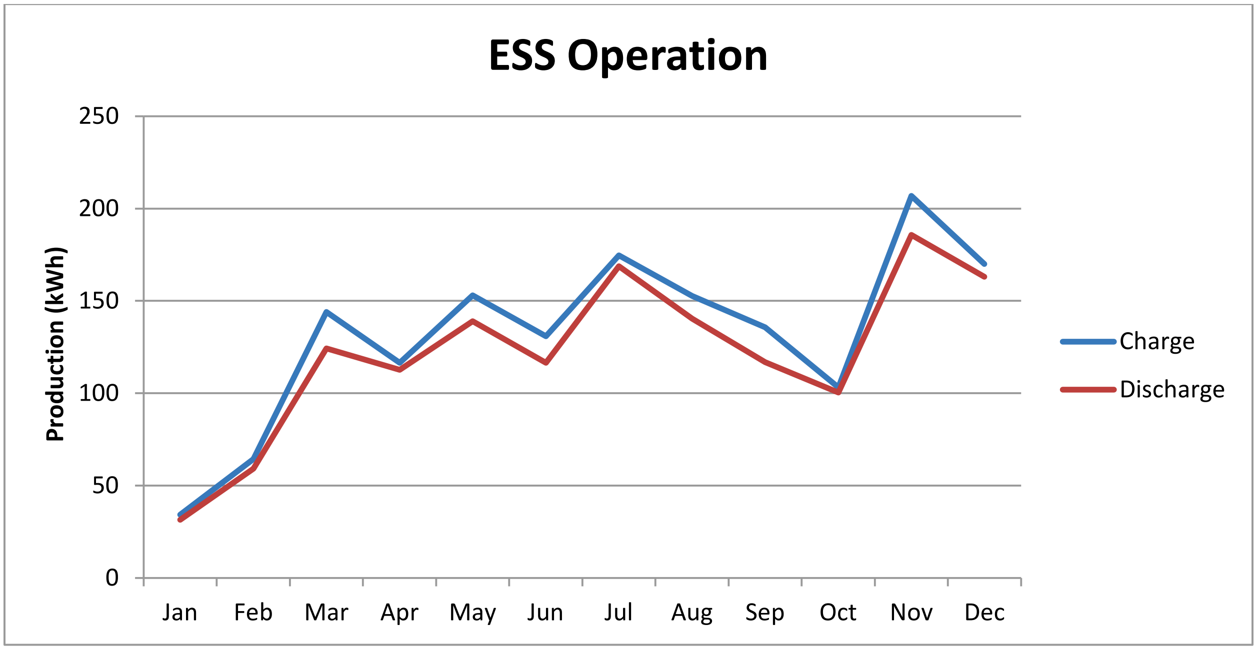
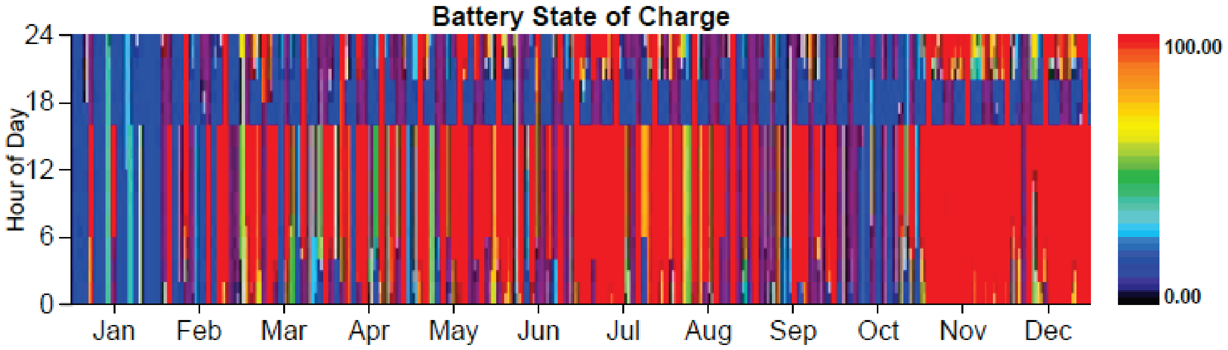


Figure 18 presents the hourly operation of the ESS in an example node in the form of a heat map. This representation demonstrates how the ESS units operate. Typically, the units are charged to a high SOC in the middle of the day. The operations represent PV intermittency support, PV load shifting, peak 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 East Hampton 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 East Hampton 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 police, 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 14 –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	469	238	40,047	287,678	57,646
	Summer	448	222	37,380	10,918	10,873
2	Winter	56	28	4,667	10,846	7,199
	Summer	58	25	4,227	0	0
3	Winter	236	130	21,894	153,471	46,400
	Summer	213	112	18,777	5,210	5,210
4	Winter	384	191	32,148	431,155	109,601
	Summer	393	222	37,241	7,079	7,079
5	Winter	86	81	13,677	44,061	31,149
	Summer	99	62	10,459	1,989	1,989
6	Winter	840	359	60,353	595,083	97,285
	Summer	718	317	53,245	15,595	14,562
7	Winter	204	87	14,543	36,091	10,385
	Summer	172	76	12,771	915	371
8	Winter	296	125	20,957	41,402	31,252
	Summer	250	110	18,490	1,081	1,081
Total	**Winter**	**2,573**	**1,240**	**208,286**	**1,599,786**	**390,918**
	Summer	**2,352**	**1,146**	**192,590**	**42,786**	**41,166**

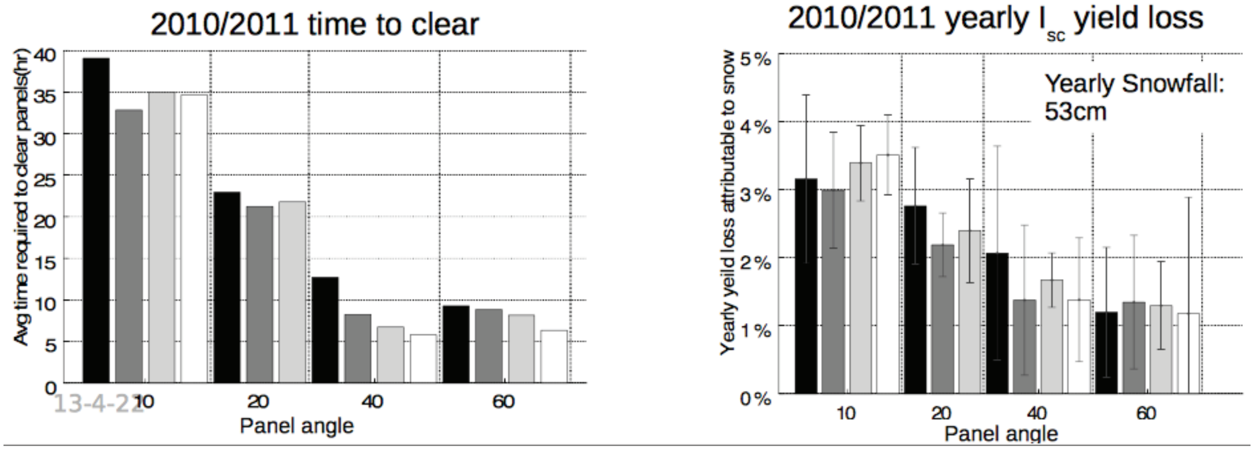
Microgrid DERs Resiliency

Under Task#1, our team assessed the resiliency risk profile for various forces of nature to inform the microgrid design. This profile was evaluated in the following areas, with the associated design emphasis results:

1. Wind / Tornado – The design of the DER structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical and thermal distribution equipment will withstand Category F2 wind speeds for this area. Installation of energy storage systems will be inside interior building electrical or mechanical rooms wherever possible.
2. Rain / Flooding / Hurricane – The design of the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical and thermal distribution equipment will withstand Category 4 Hurricane (Staffer-Simpson scale, same maximum wind speed as the Category F2 tornado on the Fujita scale). In addition, the height of the base foundation for outdoor units is designed to ensure the equipment is 1 to 1.5 feet above the 100-year flood plain level. Installation of energy storage systems will be inside interior building electrical or mechanical rooms wherever possible.
3. Earthquake – The design of the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical distribution equipment will withstand seismic event magnitude 6.9 (Richter scale), or a 100-year local seismic event, whichever is lesser. Due consideration is given to the design to overhead risk from buildings and other structures located above the microgrid equipment.
4. Extreme Heat – The design the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical distribution equipment will withstand 125°F (50°C) continuous operating temperatures. Where equipment enclosure temperatures are expected to exceed these temperatures for more than 10 minutes, space cooling is added.
5. Cold / Ice – The design of the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical distribution equipment will withstand 15°F (-24°C) continuous operating temperatures. Where equipment enclosure temperatures are expected to exceed these temperatures for more than 10 minutes, space heating is added. Enclosure design includes mitigation of ice formations that block airflow.

While deep snow on PV arrays can affect production, the typical effects are not as severe as one might guess. The performance criteria for snow cover on PV panels are based on annual loss of energy generation. A study published at Sandia National Laboratory, conducted by Queens University and Calama Consulting in Canada, on a set of PV arrays totaling 8 MW in Kingston, Ontario, Canada using 2010-2012 data (annual snowfall 21 inches) shows that snow affects about 1 to 3% annual production loss – similar to the annual production loss from sand and dust in San Diego, California.

Figure 19 – PV Impedance from Snowfall



The first graph shows the time required to clear the snow. The second graph shows the yield loss rate for having the snow in place for the duration of the first graph. Both are based on panel angle.

Reliability of Fuel Sources

Microgrid installations of natural-gas-fired generation systems at multiple locations provide opportunities to improve the quality and reliability of gas distribution that will benefit a wide range of customers throughout East Hampton.

The natural gas network is considered an uninterruptable fuel supply for the community in the face of major storms because:

(1) There are multiple network sources of natural gas

(2) The actual natural gas network load decreases in a major storm because the non-critical loads are not operating

(3) There is no history of loss of service in past major storms

In addition, interruptible service is a financial construct, not a technical limitation. Home heating is considered the highest priority for continuity of supply in the face of challenges to the natural gas network. Since this microgrid will use natural gas for CHP (heating of critical facilities), it will be given the highest priority for continuity of supply in the face of a major storm.

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 using the proposed third-party ownership business model. Under this model, the project is funded through outside 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 benefits of the microgrid, including benefits from emissions reductions, cost reductions, and resilience improvements.

Installed Cost

As part of the feasibility analysis, the project team developed a general budget for the East Hampton 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, construction, controls, start-up, commissioning, and training. 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 $9,266,000 with an accuracy of +/- 25% (within the +/- 30% set by NYSERDA). When the federal investment tax credit is applied, the net installed cost is $7,715,000. This cost does not include incentives that may be applicable to the project. The plan is to take advantage of all applicable incentives for the project.

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

- **Demand Response**: PSE&G'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. In December, the ITC was extended for three years, with a ramp-down through 2022.
- **NYSERDA Incentives**: There are many incentive programs available from NYSERDA that are likely apply to the East Hampton Community Microgrid, including programs that support sub-metering, energy efficiency, and various distributed and clean energy resources. The details of these programs are likely to change by the time the East Hampton project is ready to take advantage of them, which is why no specifics are included here.
- **NY SUN initiative:** This program provides rebates and performance incentives for new residential and commercial solar PV installations.
- **New York Power Authority – Energy Services Program for Public Utilities**: This program provides various rebates on energy efficient equipment.
- **Federal Energy-Efficient Commercial Buildings Tax Deduction**: This deduction provides $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.

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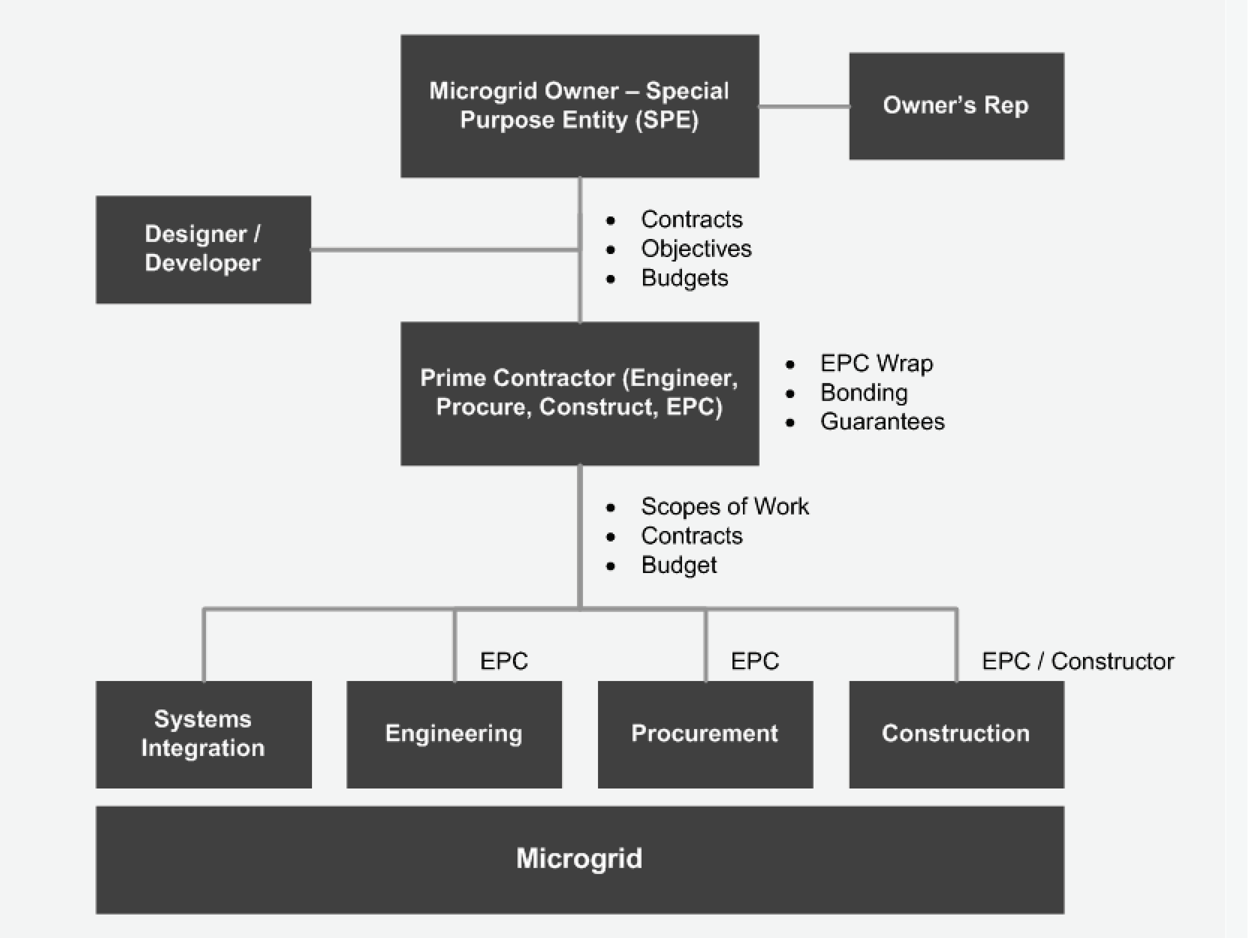
[1] Identified from the DSIRE database as of December 2015. http://programs.dsireusa.org/system/program?state=NY

Third Party Ownership

Under the proposed business model, a third party 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 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 integrating the controls and communications systems. This process is presented in the Figure 20 below.

Figure 20: 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. If selected for Stage 2, the team would evaluate how shorter PPA periods would affect the energy price and discuss those options with potential system participants.

The operation of the microgrid will leverage the autonomous functionality of the microgrid controller, and minimize the need for on site operators. The 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. In addition, the microgrid controller will monitor the performance, operation and alarms of the distributed resources. In the event of an alarm, the SPE will be notified through the network operations center, and dispatch a service technician who will be engaged through a service contract. 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 at a time that will have the least impact on the overall operation of the microgrid. As the microgrid operates, a history of performance, trending and signature analyses will develop, adding to the microgrid's ability to anticipate failures.

The project team conducted a thorough econometric analysis of the proposed East Hampton Community Microgrid to determine the financial viability of the project. Hitachi has developed proprietary economic modelling software, known as EconoSCOPE™, that is specifically designed to support financial analysis for public infrastructure projects. The project team used this software to support the analysis of the financial viability of the East Hampton Community Microgrid project. Financial institutions do not yet allow for recognition of incentives in their evaluations of project attractiveness. Therefore, the project team did not include them in the underlying economic analysis at this time. During the detailed design phase, financial incentives will be evaluated as part of the entire system costs.

The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately $0.181/kWh. Based on estimated project financing costs and the 25 year contract term, the study supports a PPA electric rate with an electric cost that is higher than the average cost of electricity currently paid by potential microgrid customers. This analysis does not include Stage 2 or Stage 3 NY Prize funding, which would have the potential to significantly lower the PPA rate.

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 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) of 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 East Hampton Community Microgrid, the breakeven outage case is an average of 1.4 days of 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 1.4 days per year (Scenario 2).

Table 15 – Cost Benefit Analysis Summary Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 1.4 DAYS/YEAR
Net Benefits - Present Value	-$8,190,000	$26,100
Total Costs – Present Value	$18,200,000	$18,200,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-12.1%	6.2%

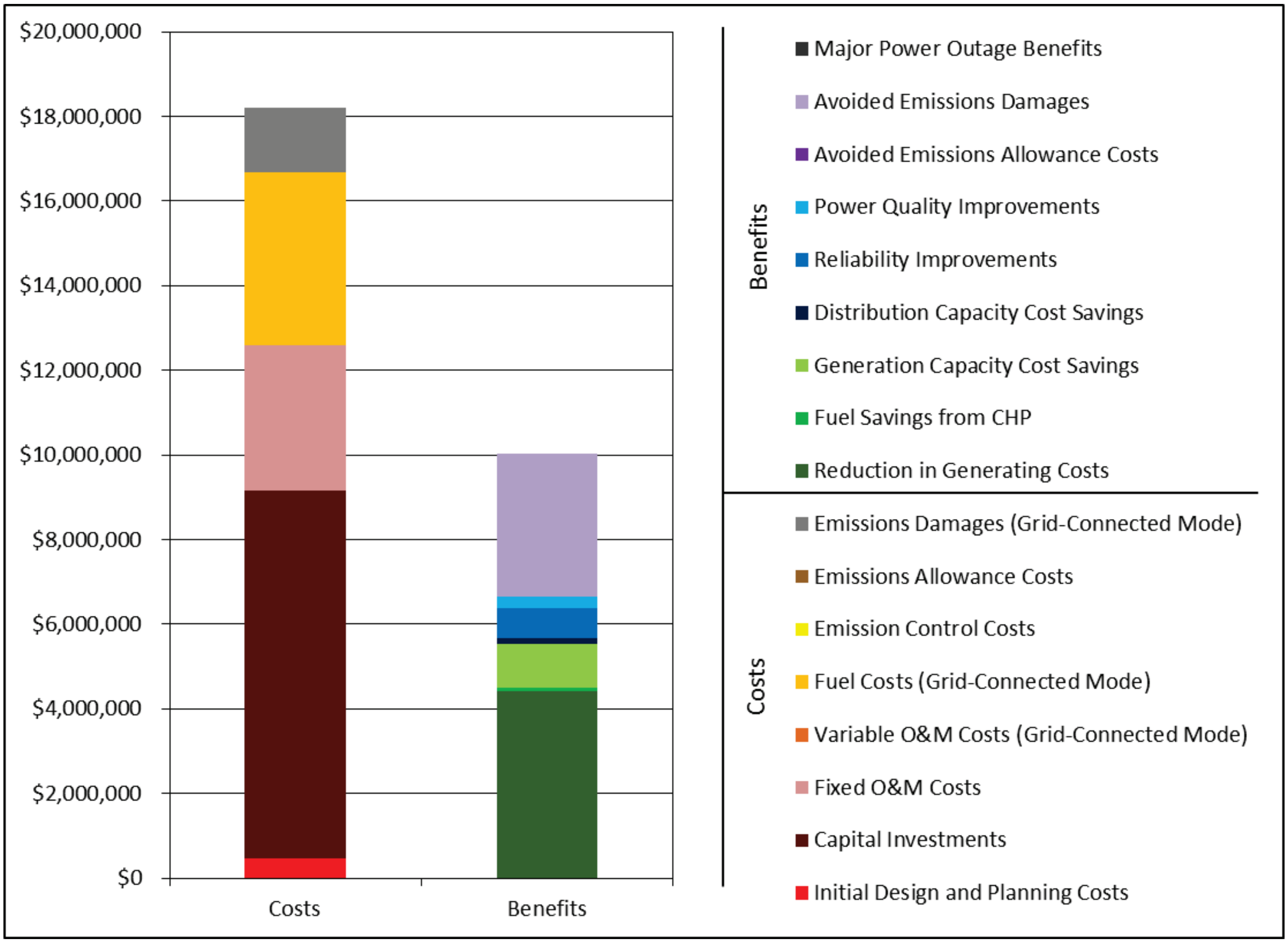
The cost benefit analysis results for scenario 1 are presented in Table 15.

Table 16 – 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	$8,690,000	$702,000
Fixed O&M	$3,420,000	$301,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$4,090,000	$360,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,540,000	$101,000
Total Costs	**$18,200,000**	
Benefits		
Reduction in Generating Costs	$4,420,000	$390,000
Fuel Savings from CHP	$89,000	$7,850
Generation Capacity Cost Savings	$1,020,000	$90,100
Distribution Capacity Cost Savings	$149,000	$13,200
Reliability Improvements	$691,000	$60,900
Power Quality Improvements	$278,000	$24,500
Avoided Emissions Allowance Costs	$2,220	$196
Avoided Emissions Damages	$3,370,000	$220,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$10,000,000**	
Net Benefits	**-$8,190,000**	
Benefit/Cost Ratio	**0.6**	
Internal Rate of Return	**-12.1%**	

Figure 21 – Cost Benefit Analysis Scenario 1

(No Major Power Outages; 7 Percent Discount Rate)

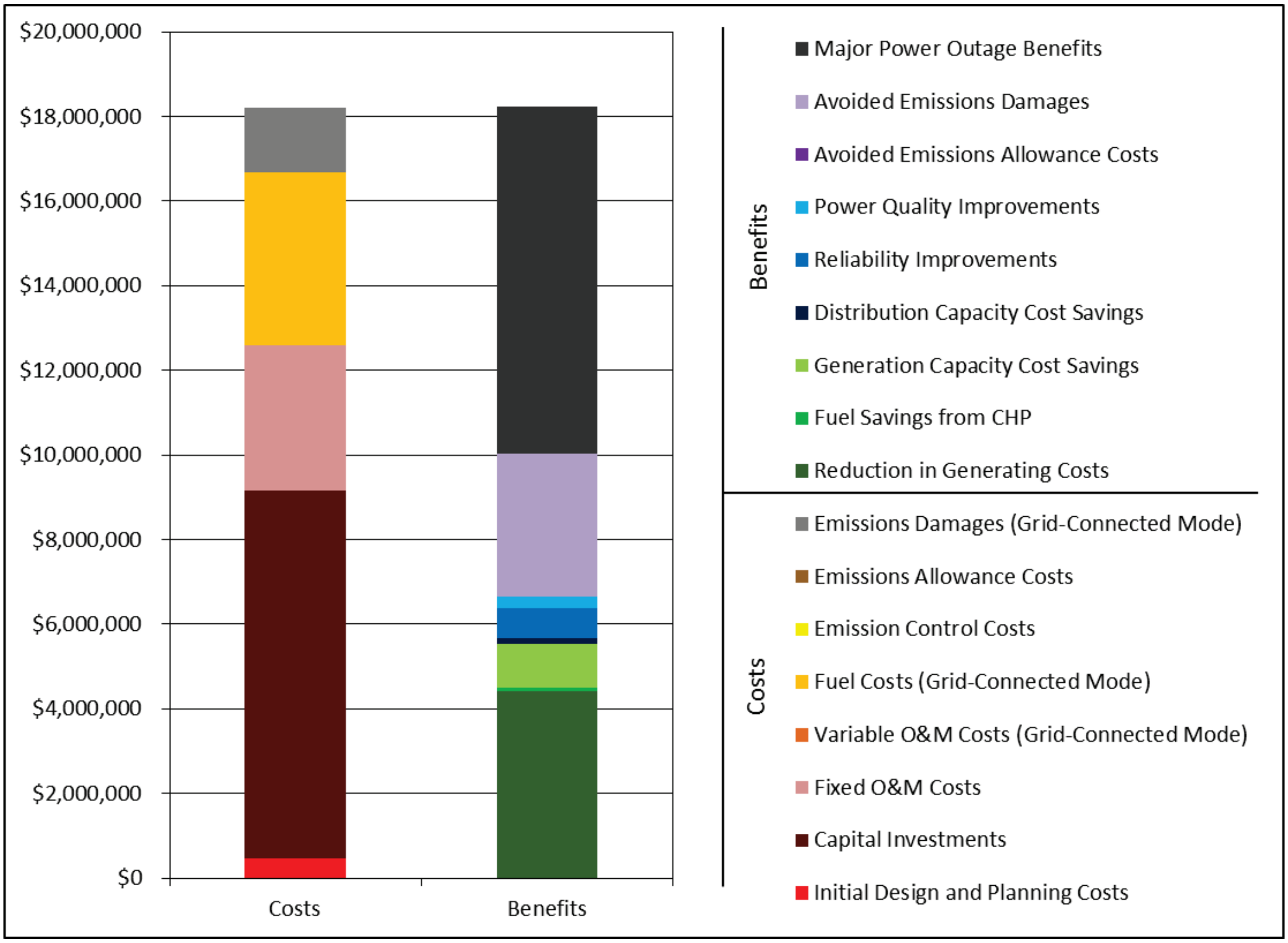


The major drivers of costs are the capital investments and fuel, where the major benefits are reduction in generation costs and avoided emissions damages.

Table 17 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 1.4 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	$8,690,000	$702,000
Fixed O&M	$3,420,000	$301,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$4,090,000	$360,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,540,000	$101,000
Total Costs	**$18,200,000**	
Benefits		
Reduction in Generating Costs	$4,420,000	$390,000
Fuel Savings from CHP	$89,000	$7,850
Generation Capacity Cost Savings	$1,020,000	$90,100
Distribution Capacity Cost Savings	$149,000	$13,200
Reliability Improvements	$691,000	$60,900
Power Quality Improvements	$278,000	$24,500
Avoided Emissions Allowance Costs	$2,220	$196
Avoided Emissions Damages	$3,370,000	$220,000
Major Power Outage Benefits	$8,210,000	$725,000
Total Benefits	**$18,200,000**	
Net Benefits	**$26,100**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.2%**	

Figure 22 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 1.4 Days/Year; 7 Percent Discount Rate)



The benefits from the 1.4 days of outages per year result in $8,210,000 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 third party ownership 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:

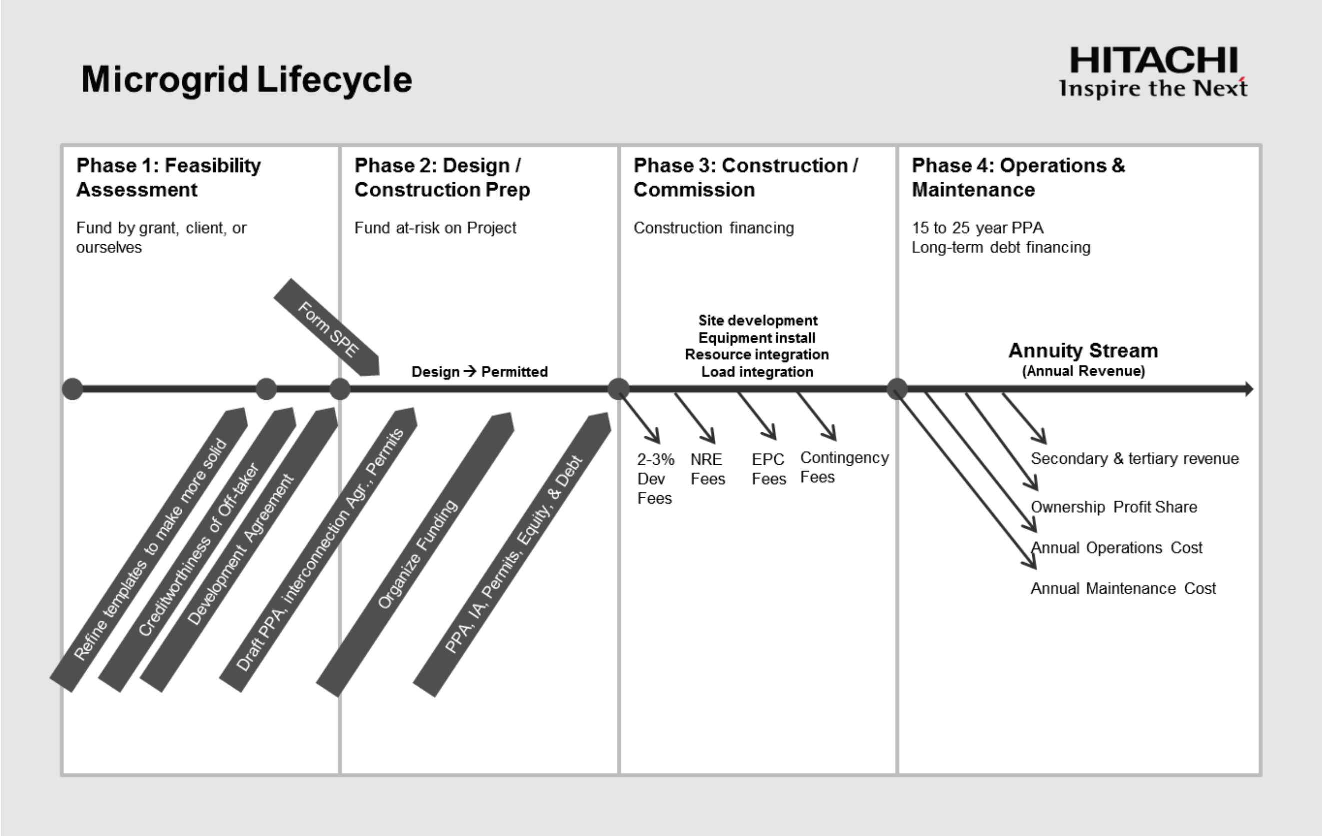
- Gas rates used in IEc's benefit-cost analysis were based on a state-wide average for commercial end-use customers. The rates used in East Hampton's financial feasibility analysis are based on available rate data from PSE&G LI, and assumptions about likely discounts associated with CHP deployments (based on experience with other New York utilities). This resulted in year 1 gas rates of $6.34 and $4.42, for the benefit-cost analysis and the financial feasibility analysis, respectively. If PSE&G LI's distributed generation rate were applied to the benefit-cost analysis, net benefits would be increased by $670,000

- 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 $1,551,000.
- Capital replacement costs used in the 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 East Hampton Community Microgrid is $302,000 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 23:

Figure 23: 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 O&M 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 East Hampton Community Microgrid has not yet been determined.

System development will involve a complex permitting process. In Stage 2, the team will 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 will address these needs in the interconnection agreement and the studies that support it. The 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 (IEEE) 1547 interconnection standard. This gives the utility more control and makes the interconnection agreement easier to approve.

Hitachi will use only underground cabling to connect loads in the East Hampton 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 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 the project team 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 Hitachi 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, Hitachi 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. Hitachi's approach to the PPA simplifies this process, billing consumed $/kWh monthly instead of the 18+ billing determinants in a typical utility electric bill. 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.

SWOT Analysis

The third party ownership approach offers the community many advantages and few risks as the following SWOT analysis demonstrates. The specific terms of the PPA will affect (amplify or mitigate) the impacts of the various characteristics described below.

Strengths

- This model is associated with no or low up-front cost to the customers. The SPE arranges all financing which enables East Hampton resources to be used for other town needs.
- The PPA establishes predictable energy prices for the customers at or below utility rates during the course of the PPA term – typically 25 years (limited allowances for fluctuations in rates are included for fuel pricing adjustments).
- The PPA secures the electricity output from the microgrid for critical community facilities.
- The PPA clearly defines the annual energy delivered and the associated costs.
- A tax-exempt entity (e.g., local government) can receive reduced electricity prices due to savings passed on from federal and state tax incentives available to the SPE.
- A third-party SPE can take advantage of the Federal Investment Tax Credit for qualified costs to essentially reduce the total project cost.
- The SPE, rather than the municipality, handles billing for each facility on the microgrid (lower overhead expense for East Hampton).
- The SPE handles regular operation, maintenance, and equipment replacement.
- Additional distributed energy resources can easily be added to the microgrid as energy requirements increase.

Weaknesses

- At the end of the PPA term, the PPA must be renegotiated. Alternatively, the assets can be transferred to the facility owner(s). This can also occur before the end of the PPA termination period, subject to "fair market value" terms defined in the agreement.

- If the buyers’ demand for energy significantly decreases, the PPA requires the buyer to continue to purchase the guaranteed amount of kilowatt-hours energy at the price agreed upon in the PPA.
- Savings from new, more cost-effective solutions that are integrated into the microgrid over the life of the PPA are captured by the SPE rather than the community.
- Additional coordination is required for maintenance and replacement of facility infrastructure (e.g., roofs) for facilities housing microgrid components (e.g., PV panels).

Opportunities

- The community will have capital and operating expense resources available to pursue other town resilience projects or other priorities.
- East Hampton may be able to integrate existing distributed generation resources into the microgrid (and receive fair market value for these assets), optimizing return on investment for these existing assets.
- East Hampton has a set of resources at specific critical facilities to include in a comprehensive emergency preparedness plan.

Threats

- Municipal ordinances, public utility rules and requirements, and state regulations may cause constraints, including:
    - Debt limitations in state and local codes and ordinances
    - Limits on contracting authority in city codes and state statutes
    - Budgeting, public purpose, and credit-lending issues
    - Limits on authority to grant site interests and buy electricity
- The PPA will be dependent on the long-term viability of the SPE. During the 15-25 year term of the PPA, the SPE could face difficulties and dissolve, requiring a change in ownership.
- The microgrid arrangement may trigger interconnection agreements and fees from the electrical distribution utility.
- Regulatory changes may burden the PPA arrangement.
- Price adjustments due to fuel cost fluctuations may threaten the value proposition for 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 East Hampton Community Microgrid team has engaged with nearly all of the major community stakeholders. Local government representatives and University participants from East Hampton have led this project from the beginning, and have signaled East Hampton’s clear interest in participating in a microgrid that can deliver resilient, cost effective energy. The community has not stated interest in any kind of public-private partnership at this time, but the project team will continue to consider the potential benefits of such an approach as the project is designed. This may take the form of partial ownership of the SPE by one or more local government agencies.

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 will hold face-to-face meetings with participants to review the results of the feasibility study and confirm their interest in participating in the microgrid through a development agreement.

PSE&G LI is aware of this project, provided letters of support for the initial feasibility study and participated in the project kick-off meeting. Throughout the process, the project team has engaged PSE&G LI in design discussions through there RFI process. As of this date, PSE&G LI has not yet weighed in on the value of this project based on the results of the feasibility study. The plan for locations and preliminary sizes of new CHP systems was shared with PSE&G LI. They evaluated the plan and indicated that the local natural gas infrastructure can support the added load attributed to the new CHP systems. Several customers will require upgrades to their service to accommodate the pressure and volume needed for the CHP units.

If the East Hampton community decides to move forward with the microgrid project, they will need to engage partners to fill the following roles:

- Project Leader
- Project Financiers
- Microgrid Control Provider
- Energy Procurement Contractor (EPC)
- CHP Design Firm
- PV System Design Firm
- Operations and Maintenance Firm
- Legal and Regulatory Advisor

LEGAL VIABILITY

The project team has developed a model for the legal organization of the East Hampton 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.

Other team members or community stakeholders may decide to take an ownership stake in the system. However, at this time, no community customers or stakeholders have expressed interest in an ownership role.

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, and have received their provisional approval.

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:

<u>Financing:</u> 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 PPAs 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.

<u>Stage 2 NY Prize Funding:</u> 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 East Hampton 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 is critical to moving forward to the next stage of project development.

<u>Customer Commitments:</u> 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.

<u>Utility Cooperation:</u> 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 LI has demonstrated neutral levels of support and cooperation with the feasibility study phase. Should this trend continue, East Hampton can expect this risk to be fairly small in the next phase.

Regulatory Issues

The ownership model of the East Hampton 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

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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

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 East Hampton Community Microgrid is technically viable and is potentially economically viable with additional NY Prize grants. East Hampton's location at the eastern end of the south shore makes it one of the communities in the state most susceptible to storm damage. The resilience strategies employed by the microgrid will yield lessons for similarly vulnerable communities in New York and across the country. The feasibility assessment yielded several key findings:

1. ***Engaged Stakeholders***: The larger loads in the East Hampton Community Microgrid are all at facilities and institutions that are well established, and committed to the project, including the airport, healthcare center, and many facilities that are directly managed by town government.
2. ***Many Small Distributed Systems***: The fact that the microgrid includes eight nodes, and that several of them are quite small, contributes to a higher total installed cost.

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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.

3. ***Natural Gas Costs***: One of the other cost drivers for the project is natural gas. Increasing costs for natural gas will have a negative impact on the PPA rates for each of the facilities. However, the PPA rate is likely to grow at a slower rate over time than the total cost of electricity from the grid.
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 East Hampton Community Microgrid project is not likely to meet the financial requirements for third party financing and ownership. In order to meet these requirements, 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.
6. ***Potential Removal of Montauk Node***: As noted above, the removal of smaller nodes could help to control the installed cost of the microgrid, and improve the overall financial strength of the design. Node 4, which includes several facilities in Montauk, is a particularly good candidate due to the high cost associated with connecting the distributed facilities contained within it through new underground infrastructure. This node accounts for 12% of the electrical load for the entire system, but 29% of the cost. Preliminary analysis of this option suggests that if the Montauk node were removed, the project cost would decrease by approximately $2,679,000, to $6,587,000. Including the ITC tax deduction, the removal of the Montauk node would decrease the project cost by $2,428,000, to $5,286,000. This configuration would result in a PPA electric rate at or slightly above the $0.181/kWh average electric rate currently paid by participants.

Regulatory and Policy Recommendations

In the process of performing this feasibility analysis, the project team has identified several key regulatory and policy recommendations that will help control the costs associated with community microgrid development, and help to maximize the benefits these systems can yield:

1. ***Franchises and Rights-of-Way***: Community microgrids almost always include critical facilities that are not co-located on the same parcel of land. To interconnect these facilities requires the crossing of one or more public right of ways. The installation of electrical distribution lines (above or below ground) or thermal distribution infrastructure across a public right of way will usually infringe on an existing franchise, or require a new one to be issued. In New York State, each municipality (town, village,

city, etc.) has the statutory authority to grant franchise rights or similar permissions. In many cases, these franchise rights have already been granted to the distribution utility, and the installation of microgrid infrastructure by a third party may represent an infringement of that franchise.

At the state level, a program to standardize and expedite the issuance of franchise rights to microgrid developers would significantly reduce associated development costs for community microgrids. For instance, the State Supreme Court in Connecticut ruled that installing a distribution wire from one parcel to another and selling power across that line cannot encroach on a utility franchise (and won't trigger PUC jurisdiction).[3]

2. ***Utility Ownership***: The rules governing utility ownership of microgrids in New York State, and specifically DER within the microgrid, are not clearly defined. After ruling in 1996 that distribution utilities must end all investments in generation assets, the Public Service Commission (PSC) carved out a general criterion for exceptions in a 1998 ruling known as the Vertical Market Power Policy. This policy stated that distribution utilities could own DER if they could demonstrate "substantial ratepayer benefits, together with [market power] mitigation measures."[4] In February, 2015, the PSC published the "Order Adopting Regulatory Policy Framework and Implementation Plan"[5] which described several circumstances when utility ownership of DER would be allowed. One of these circumstances is for a project that is "sponsored for demonstration purposes." This may be applicable to some NY Prize projects, but it is unclear what the criteria would be for an acceptable demonstration project. Also, this does not help drive the broader market for microgrids as this limits the number of systems that will be implemented in the near term.

   Greater clarity from the state on the circumstances under which utility ownership of microgrid assets would help communities interested in microgrid development assess utility ownership as an option, and evaluate the costs and benefits of this ownership model.

3. ***CHP Natural Gas Tariffs:*** The resilience of natural gas infrastructure to storm damage and other disruption makes it an attractive fuel source for powering microgrid energy resources (such as combined heat and power plants). The economic health of microgrids that use natural gas plants to meet base loads is subject to favorable natural gas tariffs. The application of natural gas generators create benefits in the form of a base natural gas load (including in the summer months when natural gas demand is lowest), and improved system efficiency (through generation located at the load, efficient operation on the power curve, and recovery of heat to offset other heating loads). Most utilities offer specific tariffs for the operation of distributed generation

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[3] See *Texas Ohio Power v. Connecticut Light and Power*, 243 Conn. 635, 651 (1998).

[4] New York Public Service Commission. 1998. "Vertical Market Power Policy (VMPP) Statement."

[5] New York Public Service Commission. 2015. "Order Adopting Regulatory Policy Framework and Implementation Plan."

equipment. State support for attractive natural gas tariffs helps to assure viable business models for both CHP and microgrid development.

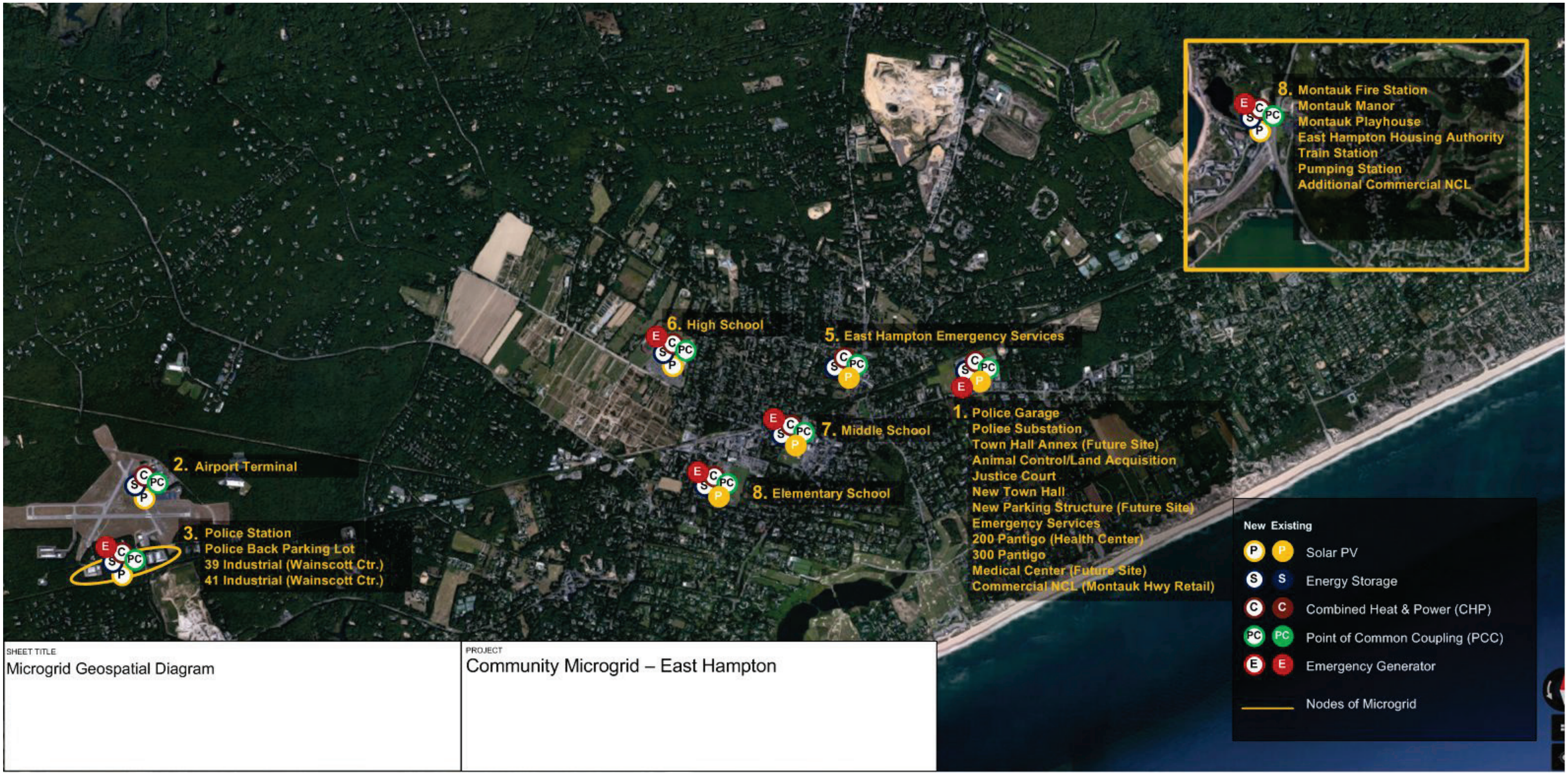
4. ***Multiple Customer Contracting:*** Multiple customers within the community microgrid create challenges of financing, procurement, and operations across the stakeholders in the community. Continued state support for the NY Green Bank mission of implementing structures that address gaps and overcome barriers in current and clean energy financing markets, particularly as related to community microgrids with multiple customers and customer types, may lead the industry toward sustainable solutions for addressing these issues.
5. ***Stage 2 and Stage 3 Funding Structure:*** Stage 2 funding should focus on advancing the project towards the construction phase, and less on reporting deliverables. Stage 3 funding sends a poor market signal, indicating that microgrids need subsidies in order to be cost effective, which is often not the case.
6. ***Municipal Lowest Rate Requirement:*** Regulations that require that municipal customers pay the lowest available rate for electricity and gas may prevent investment in microgrid infrastructure and resilience benefits through a PPA in certain cases. Projects that provide other societal benefits (support critical loads, serve the community at times of natural disaster, reduce emissions, etc.) should be eligible for consideration as projects that municipalities may execute.
7. ***Competitive Procurement Requirements*****:** Given cost share requirements in Stage 2, development firms are going to hesitate to invest unless they are assured work in Stage 3. This could potentially be mitigated by state-issued guidance for special exemptions for the NY Prize program, or by encouraging a single procurement process for Stage 2 and 3.

Based on the findings of this feasibility analysis, there are several next steps for the project team to undertake. First, the project team should solicit confirmation from each stakeholder that they are interested in continuing to participate in this effort to build a community microgrid. Based on the final customer list, the project should be remodeled project to estimate the technical and economic impact of any additions or subtractions.

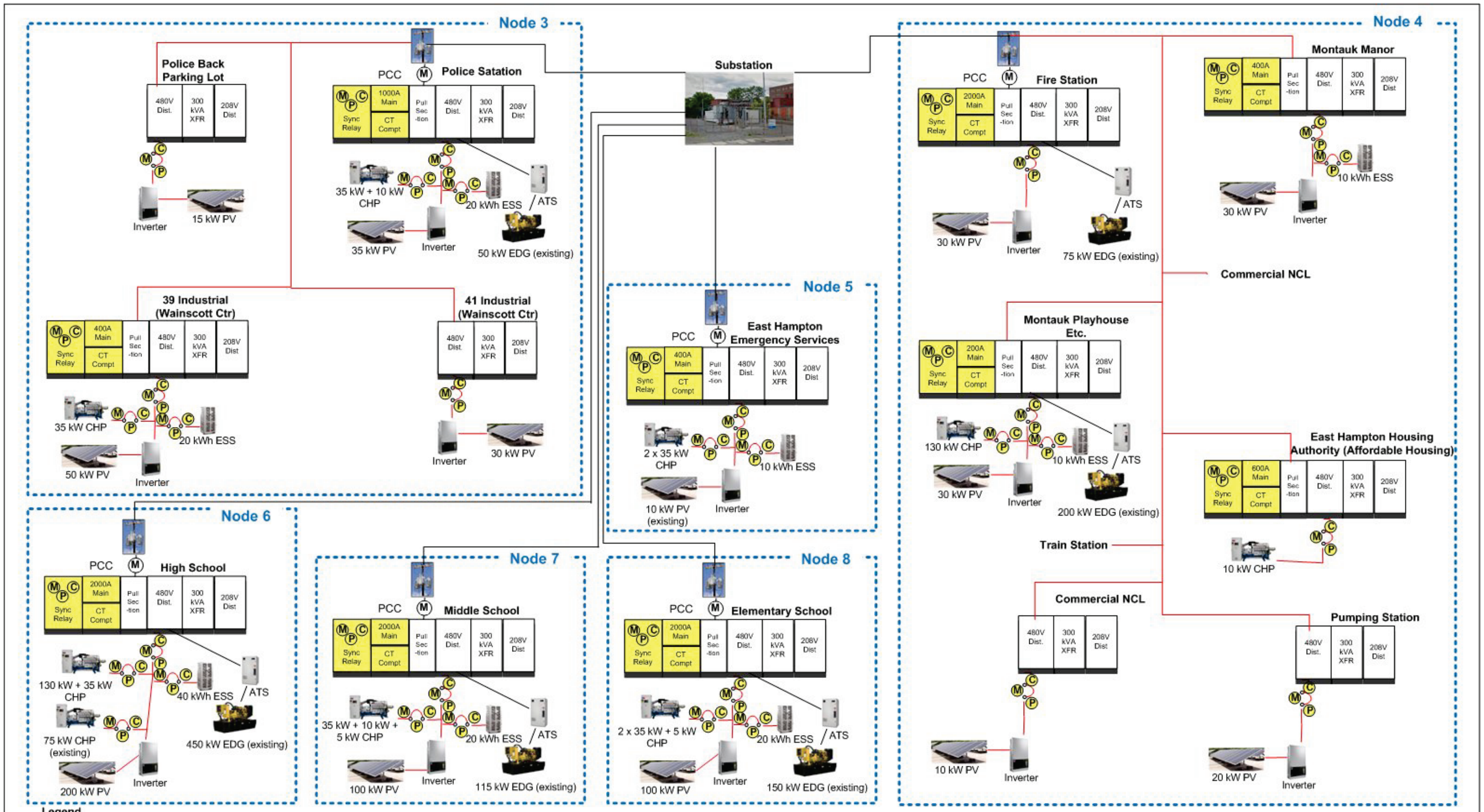
Once the model is final the project team will need to make a go/no go decision about moving forward. If a decision is made to move forward, a project team will need to be finalized. This team will draft a proposal to NYSERDA to compete in Stage 2 of NY Prize. This Stage 2 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. A Stage 2 will require cost-share, and a determination should be made about who which parties will take this on.

[End of Report]

APPENDIX A: EAST HAMPTON MICROGRID LAYOUT DIAGRAM



APPENDIX B: EAST HAMPTON 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

Existing Cable
New Underground Cable
New Control, Monitoring, & Protection as required

SHEET TITLE
Microgrid One-Line Diagram

PROJECT
Community Microgrid – East Hampton

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 East Hampton 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."[6] 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. The same caveat applies to PSE&G Long Island, which falls under LIPA's jurisdiction, and is generally exempt from PSC oversight.

2. Utility Ownership of Non-Generation Microgrid Assets Only

Even if LIPA does not own any of the DER assets within the East Hampton 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/PSE&G 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 allow 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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[6] 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.[7]

In the East Hampton 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.[8]

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 at in its tariffs under the Third Revised Leaf No. 251.[9]

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 East Hampton 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. <u>Privately-Owned Microgrid Distribution</u>

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[7] NY PSL § 66-j.

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

[9] Id.

East Hampton 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 East Hampton 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[10] (investigating the manufacture, distribution, and transmission of electricity; ordering improvements; and performing audits), rates,[11] safe and adequate service,[12] all aspects of the billing process, financial, record-keeping, and accounting requirements,[13] corporate finance and structure,[14] and more. This expansive purview of regulation may prove too administratively onerous for a small project like the East Hampton 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

East Hampton'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,[15] is under 80 MW,[16]

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[10] PSL § 66.

[11] PSL § 65.

[12] PSL § 66.

[13] PSL § 66, 68(a).

[14] PSL § 69.

[15] 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

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 East Hampton 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 East Hampton 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.[17] 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."[18] 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 East Hampton 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.[19] 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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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.

[16] Id.

[17] 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).

[18] Id.

[19] 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.[20]

In the East Hampton 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 distance between properties proposed to be incorporated in the microgrid exceeds 5 miles. However, the project will most likely settle on much more modest private distribution facilities. Where facilities are adjacent, but not yet linked, new underground distribution cables will be evaluated to establish this link. The feasibility study will not be considering new underground lines between nodes.

If private distribution is proposed exclusively within each node, the project may compare more favorably to precedent. Private distribution facilities would have to cross property lines, and several rights of way. Declaratory rulings addressing facilities in comparable environments have exceeded similar distances, including *Burrstone* (approximately half a mile),[21] *Nissoquogue Cogen Partners* (1.5 miles),[22] and *Nassau District Energy Corporation* (1.7 miles).[23] 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 East Hampton microgrid opts to own private distribution entirely within nodes, it would be comfortably within the length for which positive precedent exists.

In light of the above factors, the East Hampton 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 East Hampton 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.[24] 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.[25] The precedent of microgrids receiving lightened regulatory burden

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[20] Id.

[21] 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).

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

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

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

[25] 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).

under this standard is very thin, however, and it is difficult to prognosticate how this standard would be applied to the East Hampton project.

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,"[26] 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 East Hampton 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.

East Hampton'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,[27] and the Borrego Springs microgrid owned by San Diego Gas & Electric.[28]

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

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

[28] 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,"[29] 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.[30]

In the East Hampton 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:

- Applicable tariff under which different levels of power export will occur

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

[30] 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."

- 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.[31] 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 East Hampton project.

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[31] 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.[32] "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.[33]

In both the town and the village of East Hampton, 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 and N.Y. Vil. Law, the Town and Village Boards will have discretion in determining the application process to obtain a franchise or lesser consent, subject to a public hearing preceded by proper notice.[34] Comparable jurisdictions have adopted specific franchise requirements that East Hampton may look to.[35]

IV. Application of Other Local Codes

1. Zoning

The candidates to receive microgrid service in East Hampton are zoned as follows:

- East Hampton Town Hall, 159 Pantigo Rd, East Hampton, NY 11937: Town CI Commercial Industrial District
- Baker House, 181 Main St, East Hampton, NY 11937: Village R-80 Residential District
- Justice Court, 159 Pantigo Rd, East Hampton, NY 11937: Town CI Commercial Industrial District
- Police Substation, 159 Pantigo Rd, East Hampton, NY 11937: Town CI Commercial Industrial District
- Emergency Services Building, Cedar and North Main: Village Commercial District
- Animal Control, 159 Pantigo Rd, East Hampton, NY 11937: Town CI Commercial Industrial District
- East Hampton Healthcare, 200 Pantigo Place, East Hampton, NY 11937: Town CI Commercial Industrial District
- East Hampton High School, 2 Long Lane, East Hampton, NY 11937: Town A5 Residential District

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[32] N.Y. Twn. Law § 64.

[33] 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)

[34] N.Y. Twn. Law § 64.

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

- East Hampton Middle School, 76 Newtown Ln, East Hampton, NY 11937: Village R-40 Residential District
- East Hampton Airport, 200 Daniels Hole Rd, East Hampton, NY 11975: Town CI Commercial Industrial District, including
    - Airport Buildings
    - Airport Hangar North
    - Airport Hangar South
- Airport Buildings West, 88 Industrial Rd, East Hampton, NY 11963: Town CI Commercial Industrial District
- East Hampton Airport SW Building, 50 Industrial Rd, East Hampton NY 11975: Town CI Commercial Industrial District
- East Hampton Police Station, 131 Industrial Rd., East Hampton NY 11975: Town CI Commercial Industrial District
- Police Back Parking Lot, 57 Industrial Rd., East Hampton NY 11975: Town CI Commercial Industrial District
- 39 Industrial Rd., East Hampton NY 11975: Town CI Commercial Industrial District
- 41 Industrial Rd., East Hampton NY 11975: Town CI Commercial Industrial District
- 15 Industrial Rd., East Hampton NY 11975: Town CI Commercial Industrial District
- 7 Industrial Rd., East Hampton NY 11975: Town CI Commercial Industrial District

Generation as Permitted Use

Candidates for microgrid service spread throughout the Town and the Village of East Hampton, which have adopted separate zoning codes. This section will consider the relevant provisions for each municipality separately.

Town of East Hampton

In the Town of East Hampton, electric generation must be authorized as either an expressly permitted use, an accessory use, a specially permitted use, or a variance. Between the two districts (CI Commercial Industrial and A5 Residential) in which microgrid customers have been proposed, the relevant zoning considerations will be identical. This section will deal with the relevant zoning provisions for both types of district in one condensed analysis.

Expressly Permitted Use: The Town of East Hampton does not expressly permit electrical generation or any other use that could be interpreted to encompass electrical generation.

Accessory Use: The Town of East Hampton's Zoning Code permits accessory uses that are "customarily incidental or subordinate to a principal use,"[36] where that principal use is expressly permitted. 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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[36] Town of East Hampton Code §255-1-20.

Special Permit Use: The Town of East Hampton Code authorizes the Planning Board to issue Special Use permits for "Any land use … if the text of [§ 255-5-20] or the Use Table, § 255-11-10 hereof, denotes the use or activity as being either the subject of a special permit or simply a special permit use."[37] While there is no mention of a relevant special permit use in the Town's Use table, the text of §255-5-20 outlines a special permit for public utility uses which applies to each of the relevant zones under consideration in this project.

For these purposes, a Public Utility is defined as "A governmental **or privately owned** nonnuclear power plant; electrical substation; water well site or pump house; water tank; water or sewage treatment plant, utility company headquarters, branch office, garage or storage barn; telephone exchange; communications center; antenna farm; broadcast facility as herein defined; or any other similar land use providing for the distribution or supply to East Hampton residents of utility-type or communications services, except for personal wireless services and the personal wireless service facilities deployed in those services, as defined in this section," (emphasis added).[38] This broad definition of public utility facilities, incorporating private developers in addition to traditional utilities, would appear to cover all of the microgrid facilities anticipated in this project.

A grant for a special use permit is appropriate where:

> (1) With the exception of personal wireless service facilities, which are discussed above, the facility shall have as a primary purpose the distribution or delivery of utility, communication or similar service to some or all of the residents of East Hampton, and, in this connection, the nature of the use shall conform to any limitations which this chapter, either by its general definition of public utility, a more specific definition of the particular use or otherwise, places upon the same.
>
> (2) For uses proposed in any district other than the Commercial-Industrial District (CI), it shall be demonstrated that placement of the use on a property in the CI District is impossible or impracticable because of the unavailability or unsuitability of such property, the nature of the service to be provided, the location of the residents to be served or other similar constraint.[39]

These provisions would also appear to permit the scope of facilities anticipated by the microgrid, with the exception that proposed microgrid facilities not located in a CI district (only the East Hampton High School) would have to show that it is impossible or impracticable to otherwise place such facilities in a CI district. Since the majority of microgrid customers in the Town of East Hampton are located in CI zones, this restriction should pose a small burden.

Variances: If generation could not be sited as an expressly permitted, accessory, or specially permitted use, it could only be allowed pursuant to a variance granted by the Zoning Board of Appeals. The Zoning Board of Appeals will apply the following standards to the review of any variance application:

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[37] Town of East Hampton Code §255-5-20.

[38] Town code §255-1-20.

[39] Town of East Hampton Code §255-5-50.

> (1) Under the use regulations contained in this chapter, the applicant cannot realize a reasonable economic return from the property, lot or land in question, under any of the uses permitted by this chapter, and that such lack of reasonable return is substantial and has been established by competent financial evidence.
> (2) The hardship relating to the property is unique and does not apply to a substantial portion of the use district or neighborhood in which the property lies.
> (3) The use variance to be granted will not alter the essential character of the neighborhood.
> (4) The hardship relating to the property has not been self-created.
> (5) The use variance to be granted is the minimum variance necessary and adequate to alleviate the unnecessary hardship shown by the applicant, while at the same time preserving and protecting the character of the neighborhood and the general health, safety and welfare of the Town as a whole.[40]

These provisions are consistent with New York State precedent,[41] as well as State law incorporating that precedent. 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.

<u>Village of East Hampton</u>

In the Village of East Hampton, electric generation must be authorized as either an expressly permitted use, an accessory use, a specially permitted use, or a variance. Between the three districts (R-40 Residential, R-80 Residential, and Commercial) in which microgrid customers have been proposed, the relevant zoning considerations will be identical. This section will deal with the relevant zoning provisions for each type of district in one condensed analysis.

<u>Expressly Permitted Use</u>: The Village of East Hampton does not expressly permit electrical generation or any other use that could be interpreted to encompass electrical generation. The Code is clear that "If a particular land use is not listed on the Use Table, that particular use is prohibited and unlawful in the district or zone to which the table applies."[42] It is unlikely that this omission constitutes oversight, as "Electric Lighting and Power Plant" is an expressly permitted use in manufacturing-industrial zones.

<u>Accessory Use</u>: The Village of East Hampton Code defines an accessory use as "A subordinate use, building or structure customarily incidental to and located on the same lot occupied by the main

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[40] Town of East Hampton Code §255-8-50.

[41] *See* Otto v. Steinhilber, 282 N.Y. 71 (1939). In that case, the owner of a parcel of property which was located in both a residential and commercial zone applied for a variance enabling him to use the entire parcel for a skating rink, which was a permitted commercial use. The lower court upheld the granting of the use variance, which ruling was affirmed by the Appellate Division. The Court of Appeals, the highest court in the State, reversed these holdings and in doing so, set forth the definitive rules that are still followed today.

[42] Village of East Hampton Code §278-2(A)(3).

use, building or structure."[43] 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.

Special Permit Use: No relevant special permit use is provided for in the East Hampton zoning code.

Variances: If generation could not be sited as an expressly permitted, accessory, or specially permitted use, it could only be allowed pursuant to a variance granted by the Zoning Board of Appeals. The Zoning Board of Appeals will apply the following standards to the review of any variance application:

> (1) The applicant cannot realize a reasonable return, provided that lack of return is substantial as demonstrated by competent financial evidence.
> (2) The alleged hardship relating to the property in question is unique and does not apply to a substantial portion of the district or neighborhood.
> (3) The requested use variance, if granted, will not alter the essential character of the neighborhood.
> (4) The alleged hardship has not been self-created.[44]

These provisions are consistent with New York State precedent,[45] as well as State law incorporating that precedent. 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.

In summation, microgrid generation sited in this project would have the clearest path to compliance as a specially permitted use in the Town of East Hampton, particularly in Commercial Industrial districts therein. It may be possible, however, depending on the interpretation given to "accessory use" in each municipality, to site generation under those provisions as well in both the Town and the Village.

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 has been attached in Appendix A.

2. Fire Code

The Town of East Hampton has accepted "the applicability of the State Fire Prevention Code for the Town of East Hampton,"[46] does not make any other substantive requirements impacting generation

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[43] Village of East Hampton Code §278-1.

[44] Village of East Hampton Code §287-7(C)(1)(a).

[45] *See* fn. 36.

[46] Town of East Hampton Code §141-1.

or electrical distribution. Separate from the Village Building Code, the Village of East Hampton's "Fire Regulations" code does not impose any substantive requirements impacting generation or electrical distribution.[47]

3. Building Code

The Town of East Hampton Building Construction Code incorporates New York State Uniform Fire Prevention and Building Code and the State Energy Conservation Construction Code.[48] It does not make any other substantive requirements impacting generation or electrical distribution. The Town Code also outlines a fast-track permitting process for qualifying roof-mounted solar installations. The criteria for fast-track compliance are laid out in Code §102-30.

The Village of East Hampton incorporates New York State Uniform Fire Prevention and Building Code only.[49] It does not make any other substantive requirements impacting generation or electrical distribution.

4. Electric Code

The Town of East Hampton authorizes its electrical inspector to enforce all "electrical provisions of the Building Code applicable to the Town of East Hampton and of all local laws, ordinances and the Building Code as referred to in this chapter insofar as any of the same apply to electrical wiring."[50] As noted above, the Building Construction Code of East Hampton incorporates State code exclusively, in terms of requirements affecting the siting of electrical generation and distribution.

The Village of East Hampton also authorizes its electrical inspector to enforce "the electrical provisions of the Building Code applicable to the Village of East Hampton as referred to in this chapter insofar as any of the same apply to electrical wiring."[51] As also noted above, the Villages Code Enforcement Administration provisions incorporate State code exclusively, in terms of requirements affecting the siting of electrical generation and distribution.

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

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[47] Village of East Hampton Code §150.

[48] Town of East Hampton Code, §102-1.

[49] Village of East Hampton Code, §104-1.

[50] Town of East Hampton Code §125-3.

[51] Village of East Hampton Code §130-3.

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. <u>Residential/Non-Residential DG Gas Rate</u>

The East Hampton 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 <u>Cost of Gas Service Upgrades</u>

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 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

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

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

[54] 16 NYCRR § 230.2(b).

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 the govern gas service upgrades, described above.

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[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 500kwe 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

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Town of East Hampton has proposed development of a microgrid serving numerous facilities in the town, which extends to the tip of Long Island at Montauk Point. The microgrid would focus on maintaining the town's police, fire and emergency medical services (EMS), as well as operations at East Hampton Airport.[58] As shown in Table 1, the microgrid would also serve a mix of other municipal, commercial and residential facilities, including educational facilities that would serve as emergency shelters; government offices; the Montauk train station; an affordable housing facility; a recreational center; a hotel; the Montauk water pumping station; and several restaurants.

The microgrid would incorporate combined heat and power (CHP) and solar capabilities to provide base load power. Natural gas-fired CHP units would be distributed among the participating facilities; these would range in capacity from 0.005 MW to 0.13 MW; new CHP capacity included in the microgrid would total 0.71 MW. Eight new photovoltaic (PV) arrays would also be distributed among the participating facilities, ranging in capacity from 0.01 MW to 0.3 MW; total new PV nameplate capacity would be 1.0 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 6,122 MWh of electricity per year, roughly 60 percent of the amount required to meet the average annual demand of the facilities listed in Table 1. During a major outage, the project's consultants indicate that the microgrid system would supply 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.

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[58] The airport does not currently support commercial flights, but serves a mix of private pilots, charter flights, and car rental companies. Approximately 16,000 aircraft use the airport annually, primarily between the months of May to October. See http://ehamptonny.gov/HtmlPages/Airport/AirportHome.htm, accessed on April 8, 2016.

[59] In addition to these resources, the microgrid would incorporate 12 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. Also, an existing PV solar array at the Emergency Services Building with 0.01 MW of capacity and an existing CHP plant at the East Hampton High School with 0.075 MW capacity would be integrated into the microgrid; the operating profile of these resources would not be expected to change with the implementation of the microgrid.

[60] As noted previously, the capacity of the new resources appears sufficient to supply approximately 60 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.

Table 1. Facilities Served by Proposed Microgrid

Facility Name	Facility Description
Police Garage	Municipal Garage
Justice Court	Municipal Court Facility
Police Substation	Police Station
Emergency Services Bldg. (communications)	Emergency Services Dispatch Center
New Town Hall	Town Hall
Trauma Center (new medical)[1]	Emergency and Trauma Services
Pantigo Place Parking Structure	Parking Structure
200 Pantigo (Health Center)	Outpatient Healthcare Center
Animal Control/Land Acquisition	Commercial Business/Animal Control
Town Hall Annex	Town Hall Annex
300 Pantigo Place Offices	Commercial and Municipal Offices
Baker House	Commercial Offices
Goldberg's Bagels & Deli/Wine Shop	Restaurant/Wine Retail
Luigi's Italian Specialties/Smokin' Wolf BBQ	Restaurants
Airport Terminal/Radio Tower	Airport Terminal/Radio Tower
East Hampton Police Station	Municipal Police Station
Police Back Parking Lot	Parking Lot
Wainscott Industrial Center	Commercial Industrial Businesses
Montauk Fire Station	Fire Station
Montauk Playhouse	Community Recreational Center
Montauk Manor	Hotel
Avallone Apartments	Affordable Housing
Montauk Train Station	LIRR Train Station
Montauk Pumping Station	Municipal Water Pumping Station
Emergency Services Building	Fire, Police, and Rescue Center
East Hampton High School, East Hampton Middle School and John M. Marshall Elementary School	Public schools that would serve as emergency shelters during a major outage

Notes:

[1] The project team indicates that the community has plans to build the Trauma Center within the next few years.

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 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:

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[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.]

- 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 2 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 1.4 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 2. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 1.4 DAYS/YEAR
Net Benefits - Present Value	-$8,190,000	$26,100
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-12.1%	6.2%

Scenario 1

Figure 1 and Table 3 present the detailed results of the Scenario 1 analysis.

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

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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.

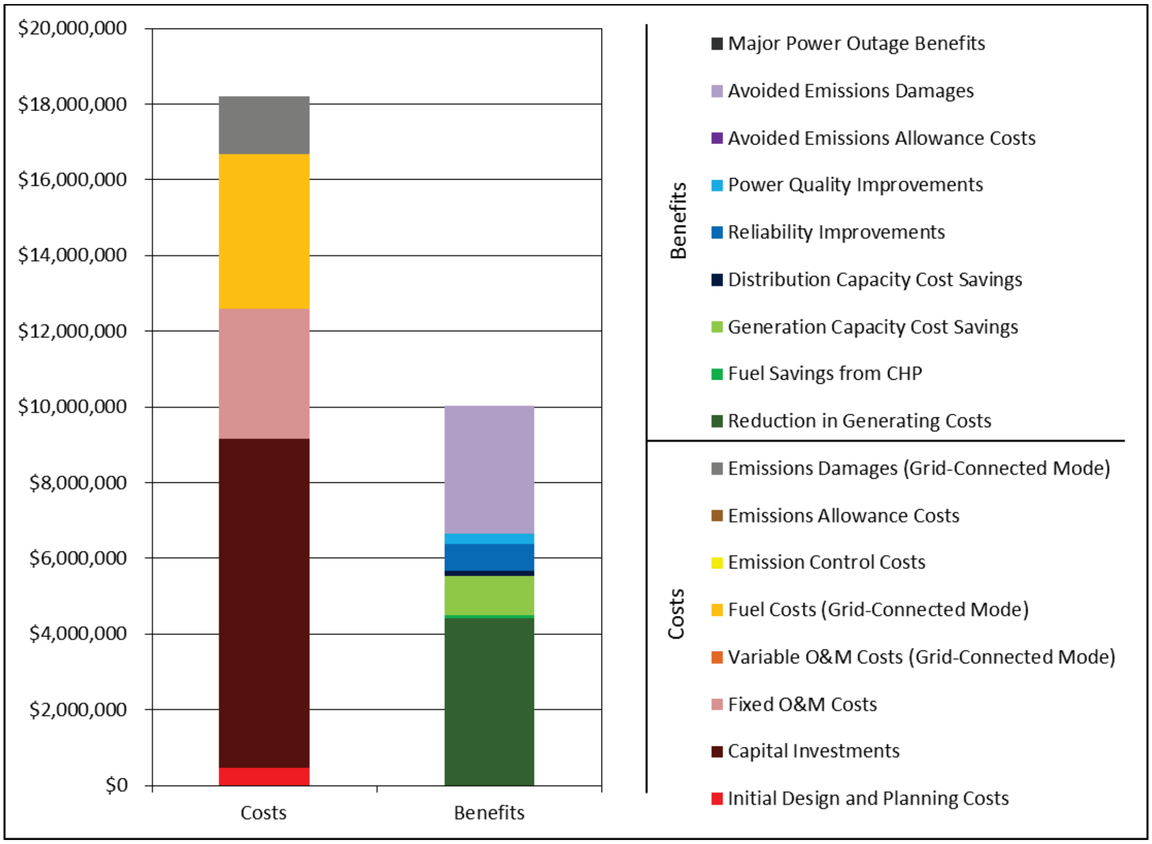
$20,000,000
$18,000,000
$16,000,000
$14,000,000
$12,000,000
$10,000,000
$8,000,000
$6,000,000
$4,000,000
$2,000,000
$0
Costs
Benefits
Benefits
Major Power Outage Benefits
Avoided Emissions Damages
Avoided Emissions Allowance Costs
Power Quality Improvements
Reliability Improvements
Distribution Capacity Cost Savings
Generation Capacity Cost Savings
Fuel Savings from CHP
Reduction in Generating Costs
Costs
Emissions Damages (Grid-Connected Mode)
Emissions Allowance Costs
Emission Control Costs
Fuel Costs (Grid-Connected Mode)
Variable O&M Costs (Grid-Connected Mode)
Fixed O&M Costs
Capital Investments
Initial Design and Planning Costs

Table 3. 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	$8,690,000	$702,000
Fixed O&M	$3,420,000	$301,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$4,090,000	$360,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,540,000	$101,000
Total Costs	**$18,200,000**	
Benefits		
Reduction in Generating Costs	$4,420,000	$390,000
Fuel Savings from CHP	$89,000	$7,850
Generation Capacity Cost Savings	$1,020,000	$90,100
Distribution Capacity Cost Savings	$149,000	$13,200
Reliability Improvements	$691,000	$60,900
Power Quality Improvements	$278,000	$24,500
Avoided Emissions Allowance Costs	$2,220	$196
Avoided Emissions Damages	$3,370,000	$220,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$10,000,000**	
Net Benefits	**-$8,190,000**	
Benefit/Cost Ratio	**0.6**	
Internal Rate of Return	**-12.1%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $475,000.[63] The present value of the project's capital costs is estimated at approximately $8.69 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 $3.42 million, based on an annual cost of $301,000.

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 $4.09 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 $101,000 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 $1.54 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 $4.42 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 $89,000. The reduction in demand for electricity from bulk energy suppliers and reduction in fuel consumption for space heating purposes would also reduce emissions of air pollutants, yielding emissions allowance cost savings with a present value of approximately $2,220 and avoided emissions damages with a present value of approximately $3.37 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 $1.02 million over a 20-year operating period. Similarly, the project team estimates that the microgrid project would reduce the need for local distribution capacity by approximately 0.36 MW/year, yielding annual benefits of approximately $13,200. Over a 20-year period, the present value of these benefits is approximately $149,000.

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 $60,900 per year, with a present value of $691,000 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 $278,000 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 East Hampton's proposed microgrid project would serve 28 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 4 summarizes these parameters for the facilities included in the microgrid. As the table shows, facilities are grouped as follows for purposes of analyzing the effects of a major power outage:

- **Emergency Response Services –** The East Hampton Police Station, the Emergency Services Building (EMS service), and the Montauk Fire Station all have backup generators and would maintain full service in the event of an outage. The analysis calculates the impact of an outage on these facilities using standard FEMA methodologies.
- **Emergency Shelters –** The project consultants indicate that the town's high school and middle school and the John M. Marshall Elementary 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 5,700 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). The three schools would all use existing backup generators to maintain full service in the event of an outage.
- **Water Services –** The Montauk Pumping Station 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 the 3,326 residents served by this pumping station using standard FEMA methodologies.
- **Residential Electric Services –** The Avallone Apartments affordable housing complex 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 facility using standard FEMA methodologies.
- **Facilities with Backup, operating 24/7 –** This set of facilities includes the East Hampton Airport Terminal/Tower, the Emergency Services Communications (i.e., dispatch) center, the Police Substation, and the Police Garage. Each facility has existing backup generation that would provide for full service in the event of an outage. The value of service provided by these facilities, as estimated by the ICE Calculator, is approximately $167,000 per day.
- **Facilities with Backup, operating 12 hours per day, five days per week –** This set of facilities would maintain full service using their existing backup generators. Backup for these facilities would only be required five days per week. Services provided by these facilities, which include the Montauk Playhouse, 200 Pantigo Place (Health Center), Justice Center, and Animal Control/Land Acquisition, are valued at approximately $68,000 per day, as estimated by the ICE Calculator.
- **Facilities without Backup, operating 24/7 –** The analysis assumes that these facilities would rent a backup generator to maintain 50 percent of their operations during a power outage. The collective value of service for the Montauk Manor hotel, Trauma Center, and Police Back Parking Lot, as estimated by the ICE Calculator, is approximately $207,000 per day.

- **Facilities with Backup, operating 12 hours per day, five days per week –** This subset of nine commercial facilities would rent backup generators to maintain half of their operations during a power outage. The East Hampton Train Station is included in this group. Backup for these facilities would only be required five days per week. The collective value of service, as estimated by the ICE Calculator, is $169,000.

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 $8.21 million per day. The analysis suggests that 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 4. Summary of Major Power Outage Parameters, Scenario 2

CATEGORY	FACILITIES INCLUDED	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS	
		VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY
Emergency Shelters	East Hampton Middle and High Schools, and John M. Marshall Elementary School	$285,000	Red Cross	0%	100%	$0	$1,565
Police, Fire and Emergency Services	East Hampton Police Station, the Emergency Services Building (EMS service), and the Montauk Fire Station	FEMA methodologies		0%	100%	$0	$767
Water Services	Montauk Pumping Station	FEMA methodologies		50%	100%	$500	$1,000
Residential Electric Services	Avallone Apartments	FEMA methodologies		50%	100%	$500	$1,000
Facilities with Backup, operating 24/7	Airport Terminal/Tower, the Emergency Services communications (e.g., dispatch) center, the Police Substation and the Police Garage	$166,925	ICE	0%	100%	$0	$233
Facilities with Backup, operating 12 hours per day, five days per week	Montauk Playhouse, 200 Pantigo Place (Health Center), Justice Center, and Animal Control/Land Acquisition	$68,119	ICE	0%	100%	$0	$247
Facilities without Backup, operating 24/7	Trauma Center, Police Back Parking Lot, Montauk Manor	$206,846	ICE	50%	100%	$1,500	$3,000
Facilities with Backup, operating 12 hours per day, five days per week	Pantigo Place Parking Structure, Baker house, Montauk Train Station, New Town Hall, Town Hall Annex, 300 Pantigo Place, Goldberg's, Luigi's, Wainscott Industrial	$168,846	ICE	44%[1]	100%	$4,500	$9,000

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

Notes:

[1] This figure represents the average for this group; one facility would experience no loss in service, while the remaining eight facilities would experience a 50 percent loss in operational capabilities with backup power.

Summary

Figure 2 and Table 5 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 1.4 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 1.4 Days/Year; 7 Percent Discount Rate)

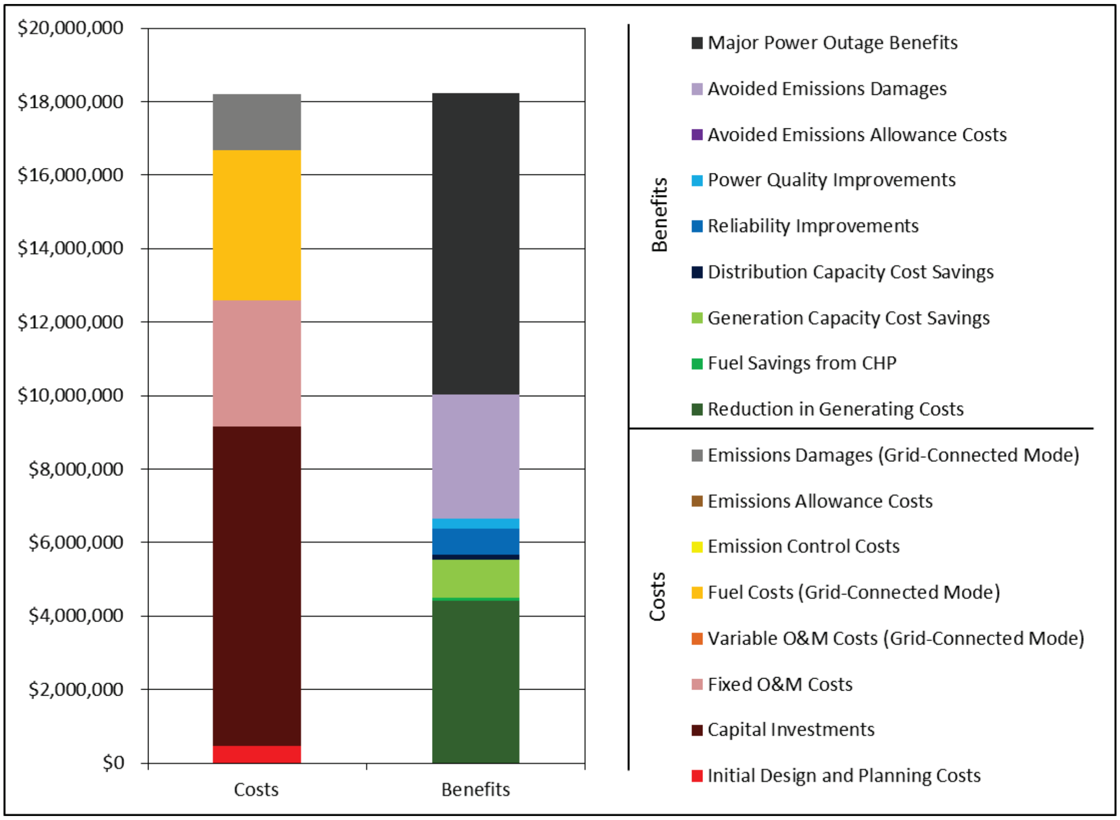

Table 5. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 1.4 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$8,690,000	$702,000
Fixed O&M	$3,420,000	$301,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$4,090,000	$360,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$1,540,000	$101,000
Total Costs	**$18,200,000**	
Benefits		
Reduction in Generating Costs	$4,420,000	$390,000
Fuel Savings from CHP	$89,000	$7,850
Generation Capacity Cost Savings	$1,020,000	$90,100
Distribution Capacity Cost Savings	$149,000	$13,200
Reliability Improvements	$691,000	$60,900
Power Quality Improvements	$278,000	$24,500
Avoided Emissions Allowance Costs	$2,220	$196
Avoided Emissions Damages	$3,370,000	$220,000
Major Power Outage Benefits	$8,210,000	$725,000
Total Benefits	**$18,200,000**	
Net Benefits	**$26,100**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.2%**	

APPENDIX E: NREL RENEWABLE ENERGY FEASIBILITY AND MICROGRID CONSIDERATIONS

East Hampton Renewable Energy Feasibility and Microgrid Considerations: Report Excerpt

Report for Hitachi Consulting[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 East Hampton 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 East Hampton 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 East Hampton 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 East Hampton 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 East Hampton 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 East Hampton 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 East Hampton 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.

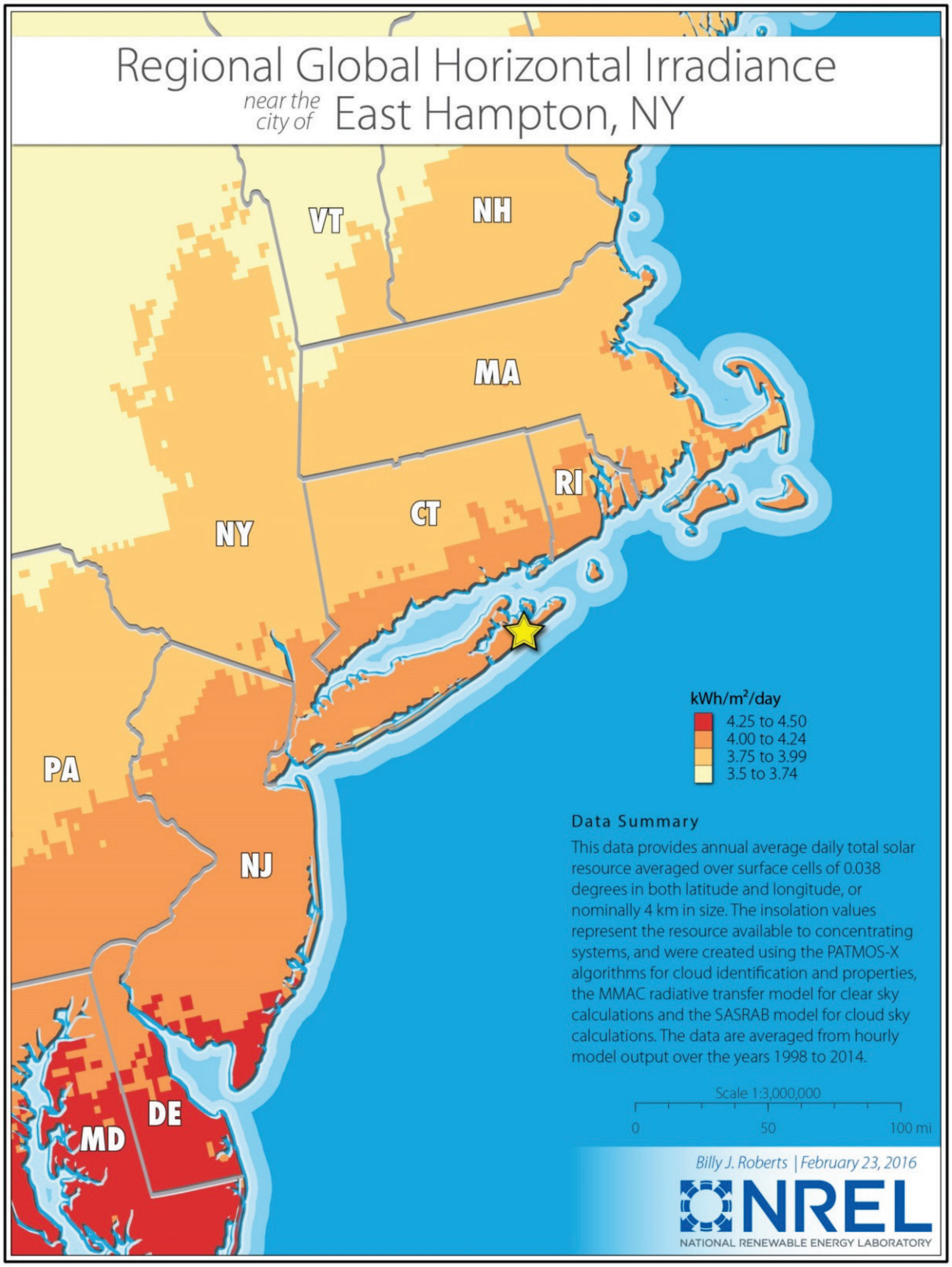
2.3 Power Factor Considerations

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 Company, Long Island
- PV- solar photovoltaics
- REV- Reforming the Energy Vision
- RFI- request for information
- RFP- request for proposals
- RTO- Regional Transmission Organizations
- SCADA – supervisory control and data acquisition
- SGIP- Smart Grid Interoperability Panel
- SOC- state of charge
- SPE- special purpose entity