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August 2016

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Image Credit: Daniel Case

Ossining Community Microgrid

Final Report – NY Prize Stage 1: Feasibility Assessment

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April 2016

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PROJECT STAKEHOLDERS

- Village and Town of Ossining Government
- Ossining Public Works Department
- Ossining Union School District
- Cablevision

FOSSINING COMMUNITY MICROGRID - KEY OVERVIEW METRICS

Team

Lead:	Green Energy Corp.
Community Partner:	Village of Ossining
Additional Consultants:	Hitachi Microgrids, Pace University, Sustainable Westchester, GI Energy

Utilities

Electric:	Con Edison
Gas:	Con Edison

Supporting Organizations

- Village of Ossining
- Hitachi Consulting
- PACE Energy
- Green Energy Corp
- GI Energy
- Sustainable Westchester

Microgrid Financials

Total Installed Cost:	$ 5,495,000
Net Installed Cost:	$3,094,000
Annual Resiliency Savings:	$ 279,000
Annual GHG Offset:	$ 89,600
Current Avg. Electric Rate:	$0.115/kWh

Microgrid System Design

Size:	1,832 kW
Electric Load:	6,574,020 kWh/yr

DER*	Quantity	Capacity
Combined Heat & Power:	-	-
Photovoltaic:	11	1,832 kW
Existing Photovoltaic:	-	-
Energy Storage Systems:	11	450 kWh
Existing Emergency Gen:	11	2,940 kW

Customer Types

Gov't Administrative:	3
Emergency Services:	2
Municipal Services:	2
Education	3
Health Care:	0
Large Commercial:	1
Small Commercial:	0
Multi-Unit Residential:	0
Total:	**11**

Electric Demand & Consumption with Microgrid

	Max kW	Avg kW	kWh / yr
Node 1	621	292	2,559,137
Node 2	136	38	331,643
Node 3	386	106	931,993
Node 4	59	15	128,854
Node 5	73	20	171,698
Node 6	223	68	599,207
Node 7	171	46	407,297
Node 8	498	111	973,407
Node 9	101	54	470,784
Total	**2,268**	**750**	**6,574,020**

Benefit Cost Analysis Outputs

	Scenario 1	Scenario 2
Days of Major Outage	0 days/yr	0.5 days/yr
Total Benefits**	$ 4,600,000	$ 8,610,000
Total Costs**	$ 8,490,000	$ 8,490,000
Net Benefits**	$ -3,880,000	$ 124,000
Benefit/Cost Ratio	0.5	1.0

***Net Present values*

**Estimates based on financial modelling*

EXECUTIVE SUMMARY

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

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

This report describes the results of Stage 1 of the NY Prize Feasibility Assessment for the Ossining Community Microgrid. A technical team led by Hitachi Consulting developed the microgrid design based on NYSERDA's requirements and the specific needs of and priorities of Ossining stakeholders. This team also led the feasibility assessment, in collaboration with the Ossining government. Various community organizations and partners, including the future customers of the Ossining Community Microgrid, lent additional support.

Community Overview

The Town of Ossining is located at the junction of the Hudson River and Croton River in Westchester County, about 25 miles north of New York City. The town is governed by a town supervisor and includes the Village of Ossining, part of Briarcliff Manor, and some unincorporated territory. Each village maintains its own police department and village justice court. In addition to the two incorporated villages there is an unincorporated section of the town that is not part of either village. The town's police department disbanded in 2011, but both villages maintain a police department and provide policing to the unincorporated section via an inter-municipal agreement. Fire, EMS, and water services are also administered at the village level.

The Ossining Community Microgrid is designed to provide resilient energy services to a group of facilities with critical loads in the community, such as schools, administrative buildings, and emergency services. The Ossining project is unique from a resiliency perspective. The town has already undergone significant installation of natural gas and diesel emergency generation due to a series of storms and extended grid outages over the last few years. Without the microgrid option available to Ossining, the village took the logical step to increase backup generation units to satisfy the needs of the community in times of emergency. As a result, most critical facilities in Ossining have backup generators.

This project seeks to offset the costs of operations and the emissions from these backup generators through the addition of solar PV and associated energy storage to integrate with the backup generators during times of grid outage. In this way, the cost of electricity and emissions can be reduced in keeping with the goals of NY Prize and the NY REV proceedings. The proposed microgrid will include a total of nine "nodes" that make up the Ossining microgrid.

Community Requirements and Microgrid Capabilities

The Ossining Community Microgrid is designed to meet specific needs within the community. Specifically, it is designed to improve the already impressive energy resilience the town has achieved and to ensure continuity in the provision of emergency and other critical services.

First, the microgrid is designed to improve energy resilience within the town. Although significant emergency generation has already been installed in most critical town facilities, many of these generators run on diesel fuel. The microgrid will be actively managed to minimize the operation of these diesel generators. This will help to reduce the emissions and fuel costs associated with their operation. It will also greatly extend the overall life of the backup generation equipment and allow facilities covered by the microgrid to operate in island mode for a longer period time, regardless of diesel fuel supply.

The microgrid includes facilities that provide many of the services critical to the health and safety of Ossining residents. These include water provision and public works (Indian Brook Water Plant and Pleasantville Road Pump House, and JPR Operations Center), police and fire (Ossining Fire Dept. and Birdsall Fagan Police and Court Facility), and municipal government (Ossining Municipal Building). The microgrid will help to ensure that these services can continue to operate at 100% even during an outage to the utility grid.

The microgrid also includes three schools with a combined enrollment of about 3000 students. The microgrid will also help to ensure that there is no interruption in classroom instruction or school activities, and that parents and guardians can attend work as usual. Finally, the microgrid will cover a cablevision hub, which may be necessary for emergency communication, and the Joseph G Caputo community center, which may serve as an emergency shelter if there should be a need.

The Ossining Community Microgrid is designed to address these resiliency needs with clean, efficient, and cost effective technologies and architecture.

The microgrid is also designed to provide some benefit to the utility. First, this microgrid will help relieve distribution system congestion. The year-round generation sources and demand reduction at this site will reduce the stress on the existing system, possibly allowing the utility to consider postponing replacements or upgrades to distribution equipment. Second, in the case of an outage, the community will be able to operate independently for an extended period, making utility line repair in the neighborhood less critical. This independence will allow the utility to more rapidly address the connection needs of other communities not covered by the microgrid. Finally, this system will have the capability to provide black-start power for nearby generation stations, pending approval from the utility.

Technical Design

Analysis of the Ossining 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 Ossining 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), 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 DER. The goal of this approach is to enable microgrid resources to serve the microgrid loads more efficiently, more cost effectively, and with lower emissions per unit of energy consumed.

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.

The microgrid is designed to include critical facilities located throughout the Ossining community. In order to include non-adjacent facilities, the design is based on nine separate nodes, each of which have their own microgrid resources and are able to island individually. As illustrated in the photo in Appendix A, the nine facility groupings are not in close proximity to each other, making unifying them into a single system technically difficult and quite expensive. The areas between each node are primarily residential homes which are too small in load to justify the cost of connecting to a microgrid system. In grid connected mode, the resources will be dispatched to minimize costs and emissions. The table below, which also appears in the report that follows, summarizes the DER, new and existing, that will be included in the proposed microgrid design.

Executive Summary Table 1 - Microgrid Resources Comparison

Node	Operation Scenario	Grid	PV		Battery Energy Storage		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW
1	Business as Usual	621	-	-	-	-	2	1,500
	Microgrid	365	1	250	1	55/110	2	1,500
2	Business as Usual	136	-	-	-	-	1	100
	Microgrid	105	1	120	2	10/20	1	100
3	Business as Usual	386	-	-	-	-	2	80
	Microgrid	289	2	600	2	60/120	2	80
4	Business as Usual	59	-	-	-	-	1	50
	Microgrid	45	1	60	1	10/20	1	50
5	Business as Usual	73	-	-	-	-	-	-
	Microgrid	62	1	40	1	5/10	-	-
6	Business as Usual	223	-	-	-	-	1	660
	Microgrid	197	1	120	1	20/40	1	660
7	Business as Usual	171	-	-	-	-	1	150
	Microgrid	162	1	12	1	5/10	1	150
8	Business as Usual	498	-	-	-	-	1	100
	Microgrid	330	1	480	1	45/90	1	100
9	Business as Usual	101	-	-	-		2	300

	Microgrid	100	2	150	1	15/30	2	300

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, electric consumption, and thermal load.

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

	Electric Demand		Electric Consumption		Thermal Load	
Node	**Max (kW)**	**Avg (kW)**	**kWh/year**	**kWh/month**	**kBTU/year**	**kBTU/month**
1	621	292	2,559,137	213,261	1,274,339	106,195
2	136	38	331,643	27,637	6,129,572	510,798
3	386	106	931,993	77,666	35,353,429	2,946,119
4	59	15	128,854	10,738	366,418	30,535
5	73	20	171,698	14,308	14,022	1,168
6	223	68	599,207	49,934	2,886,179	240,515
7	171	46	407,297	33,941	140,185	11,682
8	498	111	973,407	81,117	25,081,288	2,090,107
9	101	54	470,784	39,232	1,423,206	118,601
Total	**2,268**	**750**	**6,574,020**	**547,835**	**72,668,638**	**6,055,720**

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

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

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

Financial Feasibility

The project team developed a general budget for the Ossining 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 $5,495,000 with an accuracy of +/- 25% (within the +/- 30% set by NYSERDA). The net cost with the federal investment tax credit (ITC) that was recently extended by the US Congress is $3,094,000. 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 agreements (PPAs) 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, 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 community 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. Community stakeholders have indicated that a third party ownership of the microgrid is currently the preferred ownership structure. The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately $0.115/kWh. Based on the estimated energy savings, assumed project financing costs, and the 25 year contract term, the study indicates that the PPA rate for energy generated by the microgrid would be significantly higher than this current rate (in the absence of additional funding through NY Prize Stage 2 and 3 or other incentives).

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

Executive Summary Table 3 – Cost Benefit Analysis Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	**Scenario 2: 0.5 DAYS/YEAR**
Net Benefits - Present Value	-$3,880,000	$124,000
Total Costs – Present Value	$20,700,000	$20,700,000

Benefit-Cost Ratio	0.5	1.0
Internal Rate of Return	-4.7%	6.4%

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:

- 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 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 $2.4 million.
- Capital replacement costs used in the benefit-cost analysis 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 Ossining Community Microgrid is $219,000 less than the full cost of replacement.
- 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.

The outcomes above are based on a model that employs a third party entity to develop, operate, and maintain the system. Under this model, a third party would fund all development and construction, own the assets and sell the energy generated from the microgrid to community customers through a power purchase agreement (PPA). The community would incur no costs to build the project but would get receive all of the benefits of energy resilience during a grid outage, improved sustainability, and lowered energy costs.

Feedback from the community indicates that a third party ownership of the microgrid is currently the preferred ownership structure.

Conclusions and Next Steps

In developing this project, the team attempted to design a system that will meet the current and future resilience needs of the community, and that is replicable enough to yield lessons learned for the rest of New York State and advance statewide objectives for resilience, sustainability, and technological innovation.

The Ossining project is unique, because its goal is to augment existing emergency generation with renewable energy resources. For this reason, the design team aimed to develop a system that incorporates those emergency generators and only includes PV and energy storage as new energy sources. This analysis yields some important lessons learned about the current potential for microgrids for communities with significant existing emergency generation, and the importance of current emergency generation capabilities when evaluating the incremental resilience potential for a microgrid design.

The New York REV proceedings are intended to encourage new energy business models that will contribute to the goals of grid efficiency, facility energy efficiency, the development of clean distributed generation and storage, and the use of behind-the-meter resources for demand management. The unique qualities and lessons learned from the feasibility assessment of the Ossining Community Microgrid project can yield value for the proceedings of New York's REV proceedings.

As it stands, the Ossining Community Microgrid project is not likely to meet the financial requirements for third party financing and ownership. In order to meet these requirements, the project will need to secure Stage 2 and Stage 3 NY Prize grants from NYSERDA, and/or employ PPA rates significantly higher than the current cost of energy for prospective microgrid customers.

Given the challenging financial situation of the Ossining Community Microgrid Project, the village government will need to make a decision about whether or not to proceed with Stage 2 of the NY Prize program. If the community does decide to proceed, an ownership approach and project team will need to be identified to prepare for the NY Prize Stage 2 proposal process. This Stage 2 and 3 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. Stage 2 of the NY Prize program will require additional cost share, and a determination will need to be made about which parties will take this on. If Ossinging decides not to move forward with a microgrid, it can continue to improve its energy resilience through use of back up generation. The community may also consider engaging a developer to install a photovoltaic system on Village land or even participate in Community Choice Aggregation to reduce energy costs.

Ossining 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, water treatment, and student populations of Ossining. 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 includes three schools, a fire station, water treatment and a pump house, municipal services, telecom services, and a community center. Collectively, there are a total of 9 "nodes" that make up the Ossining Community Microgrid.

The nine Ossining nodes and included facilities and functions are listed in the table below.

Table 1 – Overview of Microgrid Nodes

Microgrid Node #	Facilities	Functions
1	• Indian Brook Water Filtration and Treatment Plant	• Water treatment
2	• John Paul Rodrigues Operation Center	• Municipal services
3	• Claremont School • Anne M Dormer Middle School	• Education • Emergency shelter
4	• Cablevision Hub and Dispatch Operations	• Telecom services
5	• Municipal Building	• Municipal services
6	• Joseph G Caputo Community Center	• Recreation
7	• Pleasantville Road Pump House	• Utilities
8	• Ossining High School	• Education • Emergency shelter
9	• Birdsall Fagan Police and Court Facility • Fire Department	• Fire and emergency services • Municipal services

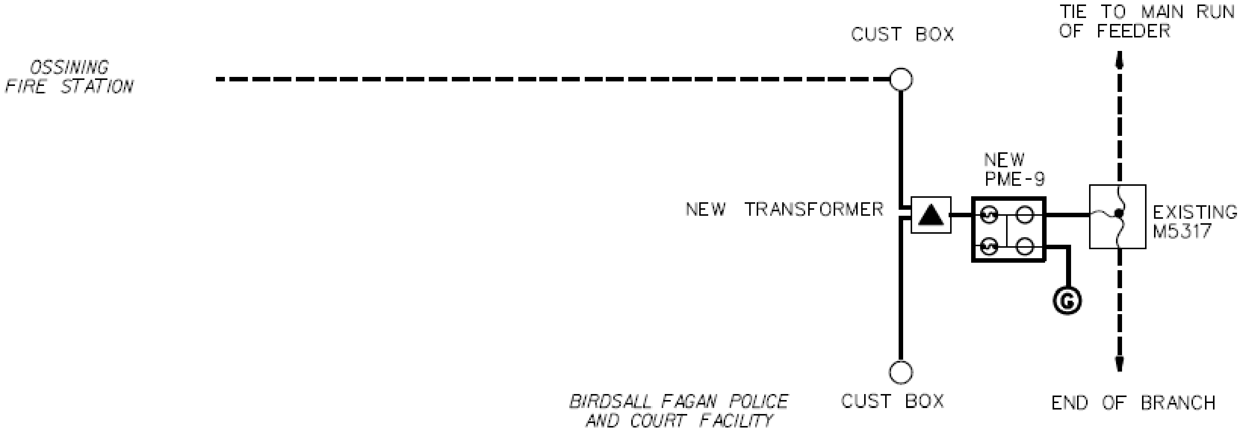
The utility feeders are mainly overhead lines, which cannot be relied upon in the event of a major storm. The microgrid design employs underground cabling to support each microgrid node in key areas where it is cost effective for the overall project. While this greatly improves resiliency within a microgrid 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 a Con Edison distribution engineering team to review utility infrastructure that impacts the microgrid design. The Con Edison engineers have provided a proposed modification to their infrastructure that is presented in Figure 1. This includes proposed switches in pad-mounted equipment (PME) some new underground cabling, and some transformer replacements.

Table 2 - Microgrid Electrical and Thermal Infrastructure Plan

Infrastructure	Class	Associated Device	Comment / Description
4 kV, 3 phase, Underground Cabling	New	Nodes 3 & 9	Added for Microgrid Nodes that have multiple electric accounts
4 kV Transformers	Updated	Critical Facilities	Conversion from pole-top to pad mount
Utility Switches	New	All Nodes	Installation of new switches in PME
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.

Figure 1 – Con Edison Proposed Infrastructure Upgrades to Support Node 1 of Microgrid



The Birdsall Fagan Facility and Ossining Fire Station 1 are both fed by the underground secondary network. Both locations have an undeground customer box. The plan is to use a PME Switch fed by a generator and primary. The PME will tie into a new pad mount or underground transformer. The transformer will then tie into the customer boxes to supply each location.

In addition to the potential facilities identified above, the Ossining Community Microgrid will create benefits for other stakeholders. If selected for the next stage of NY Prize, the project team will continue to solicit their advice and participation. These stakeholders include:

Table 3 – Community Stakeholders to Benefit from the Microgrid

Organization	Benefits from Ossining Community Microgrid
Consolidated Edison of new York (Con Edison)	By serving the local load and providing resilient energy, the system will allow the utility to delay potential investments in the existing substation equipment. This system will also help the utility meet its customer-sited renewable energy target under New York's Renewable Portfolio Standard.
Greater Ossining Chamber of Commerce	The microgrid will protect mission continuity for several essential services in Ossining, including fire and police, which serve all businesses in town. Even those businesses that are not included in the microgrid will benefit from the improved public service the microgrid supports.
Sustainable Westchester	The village and town of Ossining are member municipalities of Sustainable Westchester, and Sustainable Westchester is a partner in this project. The microgrid will provide greater resilience and sustainability to the region, helping Sustainable Westchester to advance its stated goal to "to turn our environmental challenges into opportunities to improve the quality of life, economy and future prospects of the citizens of the county."

Key Features of the Microgrid

Community Microgrid Controller

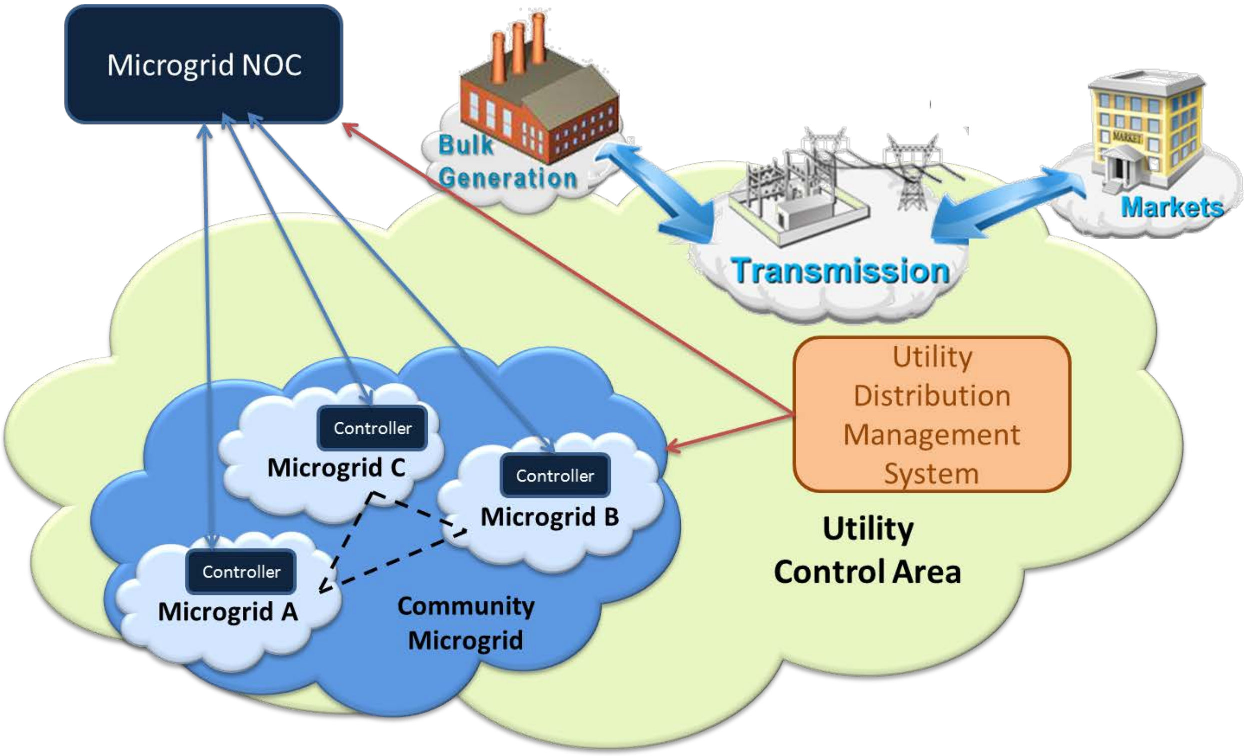
One of the challenges of community microgrids is that the facilities and the microgrid resources are distributed. To maximize the economics, reliability, and emissions reduction potential of the community microgrid, the microgrid controller architecture must have the capability to coordinate and control 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 operating center (NOC) that can operate each microgrid part separately or collectively.

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

Figure 2 presents the project team's design approach for the community microgrid controller architecture.

Figure 2: 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 the new state and island performance objectives.
5. **Islanding to grid-connected transition**: As with intentional islanding, the utility operator will provide the appropriate permission to close in the PCC. The local microgrid controller will support the reconfiguration of each dispatchable resource.
6. **Energy management**: The microgrid design incorporates a portfolio of resources. The EPRI Use Case takes a traditional energy management approach– economic dispatch, short-term dispatch, optimal power flow, and other processes typical in utility control room environments. The microgrid controller will have corresponding applications that manage a set of controllable generation and load assets. Within that portfolio, the system will also optimize the microgrid based on load forecast, ancillary services events, changes in configuration, outage of specific equipment, or any other kind of change to determine the optimal use of assets 48 hours ahead.
7. **Microgrid protection**: The microgrid controller will ensure two primary conditions. The first is that each protection device is properly configured for the current state of the microgrid, either islanded or grid-connected. The second condition is that after a transition, the microgrid controller will switch settings or test that the settings have changed appropriately. If the test is false in either condition, the controller will initiate a shutdown of each resource and give the appropriate alarm.
8. **Ancillary services**: The controller will provide fleet control of the nested microgrid parts. Specifically, the utility operation will have the ability to request and/or schedule balance up and balance down objectives for the fleet. The cloud-based controller will take the responsibility to parcel out the objectives for each microgrid part based on the available capacity.
9. **Black start**: The local microgrid controller will provide a workflow process for restarting the system. Each microgrid part will have a unique sequence of operations for predetermined use

cases. One objective will be to provide this function both locally and remotely to meet the reliability requirements of the overall design.

10. **User interface and data management**: The solution provides local controllers in each microgrid part as well as a hosted controller that can operate each microgrid part separately or collectively. The primary actors are the utility operator, local energy managers, maintenance personnel, and analyst. The user experience for each actor will be guided by a rich dashboard for primary function in the system around Operations, Stability, Ancillary Services, and Administration.

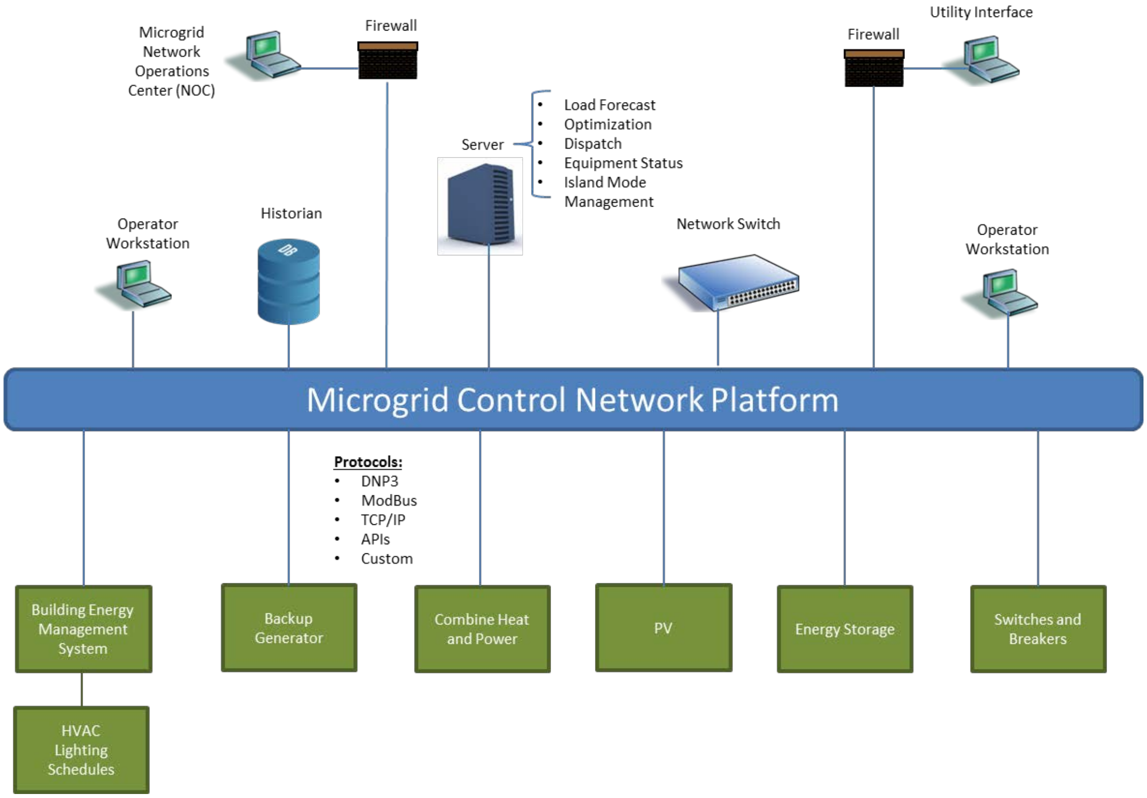
In addition, the microgrid controller will:

- Forecast variable aspects: load, 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. The microgrid includes data loggers to record voltage, load, and other electrical parameters. This information helps to inform active management through the microgrid controller.

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 programmable 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 3.

Figure 3 – Conceptual Microgrid Controller Topology



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

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

Telecommunications Infrastructure

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

The architecture will conform to requirements established by the SGIP and generally accepted communications protocols, such as ModBus (TCP/IP), DNP3 (TCP/IP), and 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 ensuresecurity 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 Infrastructure

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:

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

The Ossining 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.

Based on building evaluations from site walk-downs, the team estimated that typical facilities intended for inclusion in the microgrid could achieve energy cost savings of between five and ten percent through cost effective energy efficiency measures. These measures could be deployed either by the facility owners themselves or by the microgrid developer, with the understanding that most of these measures would reduce energy peak demand and allow for a more efficient microgrid system. Among the energy conservation measures identified by the project team were LED lighting, dimmers, daylight harvesting, smart (connected) thermostats, VFDs for fans/pumps, and/or domestic hot water heater timers/controls.

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

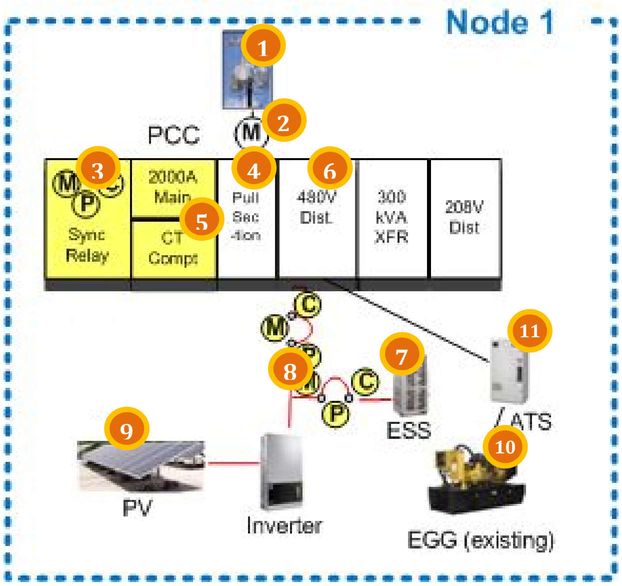
The microgrid DER selection is based on our *Microgrid Portfolio Approach* that focuses on energy requirements and a close match to the electric load profile of all covered facilities. The peak demand for critical facilities in the community occurs only a few hours per year. This means all critical facility services can be provided by “always-on” 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.

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 4 – One-Line Diagram Explanation



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

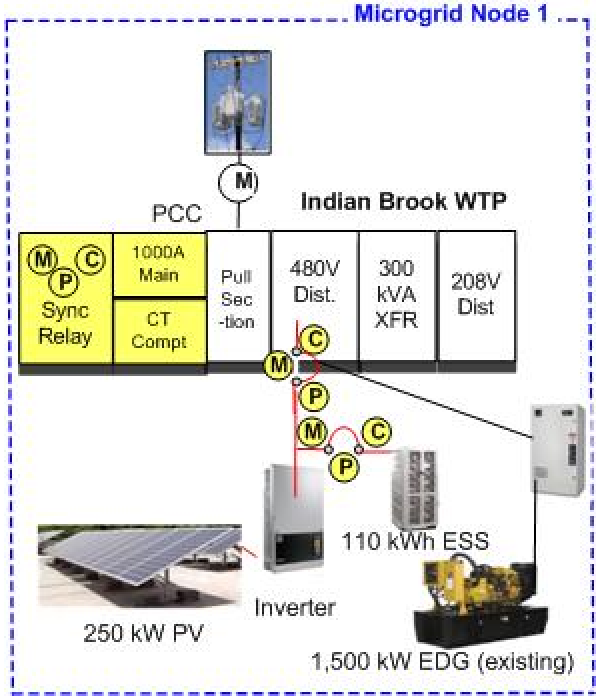
The following pages highlight the layout design and one-line diagram subsection for the eight nodes as well as a brief explanation of included energy resources.

Geospatial Diagrams and One-Line Subsections

Node 1 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- Indian Brook Water Filtration and Treatment Plant

Description

Node 1 contains the Indian Brook Water Filtration and Treatment Plant. An existing emergency diesel generator (1,500 kW) is located outside to the west of the building.

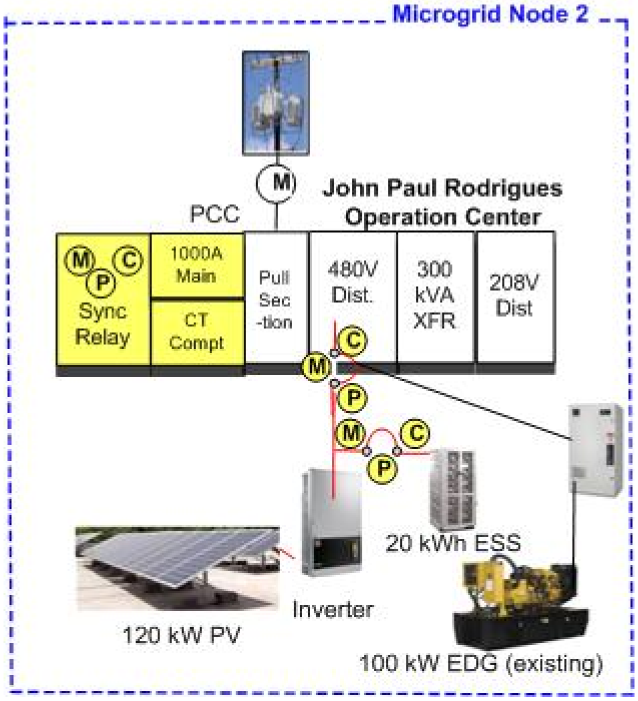
As part of the microgrid, the following will be installed:

- **PV (250 kW):** A combination of rooftop PV and ground-mounted PV will be installed.
- **ESS (110 kWh):** An ESS unit will be installed inside the building.

Node 2 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- John-Paul Rodrigues Operation Center

Description

Node 2 contains the John-Paul Rodrigues Operation Center. The facility has an existing emergency diesel generator exists located outside of the south wall (100 kW) of the main building.

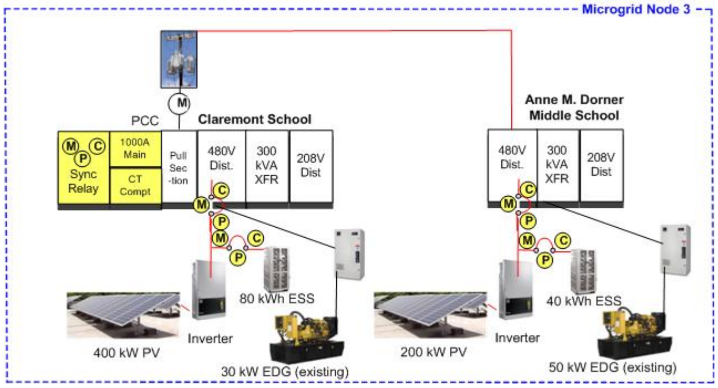
As part of the microgrid, the following will be installed:

- **PV (120 kW):** Rooftop PV will be installed on both buildings.
- **ESS (20 kWh):** An ESS unit will be located inside the east building.

Node 3 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- Claremont School
- Anne M Dormer Middle School

Description

Node 3 contains two schools. Each school has an existing emergency diesel generator as follows : 30 kW at Claremont and 50 kW at Dormer.

The microgrid design will tie both schools together electrically through a new 656 foot of underground cabling. As part of the microgrid, the following will be installed:

Claremont:

- **PV (400 kW):** PV will be installed on available rooftop spaces and as covered parking.

- **ESS (80 kWh):** An ESS unit will be placed inside the electric room.

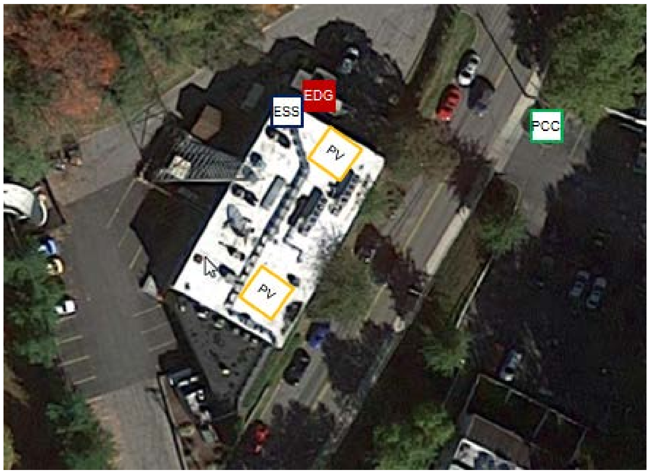
Dormer:

PV (200 kW): PV will be installed on available rooftop spaces and as covered parking

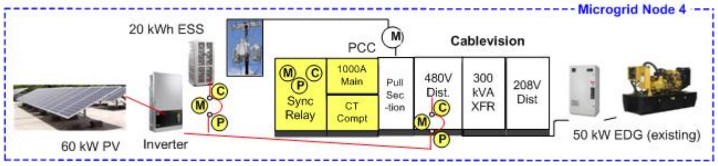
- **ESS (40 kWh):** An ESS unit will be placed inside the electric room.

Node 4 System Configuration

Geospatial Diagram



One-Line Diagram



Facility

- Cablevision Hub and Dispatch Operations

Description

Node 4 contains the Cablevision Hub and Dispatch Operation. It includes an existing emergency diesel generator (50 kW).

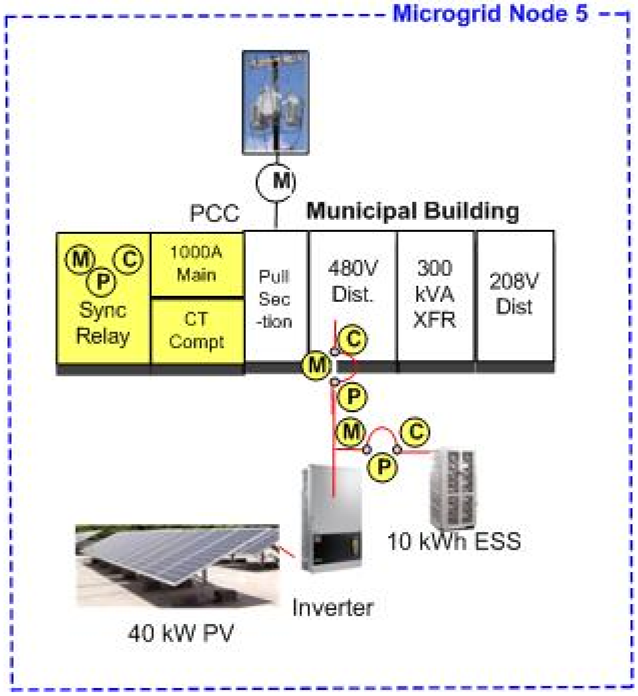
As part of the microgrid, the following will be installed:

- **PV (60 kW):** Rooftop PV units will be installed.
- **ESS (20 kWh):** An ESS unit will be placed inside the facility.

Node 5 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- Municipal Building

Description

Node 5 includes the municipal building.

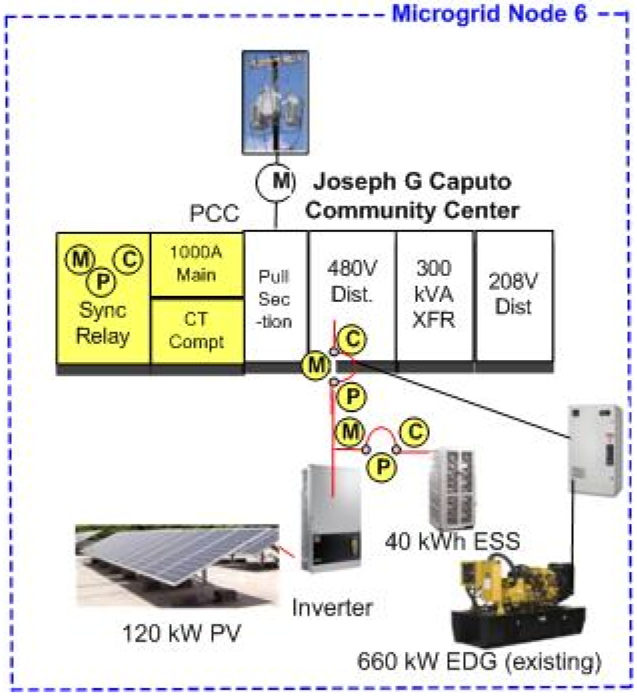
As part of the microgrid, the following will be installed:

- **PV (40 kW):** Rooftop PV will be installed.
- **ESS (10 kWh):** An ESS unit will be placed inside the facility.

Node 6 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- Joseph G Caputo Community Center

Description

Node 6 consists of the Joseph G Caputo Community Center. It includes an existing emergency diesel generator (660 kW) outside the east wall.

As part of the microgrid, the following will be installed:

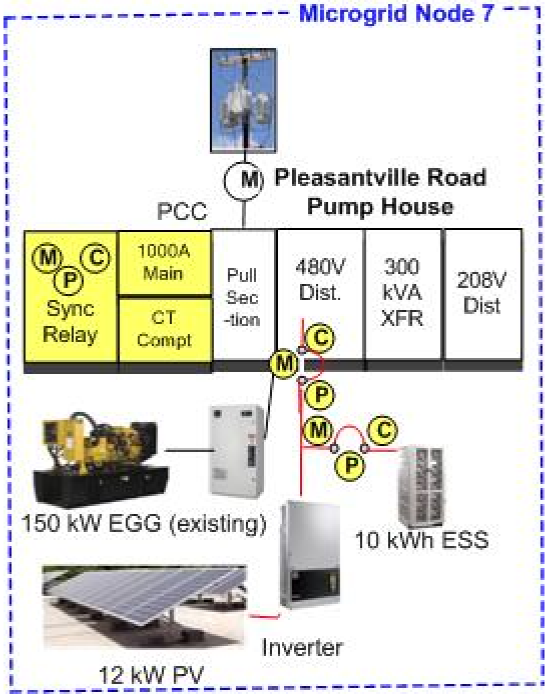
- **PV (120 kW):** Rooftop PV will be installed on the northeast and southern areas of the building.

- **ESS (40 kWh):** An ESS unit will be installed inside the building.

Node 7 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- Pleasantville Road Pump House

Description

Node 7 is a single facility node. There is an existing emergency gas generator (150 kW).

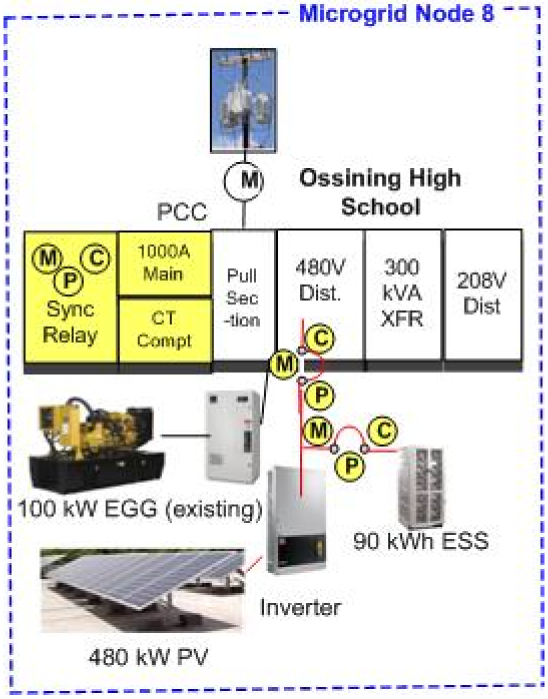
As part of the microgrid, the following will be installed:

- **PV (12 kW):** Rooftop PV will be installed.
- **ESS (10 kWh):** An ESS unit will be placed inside the facility near the emergency generator.

Node 8 System Configuration

Geospatial Diagram

One-Line Diagram



Facilities

- Ossining High School

Description

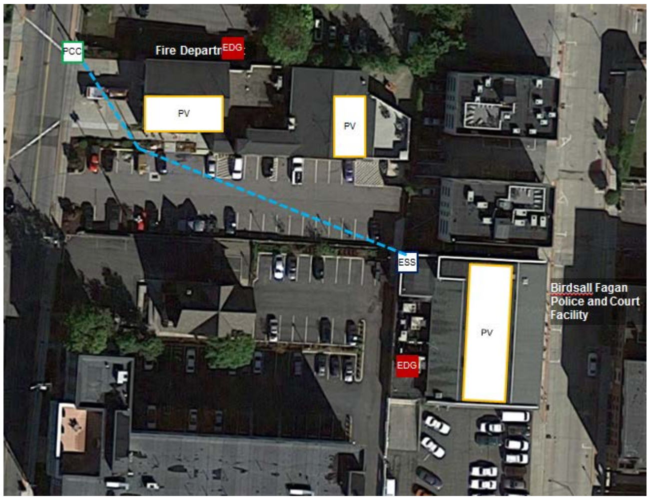
Node 8 is a single facility node. It includes an existing emergency gas generator (100 kW).

As part of the microgrid, the following will be installed:

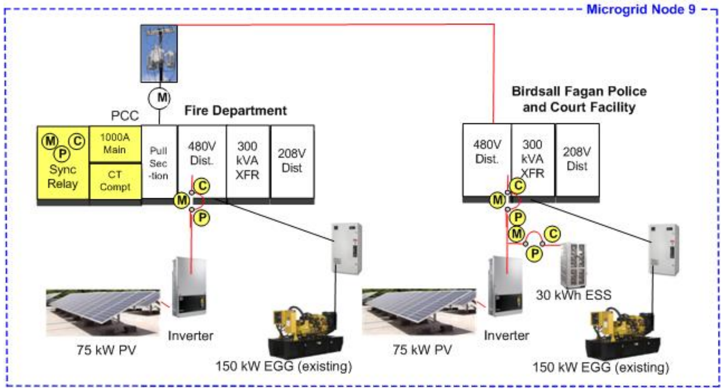
- **PV (480 kW):** A combination of rooftop PV and covered parking PV in the south lot will be installed.
- **ESS (90 kWh):** An ESS unit will be placed in a mechanical room.

Node 9 System Configuration

Geospatial Diagram



One-Line Diagram



Facilities

- Birdsall Fagan Police and Court Facility
- Fire Department

Description

Node 9 includes an existing emergency gas generator (150 kW) at the fire department, and an existing rooftop emergency diesel generator (150 kW) at the police station. There will be 328 feet of trenching.

The microgrid design will tie both facilities together electrically through new underground cabling (328 feet). As part of the microgrid, the following will be installed:

Police:

- **PV (75 kW):** Rooftop PV will be installed.

- **ESS (30 kWh):** An ESS unit will be placed inside.

Fire:

- **PV (75 kW):** Rooftop PV will be installed.

Modeling Methodology

The microgrid was modeled with HOMER Pro software. HOMER Pro is a microgrid software tool originally developed at 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 nine nodes separately. Table 4 presents an overview of the annual energy operations of the microgrid by node. The microgrid will have a maximum demand of 2,268 kW and an average demand of 750 kW. The microgrid will deliver approximately 6,600,000 kWh per year. Since the project does not incorporate CHP, no thermal heat recovery will take place.

Table 4 –Microgrid Energy Overview: Grid Connected Operation

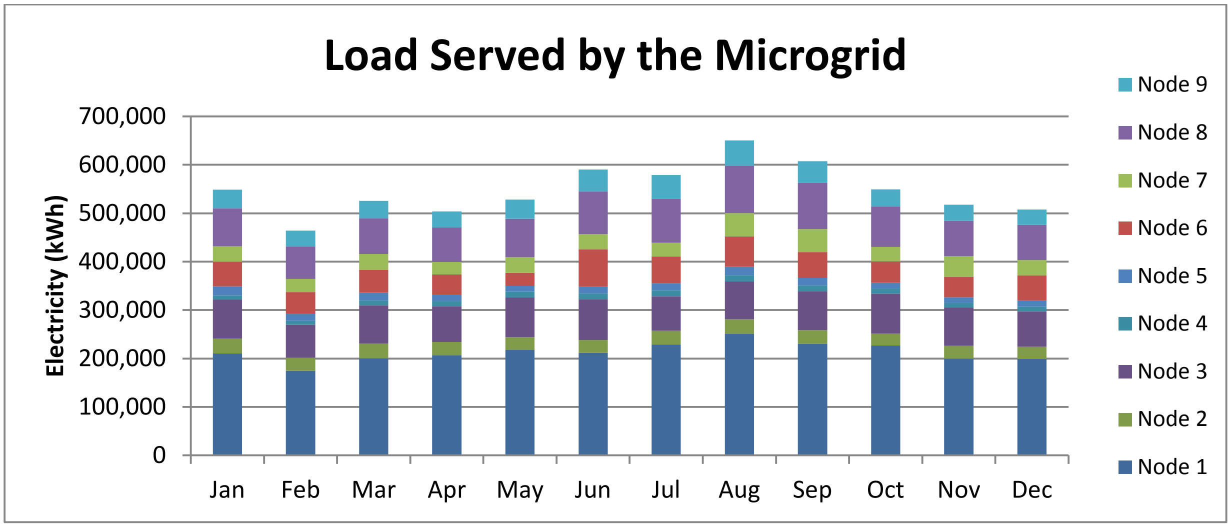
	Electric Demand		Electric Consumption		Thermal Load	
Node	**Max (kW)**	**Avg (kW)**	**kWh/year**	**kWh/month**	**kBTU/year**	**kBTU/month**
1	621	292	2,559,137	213,261	1,274,339	106,195
2	136	38	331,643	27,637	6,129,572	510,798
3	386	106	931,993	77,666	35,353,429	2,946,119
4	59	15	128,854	10,738	366,418	30,535
5	73	20	171,698	14,308	14,022	1,168
6	223	68	599,207	49,934	2,886,179	240,515
7	171	46	407,297	33,941	140,185	11,682
8	498	111	973,407	81,117	25,081,288	2,090,107
9	101	54	470,784	39,232	1,423,206	118,601
Total	**2,268**	**750**	**6,574,020**	**547,835**	**72,668,638**	**6,055,720**

The monthly energy delivery by microgrid node is presented in Table 5 and presented graphically in Figure 5.

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	Node 9	Total
		(kWh)								
Jan	210,185	31,646	80,214	8,782	18,377	51,181	31,446	78,838	38,293	548,963
Feb	174,846	27,139	67,738	8,026	15,624	44,273	26,992	67,089	32,798	464,525
Mar	200,528	30,707	78,917	10,063	15,583	47,424	33,017	73,833	35,711	525,783
Apr	207,307	27,241	73,735	10,388	12,828	41,954	26,295	71,126	33,092	503,967
May	218,040	25,795	82,079	11,967	11,887	27,532	31,728	79,643	39,422	528,093
Jun	211,798	26,432	84,293	12,456	13,589	77,175	30,939	88,654	45,299	590,634
Jul	229,121	28,238	71,120	12,940	14,441	54,910	28,225	90,428	49,532	578,957
Aug	250,445	31,041	77,588	13,334	16,891	63,270	47,885	98,194	51,764	650,413
Sep	230,576	27,905	80,828	11,753	15,302	53,745	47,120	95,493	44,994	607,714
Oct	227,262	23,858	82,864	10,738	11,919	44,045	29,974	84,008	35,082	549,749
Nov	200,065	26,305	79,158	9,376	11,884	42,152	42,121	73,598	32,968	517,627
Dec	198,963	25,336	73,459	9,031	13,373	51,548	31,553	72,504	31,828	507,595
Total	**2,559,137**	**331,643**	**931,993**	**128,854**	**171,698**	**599,207**	**407,297**	**973,407**	**470,784**	**6,574,020**

Figure 5 - Monthly Grid Connected Operation by Node



The Ossining microgrid is designed for 20% 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 Ossining Community Microgrid will be ensured with the following measures:

- Leverage the existing conventional emergency generators, automatic transfer switches, and critical load circuits
- 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)
- 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

These techniques are employed in the Ossining 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 6 summarizes the microgrid resources in each node in terms of number of devices and the total installed capacity by technology.

Table 6 - Microgrid Node Resources Comparison

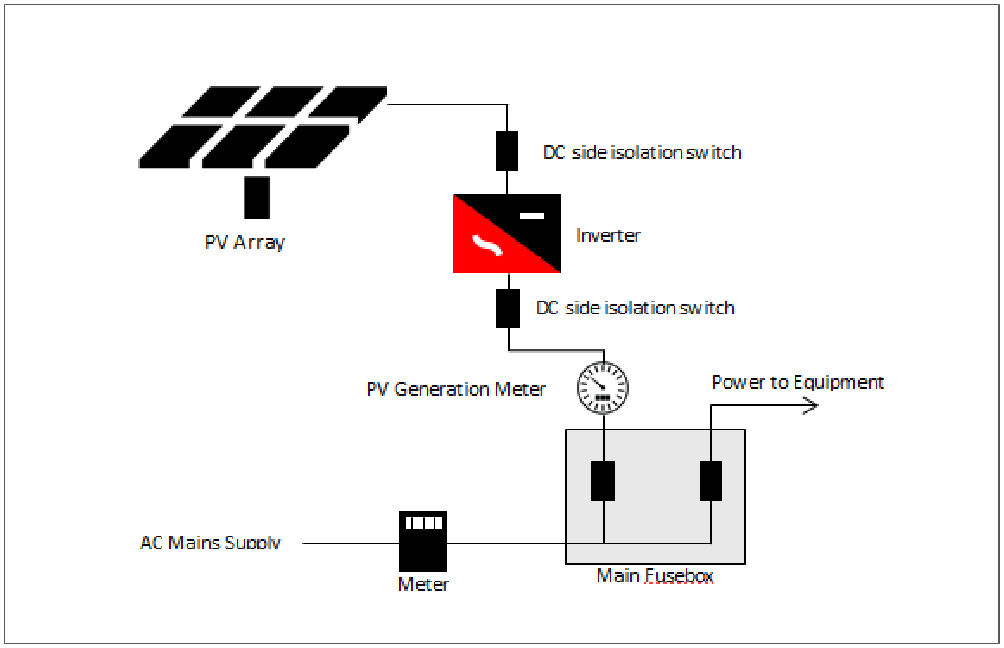
Node	Operation Scenario	Grid	PV		Battery Energy Storage		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW
1	Business as Usual	621	-	-	-	-	2	1,500
	Microgrid	365	1	250	1	55/110	2	1,500
2	Business as Usual	136	-	-	-	-	1	100
	Microgrid	105	1	120	2	10/20	1	100
3	Business as Usual	386	-	-	-	-	2	80
	Microgrid	289	2	600	2	60/120	2	80
4	Business as Usual	59	-	-	-	-	1	50
	Microgrid	45	1	60	1	10/20	1	50
5	Business as Usual	73	-	-	-	-	-	-
	Microgrid	62	1	40	1	5/10	-	-
6	Business as Usual	223	-	-	-	-	1	660
	Microgrid	197	1	120	1	20/40	1	660
7	Business as Usual	171	-	-	-	-	1	150
	Microgrid	162	1	12	1	5/10	1	150
8	Business as Usual	498	-	-	-	-	1	100
	Microgrid	330	1	480	1	45/90	1	100
9	Business as Usual	101	-	-	-	-	2	300
	Microgrid	100	2	150	1	15/30	2	300

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

Solar Photovoltaics

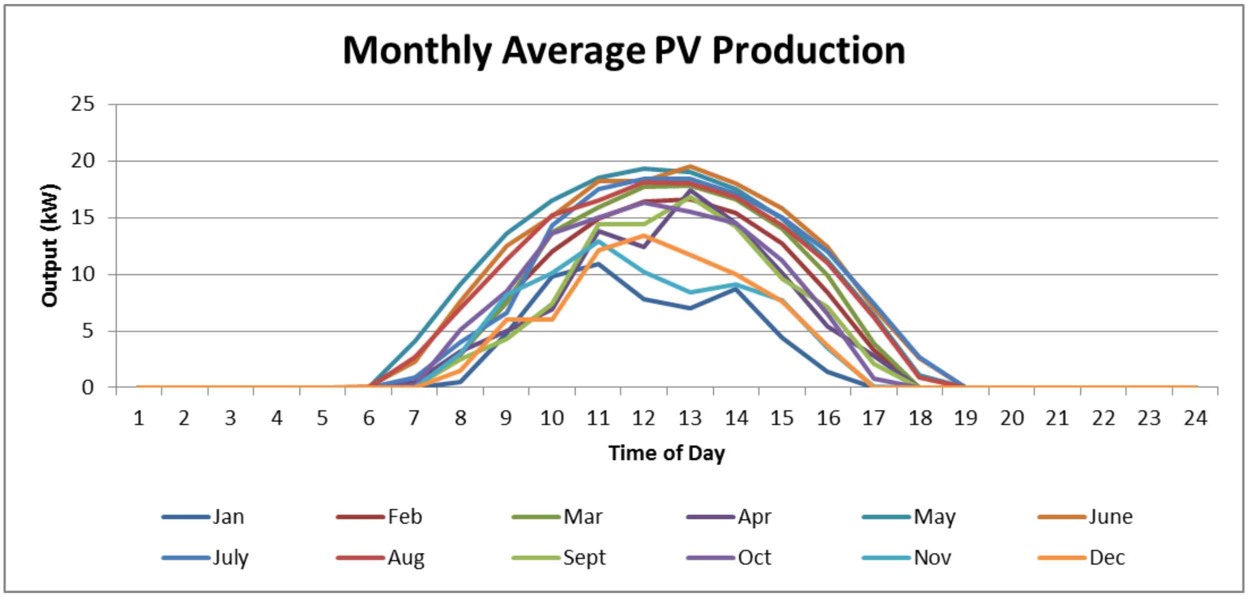
The solar PV will be rooftop, parking lot, or ground mounted using hail-rated solar panels. PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by photons and 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 6.

Figure 6 – 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 7 presents the typical average daily PV generation profiles by month and demonstrates the seasonal variation of PV as a generation resource. The HOMER model takes this variability into account when simulating and optimizing the sizing of PV as a microgrid resource.

Figure 7 – Typical PV Daily Generation Profiles



PV systems are planned for rooftops, parking spaces, and ground-mount configurations. Figure 8 presents examples of each these types of installations

Figure 8 – 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 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 7 summarizes the PV components by node of the microgrid.

Table 7 - Microgrid PV Resources by Node

Node	PV	
	# of Inverters	Total kW
1	1	250
2	1	120
3	2	600
4	1	60
5	1	40
6	1	120
7	1	12
8	1	480
9	2	150
Total	**11**	**1,832**

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

Table 8 – Microgrid PV Fleet Electric Production

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Total
	Electric Production (kWh)									
Jan	21,998	10,559	52,794	5,276	3,520	10,559	1,056	42,236	13,199	161,196
Feb	24,452	11,737	58,684	5,866	3,912	11,737	1,174	46,947	14,671	179,179
Mar	34,080	16,358	81,791	8,177	5,453	16,358	1,636	65,433	20,448	249,734
Apr	30,713	14,742	73,711	7,370	4,914	14,742	1,474	58,969	18,428	225,062
May	32,601	15,649	78,243	7,824	5,216	15,649	1,565	62,594	19,561	238,901
Jun	31,070	14,914	74,568	7,457	4,971	14,914	1,491	59,655	18,642	227,682
Jul	31,078	14,917	74,586	7,459	4,972	14,917	1,492	59,669	18,647	227,737
Aug	30,497	14,639	73,193	7,318	4,879	14,639	1,464	58,554	18,298	223,480
Sep	30,015	14,407	72,036	7,202	4,802	14,407	1,441	57,629	18,009	219,949
Oct	27,828	13,357	66,787	6,676	4,452	13,357	1,336	53,429	16,697	203,920
Nov	21,378	10,261	51,306	5,127	3,421	10,261	1,026	41,045	12,827	156,652
Dec	20,073	9,635	48,174	4,814	3,211	9,635	963	38,539	12,044	147,088
Total	**336,031**	**161,175**	**805,874**	**80,566**	**53,724**	**161,175**	**16,117**	**644,699**	**201,468**	**2,460,829**

Figure 9 – Microgrid PV Fleet Electric Production

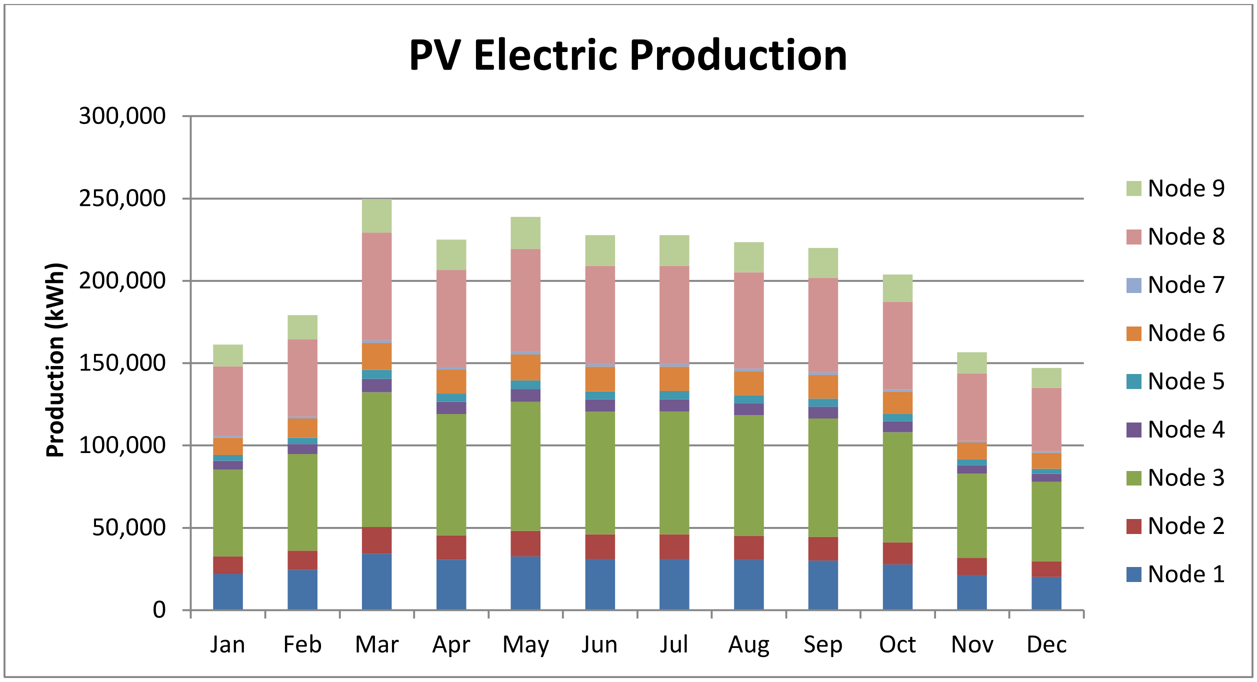
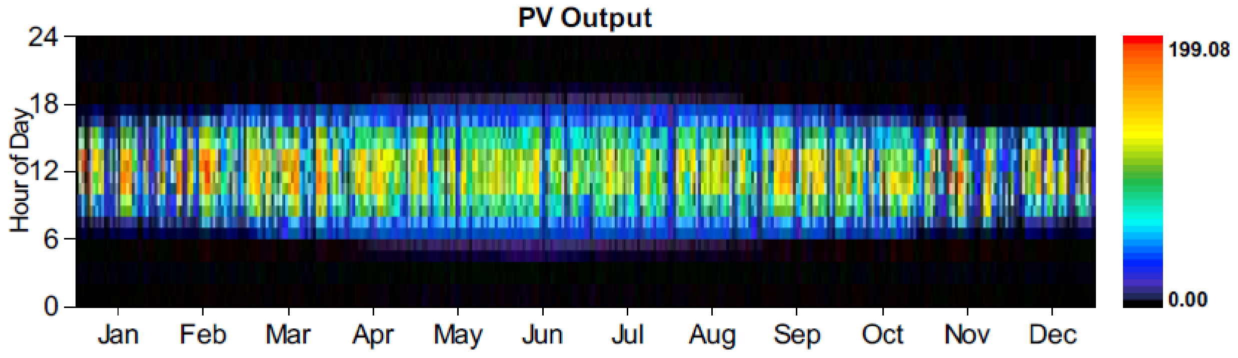


Figure 10 presents the hourly operation of the PV in a sample node in the form of a heat map. This representation demonstrates how the PV units operate during hours of sunshine with maximum production in the middle of the day, ramping up in the mornings and ramping down in the afternoon hours. This also illustrates the trend of narrower daily bands of production in the winter and then expansion to maximum production in the summer.

Figure 10 – Sample Node PV Operational Summary



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 Ossining 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:

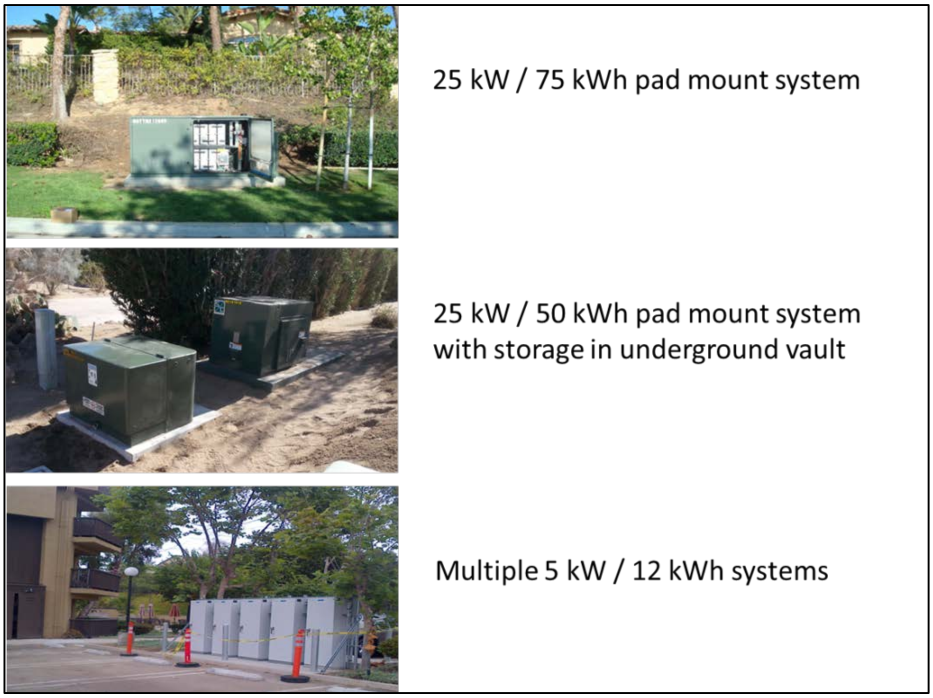
- The usable energy capacity is between a 15% and 95% state of charge (SOC)
- The life of the batteries are impacted by temperature and charge rate
- Most systems are capable of approximately 3,000 deep discharge cycles (+/- 80% SOC cycles)
- Most systems are capable of more than 100,000 shallow discharge 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 greenhouse gas (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 11 presents examples of energy storage installations for the technologies addressed for this microgrid design.

Figure 11 – 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 energy storage, 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 9 summarizes the ESS components by node of the microgrid.

Table 9 - Microgrid ESS Resources by Node

Node	Battery Energy Storage		
	Quantity	kW	kWh
1	1	55	110
2	2	10	20
3	2	60	120
4	1	10	20
5	1	5	10
6	1	20	40
7	1	5	10
8	1	45	90
9	1	15	30
Total	**11**	**225**	**450**

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 a sample node is presented in Table 10, 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 10 – Microgrid ESS Operation Sample Node

Month	Charge	Discharge	Net
		(kWh)	
Jan	2,579	2,283	296
Feb	906	833	72
Mar	465	428	37
Apr	1,723	1,585	138
May	1,429	1,315	114
Jun	1,852	1,724	129
Jul	3,085	2,818	266
Aug	6,467	5,949	517
Sep	4,241	3,902	339
Oct	2,981	2,743	239
Nov	1,456	1,339	116
Dec	1,195	1,099	96
Total	**28,379**	**26,019**	**2,360**

Figure 12 – Microgrid ESS Operation

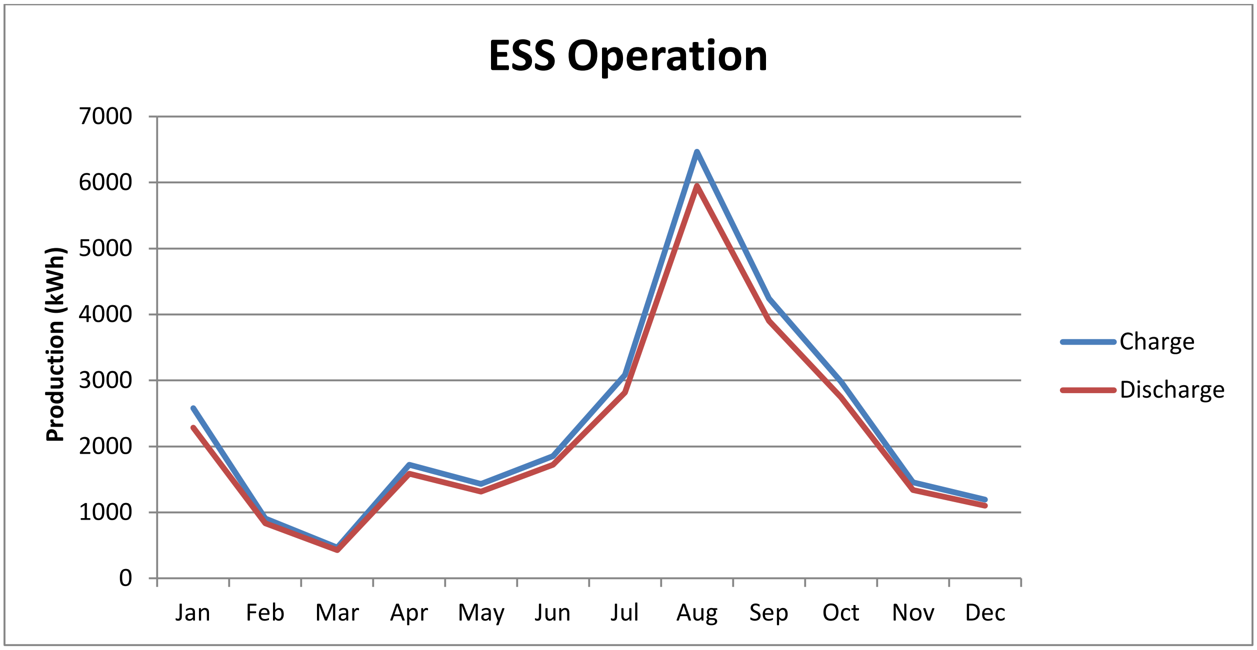
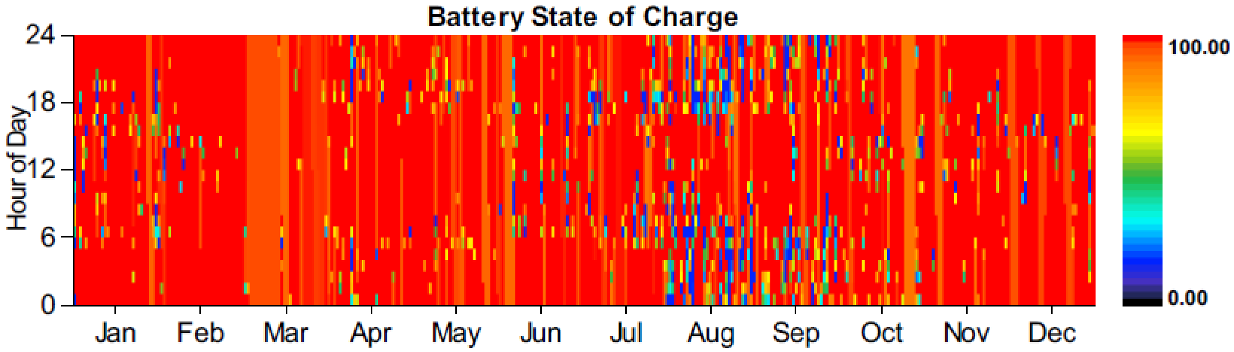


Figure 13 presents the hourly operation of the ESS in a sample node in the form of a heat map. This representation demonstrates how the ESS units operate. Typically, the units are charged to a high SOC in the middle of the day. The operations represent PV intermittency support, PV load shifting and peak shaving (to manage utility imports).

Figure 13 – Sample Node ESS Operational Summary



Backup Generators

The design does not include the installation of new backup generators. In cases where there are not backup generators, the microgrid design uses PV, energy storage, and building load control to operate the entire facility or the specified critical load during an outage. In cases where there are existing backup generators, they are included in the resource mix but operated within their onsite fuel capacity during a one week outage. The operation is supported by the other microgrid resources, which offset the need for the backup generators except at times of high electric demand.

The Ossining Community Microgrid currently has multiple backup generator installations. These generators are generally rated to run two to three days without being refueled. The microgrid is designed to extend this run time by incorporating PV and energy storage resources.

Table 11 – Existing Backup Generators

Facility	Capacity (kW)	Fuel Type
Indian Brook Water Filtration and Treatment Plant	1,500	Diesel
John Paul Rodrigues Operation Center	100	Diesel
Claremont School	30	Diesel
Anne M Dormer Middle School	50	Diesel
Ossining High School	100	Natural Gas
Cablevision Hub and Dispatch Operations	50	Diesel
Joseph G Caputo Community Center	660	Diesel
Pleasantville Road Pump House	150	Natural Gas
Ossining Fire Department	150	Natural Gas
Birdsall Fagan Police and Court Facility	150	Natural Gas

Island Mode Modeling Results

The resources included in the Ossining Community Microgrid have been sized to operate together in a manner 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 the existing backup 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 and extending the onsite fuel availability for the emergency generators.

The proposed microgrid design seeks to offset the costs of operations and the emissions typical of a single backup generator approach. The addition of the solar PV and energy storage integrated with the backup generators during times of grid outage provide a lower cost of delivered energy and reduced emissions. In addition, the PV and energy storage provide economic and environmental benefits to the facilities during a majority of the year when operating in parallel to the grid.

The design strategy for the Ossining 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 12.

Table 12 –Microgrid Energy Overview: Island Mode Operation

Node	Season	Electric Demand		Electric Consumption	Thermal Load
		Max (kW)	Avg (kW)	kWh/week	kBTU/week
1	Winter	514	330	55,415	75,247
	Summer	449	85	14,200	0
2	Winter	109	50	8,339	111,234
	Summer	88	42	7,019	4,116
3	Winter	311	112	18,789	1,984,083
	Summer	238	103	17,252	20,910
4	Winter	34	14	2,314	21,077
	Summer	46	19	3,175	236
5	Winter	43	7	1,175	310
	Summer	32	8	1,410	302
6	Winter	164	80	13,473	121,331
	Summer	172	81	13,688	0
7	Winter	147	49	8,290	7,195
	Summer	73	42	7,124	0
8	Winter	278	113	18,977	1,442,133
	Summer	287	128	21,472	14,298
9	Winter	110	60	10,081	93,438
	Summer	120	74	12,373	4,092
Total	**Winter**	**1,710**	**815**	**136,851**	**3,856,048**
	Summer	**1,506**	**582**	**97,714**	**43,954**

FINANCIAL FEASIBILITY

The outputs of the technical modeling process described above were used to evaluate the financial viability of the proposed microgrid from two perspectives. First, the project team analyzed the financial strength of the project when deployed 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.

Installed Cost

At this feasibility stage of the project, a high-level project budget was developed for the Ossining Community Microgrid project and incorporated into the technical model to ensure that the design meets both the technical and economic requirements of the project. This budget includes costs for engineering, permitting, capital equipment, site preparation, 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 $5,495,000 with an accuracy of +/- 25% (within the +/- 30% set by NYSERDA). The net cost with the federal investment tax credit (ITC) that was recently extended by the US Congress is $3,094,000. This cost does not include other incentives that may be applicable to the project that will be applied during the detailed analysis in Stage 2.

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

- **Demand Response**: Con Edison'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. 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 White Plains 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 White Plains 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**: Provides various rebates on energy efficient equipment.
- **Federal Energy-Efficient Commercial Buildings Tax Deduction**: This program 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 project team conducted a thorough econometric analysis of the proposed Ossining Community Microgrid to determine the financial viability of the project. Hitachi has developed proprietary economic modelling software, known as EconoSCOPE™, which 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 Ossining Community Microgrid project, and found that the financial case for this project is not strong. The economic analysis of this project identified its annual operating costs to be roughly equivalent to its annual PPA revenue opportunity – assuming that energy was provided at the current 'business as usual' rate. This means that without a considerable increase in energy costs for all parties involved, a microgrid would not turn a profit and provide an opportunity for an investor to recoup the considerable investment associated with building the system.

The current weighted electric rate of the key critical facilities is approximately $0.115/kWh. Based on the estimated energy efficiency improvements (5-10% decrease in peak load), estimated project financing costs, and the 25 year contract term, the study indicates that the PPA rate for energy generated by the microgrid would be significantly higher than this current rate (in the absence of additional funding through NY Prize Stage 2 and 3 other incentives). As stated above, the proposed system does not generate any profit so all financial gain for a potential investor would have to come by way of energy rate increases for system off-takers. While one or two system off-takers may decide that added resilience is worth the investment, many likely would not. This would result in an increasingly small system forcing more of the fixed costs on fewer players – resulting in even greater increases in the cost of energy.

Benefit Cost Analysis

NYSERDA contracted with IEc to conduct a benefit-cost analysis. The project team provided detailed information to IEc to support their 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 Ossining Community Microgrid, the breakeven outage case is one outage per year for a duration of half a day. The cost benefit results are presented in Table 13. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.5 days per year (Scenario 2). For a more in-depth understanding of these numbers, review Appendix D.

Table 13 – Cost Benefit Analysis Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	**Scenario 2: 0.5 DAYS/YEAR**
Net Benefits - Present Value	-$3,880,000	$124,000
Total Costs – Present Value	$8,490,000	$8,490,000
Benefit-Cost Ratio	0.5	1.0
Internal Rate of Return	-4.7%	6.4%

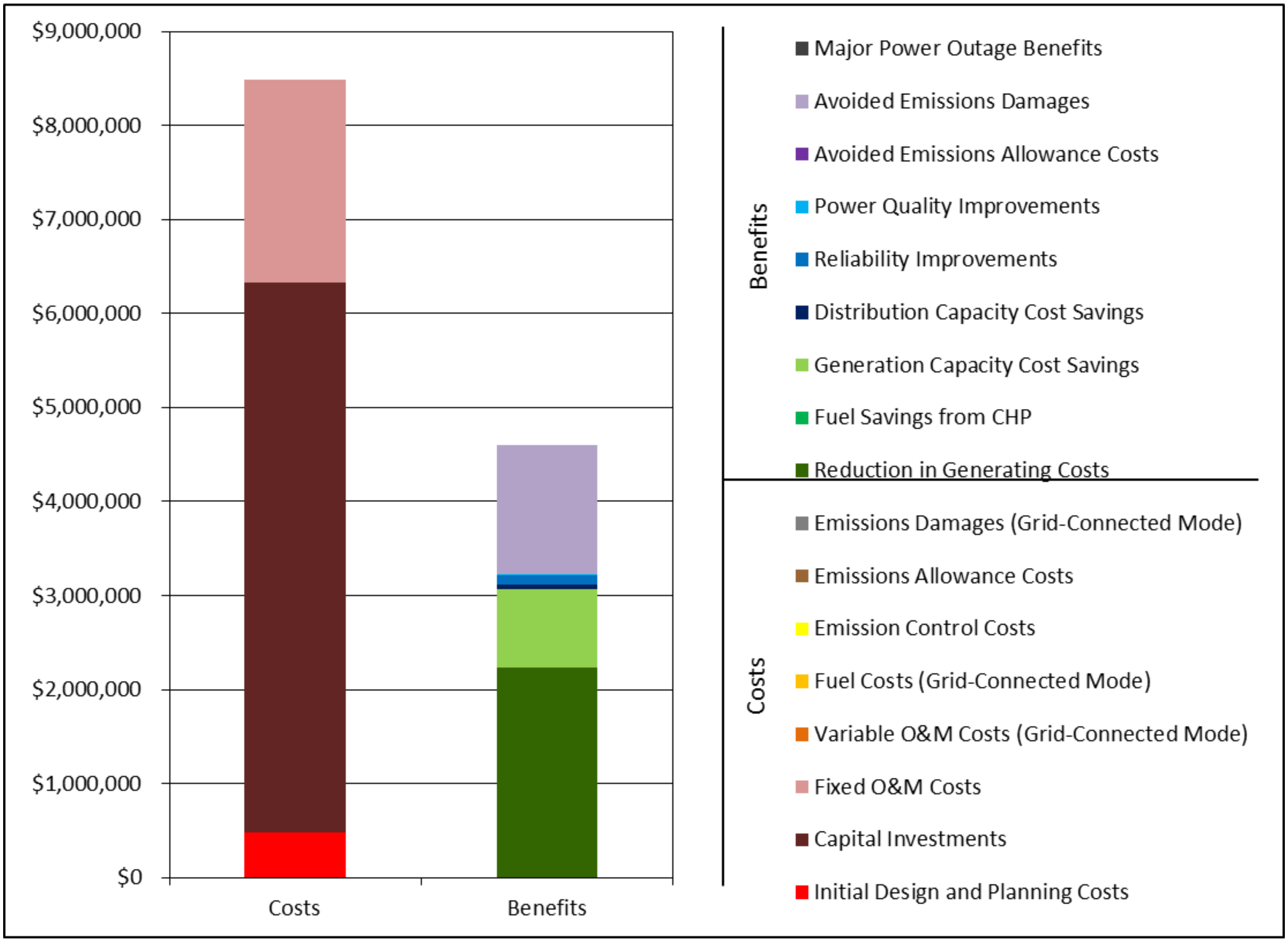
Table 13 and Figure 14 are from the IEc analysis outputs. They describe the costs and benefits associated with Scenario 1 (no power outages).

Table 14– Scenario 1: Detailed BCA Results

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$5,860,000	$472,000
Fixed O&M	$2,160,000	$190,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$0	$0
Total Costs	**$8,490,000**	
Benefits		
Reduction in Generating Costs	$2,230,000	$197,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$834,000	$73,600
Distribution Capacity Cost Savings	$47,600	$4,200
Reliability Improvements	$99,100	$8,740
Power Quality Improvements	$21,000	$1,850
Avoided Emissions Allowance Costs	$924	$82
Avoided Emissions Damages	$1,370,000	$89,600
Major Power Outage Benefits	$0	$0
Total Benefits	**$4,600,000**	
Net Benefits	**-$3,880,000**	

Benefit/Cost Ratio	**0.5**	
Internal Rate of Return	**-4.7%**	

Figure 14 – Scenario 1: Present Value Results



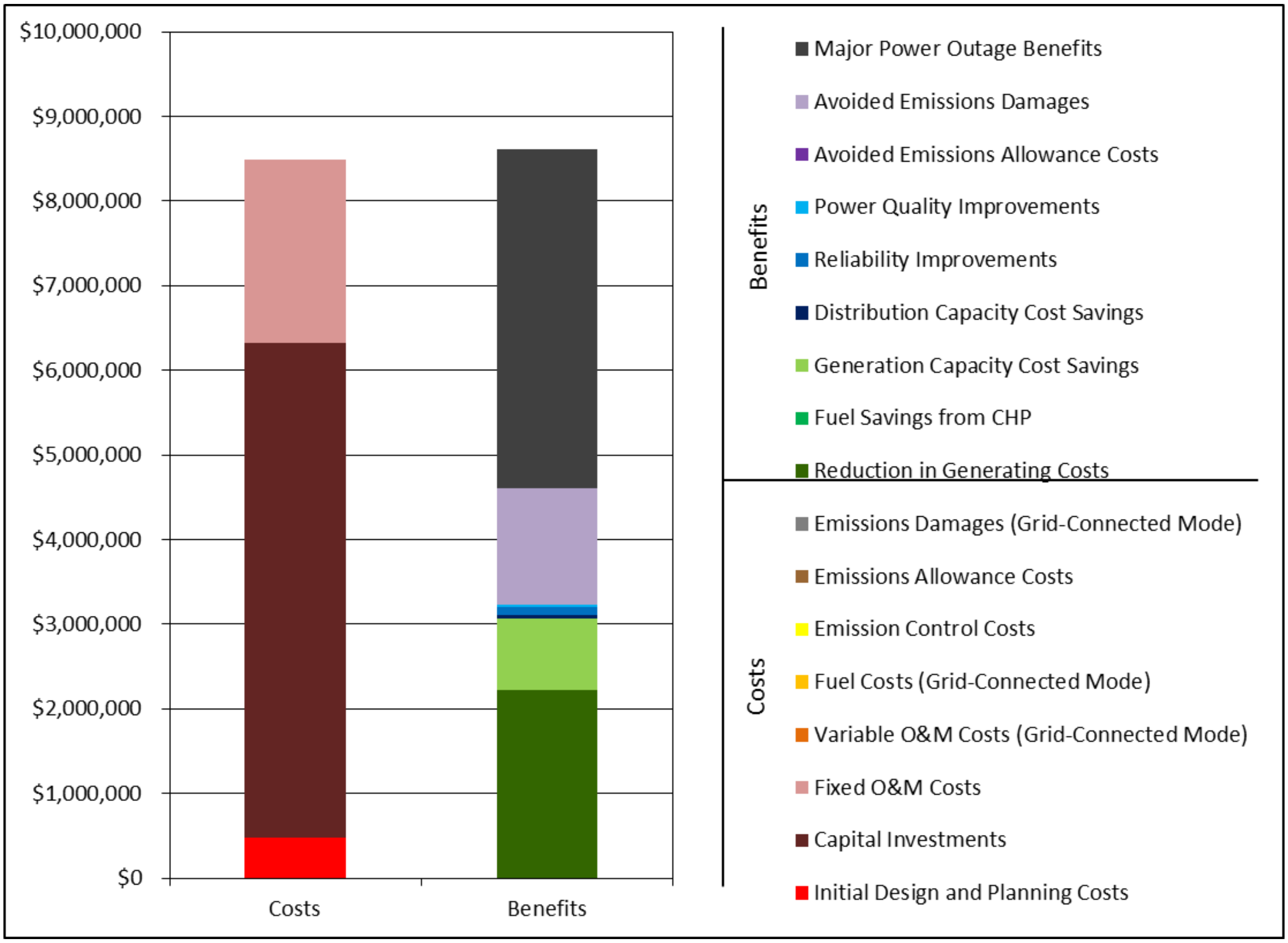
The major drivers of costs are the capital investments and Fixed O&M costs, where the major benefits are reduction in generation costs and avoided emissions damages.

Table 15 and Figure 16 are from the IEc analysis outputs. They describe the costs and benefits associated with Scenario 2 (major power outages of 0.5 days/year).

Table 15 – Scenario 2: Detailed BCA Results

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
	Costs	
Initial Design and Planning	$475,000	$41,900
Capital Investments	$5,860,000	$472,000
Fixed O&M	$2,160,000	$190,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$0	$0
Total Costs	**$8,490,000**	
	Benefits	
Reduction in Generating Costs	$2,230,000	$197,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$834,000	$73,600
Distribution Capacity Cost Savings	$47,600	$4,200
Reliability Improvements	$99,100	$8,740
Power Quality Improvements	$21,000	$1,850
Avoided Emissions Allowance Costs	$924	$82
Avoided Emissions Damages	$1,370,000	$89,600
Major Power Outage Benefits	$4,010,000	$353,000
Total Benefits	**$8,610,000**	
Net Benefits	**$124,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.4%**	

Figure 15 – Scenario 2: Present Value Results



The benefits from the half day outages result in $4,010,000 during the life of the microgrid. The entirety of the IEc analysis can be found in Appendix D of this report.

Model Comparisons

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

- 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 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 $2.4 million.

- Capital replacement costs used in the benefit-cost analysis 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 Ossining Community Microgrid is $219,000 less than the full cost of replacement.
- 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.

PROJECT TEAM

The success of this project relies on a strong team to take it from a feasibility study to an operational system. This Ossining Community Microgrid team has engaged with nearly all of the major community stakeholders. Local government representatives from Ossining have led this project from the beginning, and have signaled Ossining’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. Without ownership by the local government, no microgrid project is likely to be built in Ossining.

Con Edison is aware of this project and provided a letter of support for the initial feasibility study and participated in the project kick-off meeting. Throughout the process, the project team has engaged the utility in design discussions. As of this date, Con Edison has not yet weighed in on the value of this project based on the results of the feasibility study.

If the decision is made to proceed with a Stage 2 NY Prize proposal, a team of partners and contractors will need to be assembled. Key team members will include:

- Engineering
- Procurement
- EPC Contractor
- CHP Design Firm
- PV Design Firm
- Microgrid Controller Vendor
- Project Financiers
- Legal and Regulatory Advisors
- Operations and Maintenance Firms

LEGAL VIABILITY

The project team has developed a model for the legal organization of the Ossining 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>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, Con Edison has demonstrated positive levels of support and cooperation with the feasibility study phase.

Regulatory Issues

The ownership model of the Ossining 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,[2] is under 80 MW,[3] serves a qualifying number of users, and its related facilities (including any private distribution infrastructure) are located "at or near" its generating facilities. This saves the system from a raft of burdensome regulatory requirements.

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

Privacy

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

CONCLUSIONS AND NEXT STEPS

In developing this project, the team attempted to design a system that will meet the current and future resilience needs of the community, and that is replicable enough to yield lessons learned for the rest of New York State and advance statewide objectives for resilience, sustainability, and technological innovation.

The Ossining project is unique, because it's goal is to augment existing emergency generation with renewable energy resources. For this reason, the design team aimed to develop a system that incorporates those emergency generators and only includes PV and energy storage as new energy sources. This analysis yields some important lessons learned about the current potential for

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

[3] Id.

microgrids for communities with significant existing emergency generation, and the importance of current emergency generation capabilities when evaluating the incremental resilience potential for a microgrid design.

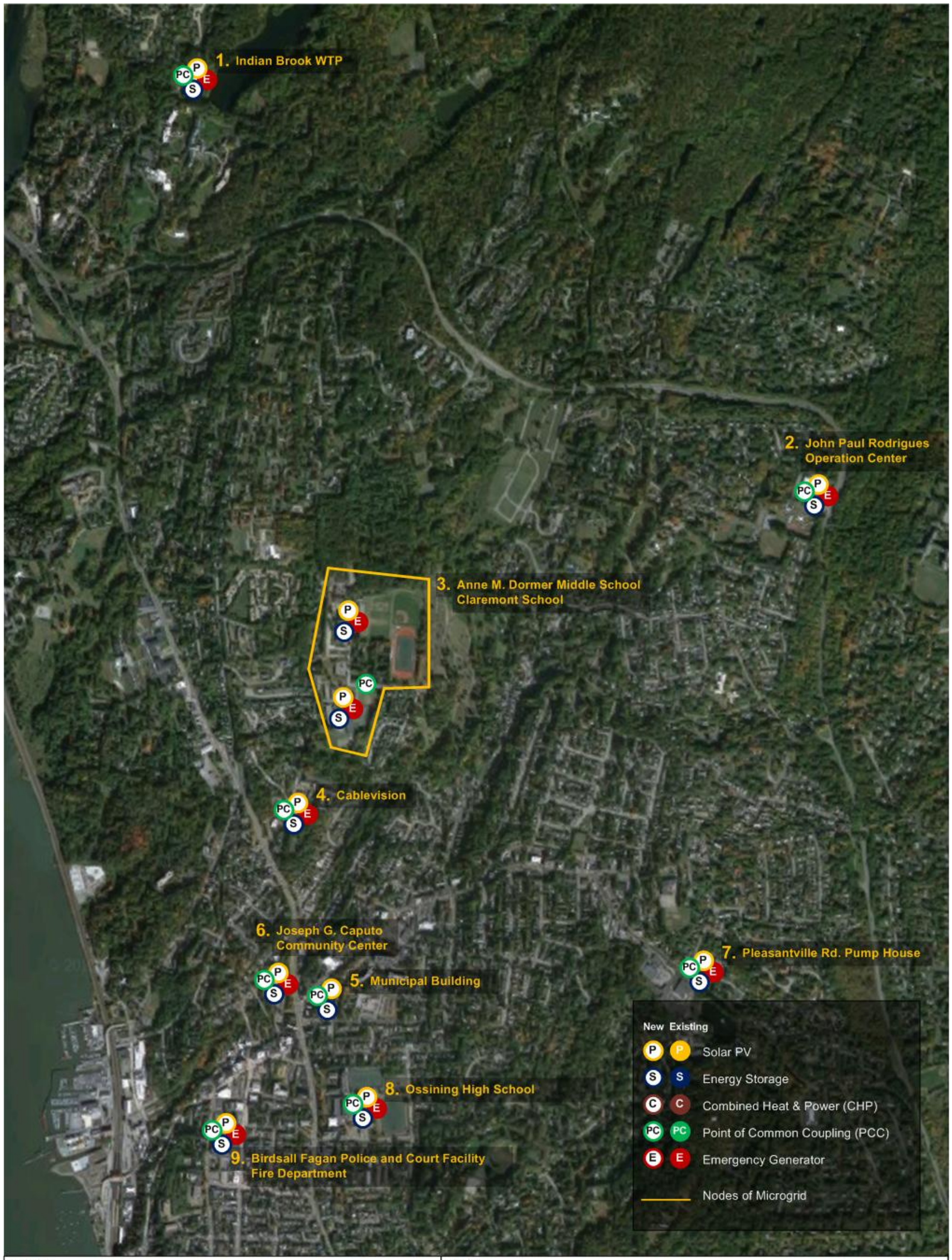
The New York REV proceedings are intended to encourage new energy business models that will contribute to the goals of grid efficiency, facility energy efficiency, the development of clean distributed generation and storage, and the use of behind-the-meter resources for demand management. The unique qualities and lessons learned from the feasibility assessment of the Ossining Community Microgrid project can yield value for the proceedings of New York's REV proceedings.

As it stands, the Ossining Community Microgrid project is not likely to meet the financial requirements for third party financing and ownership. In order to meet these requirements, the project will need to secure Stage 2 and Stage 3 NY Prize grants from NYSERDA, and/or employ PPA rates significantly higher than the current cost of energy for prospective microgrid customers. If energy resilience is the Village's chief concern, the logical approach would be to expand an already robust back up generation program. If cost savings are paramount, investing in thorough energy audits or engaging a firm that offers energy savings as a service is the most effective course of action. If sustainability is a driving concern, there are multiple companies offering solar photovoltaic power on-site through service or leasing agreements.

Given the challenging financial situation of the Ossining Community Microgrid Project, the village government will need to make a decision about whether or not to proceed with Stage 2 of the NY Prize program. If the community does decide to proceed, an ownership approach and project team will need to be identified to prepare for the NY Prize Stage 2 proposal process. This Stage 2 and 3 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. Stage 2 of the NY Prize program will require additional cost share, and a determination will need to be made about which parties will take this on.

[End of Report]

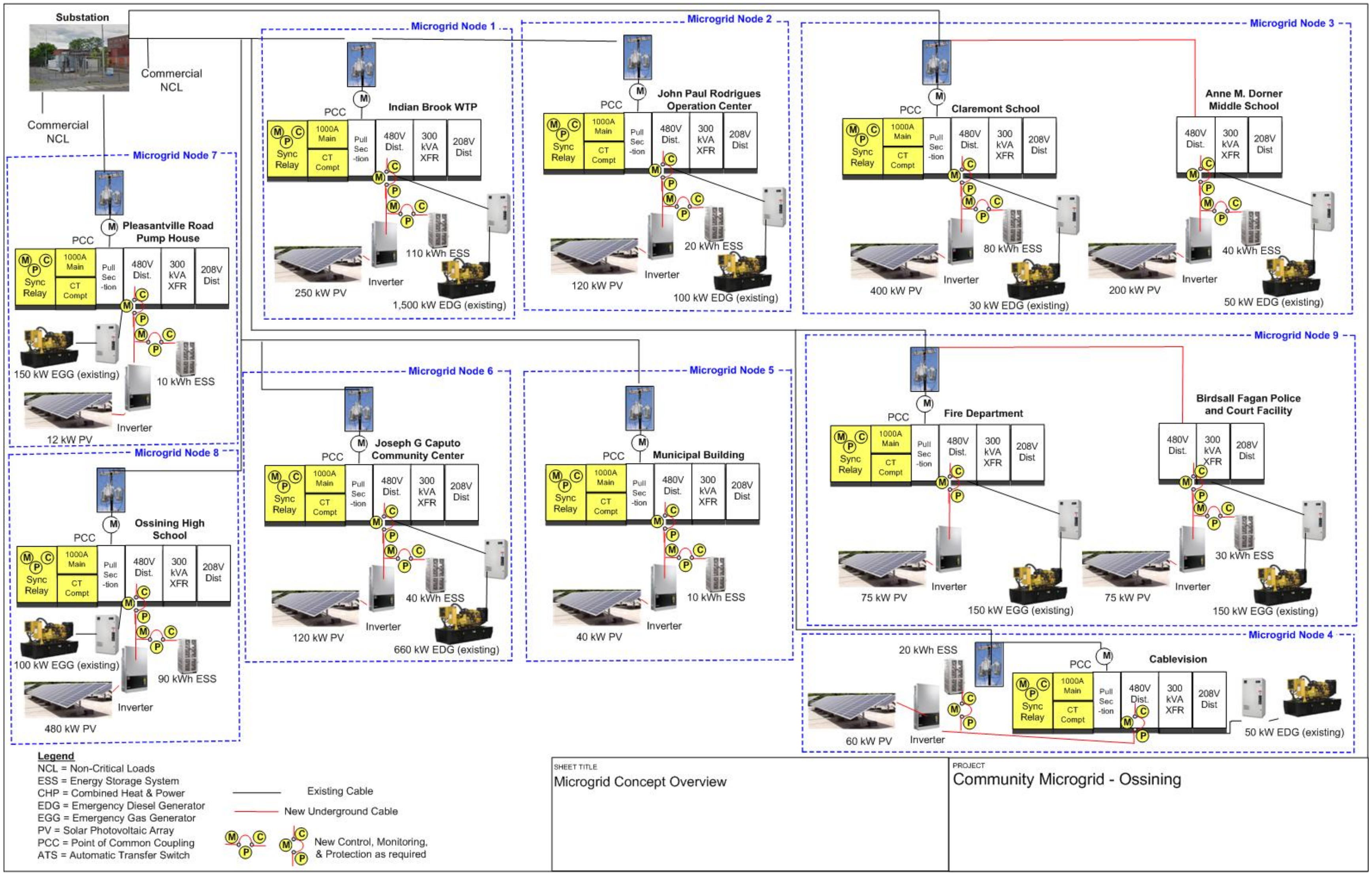
APPENDIX A: OSSINING MICROGRID LAYOUT DIAGRAM



SHEET TITLE
Microgrid Geospatial Diagram

PROJECT
Community Microgrid – Ossining

APPENDIX B: OSSINING MICROGRID ONE-LINE DIAGRAM



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

SHEET TITLE
Microgrid Concept Overview

PROJECT
Community Microgrid - Ossining

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 Ossining 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. If Con Edison ownership of various DER assets within the microgrid is proposed, it will be necessary to address how generation assets will be treated, considering ongoing discussions in REV proceedings and potential demonstration project status.

The Public Service Commission (Commission) has considered utility ownership of distributed energy resources (DERs), which would include *inter alia* microgrid generation and storage assets. The Commission's stated policy from its February 26th "Order Adopting Regulatory Policy Framework and Implementation Plan" can be summarized as follows:

> "A basic tenet underlying REV is to use competitive markets and risk based capital as opposed to ratepayer funding as the source of asset development. On an ex ante basis, utility ownership of DER conflicts with this objective and for that reason alone is problematic….As a general rule, utility ownership of DER will not be allowed unless markets have had an opportunity to provide a service and have failed to do so in a cost-effective manner…. [U]tility ownership of DER will only be allowed under the following circumstances: 1) procurement of DER has been solicited to meet a system need, and a utility has demonstrated that competitive alternatives proposed by nonutility parties are clearly inadequate or more costly than a traditional utility infrastructure alternative; 2) a project consists of energy storage integrated into distribution system architecture; 3) a project will enable low or moderate income residential customers to benefit from DER where markets are not likely to satisfy the need; or 4) a project is being sponsored for demonstration purposes."[4]

Of these four qualifying scenarios, most likely only the fourth would apply here.

Speaking to the first scenario, the utility may always appeal to the Commission to own DERs if it first conducts an open solicitation process for private owners. In the context of this feasibility study, such a solicitation process will not be undertaken, so for now we ignore this condition. If other

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[4] Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan, Feb. 26, 2015, at 67-70.

ownership models proposed by this study prove untenable following the appropriate solicitations, this condition may become relevant.

Speaking to the second scenario, while a microgrid may incidentally incorporate storage devices into utility infrastructure, it is clear from the context surrounding these comments that the Commission intends for projects qualifying under this condition to be primarily geared towards expanding the utility's understanding of how storage assets can provide benefit to the distribution grid, and specifically noted that "[w]ith respect to resources at the customer location, utility ownership should not be necessary."[5] Storage integrated into a microgrid would not seem to qualify under this condition.

Speaking to the third scenario, the proposed project does not target low/moderate income customers who may not otherwise be likely to receive microgrid service from the market. It may not gain approval for utility ownership under this provision.

Speaking to the fourth scenario, there remains substantial uncertainty regarding what will be determined a satisfactory "demonstration project" by the Commission. The only criteria for demonstration projects promulgated by the Commission to date is its December 12, 2014 "Memorandum and Resolution on Demonstration Projects," which states that:

> 1. REV demonstrations should include partnership between utility and third party service providers.
>
> 2. The utility should identify questions it hopes to answer or problems or situations on the grid and the market should respond with solutions. Hence, third party participation through a traditional RFP/RFI method where the utility has pre-diagnosed the solution(s) does not meet this requirement.
>
> …
>
> 4. The market for grid services should be competitive. *The regulated utility should only own distributed energy resources if market participants are unwilling to address the need and the utility is acting as the service provider of last resort (in this instance, "provider of last resort" and "needed" means that no one in the market is providing the solution and the distributed solution is less costly than alternatives for the problem)* (emphasis added).[6]

The fourth principle for demonstration projects articulated by the Commission leaves some uncertainty regarding what conditions utility ownership will be permitted under in the context of a demonstration project. The Commission elsewhere notes that "proponents of demonstration projects should strive for third party ownership of DER, keeping in mind that any regime of third party ownership must be done in a manner that ensures safety, reliability and consumer protection."[7]

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[5] Id. at 69.

[6] Case 14-M-0101, "Memorandum and Resolution on Demonstration Projects," Dec. 12, 2014, at Appendix A.

[7] Id. at 9.

In practice, the Commission has approved demonstration projects that involve utility ownership of DERs. Consolidated Edison's Virtual Power Plant demonstration project, for example, allows Consolidated Edison to own storage assets that are marketed as a package with PV provided by a third party to customers as, when taken together, a resilient power system.[8]

The Commission has noted that "[d]emonstration projects will be a continuing effort as the implementation of REV develops….The need for demonstrations will continue, and we will examine methods for utilities to develop a common platform for sharing of information regarding needs and potential offerings by third parties."[9] The Commission has not yet issued a formal deadline for the proposal of new demonstration projects at this time.

In the Ossining microgrid, it is plausible that Con Edison would be allowed to act as the owner/operator of a substantial set of DERs if such an arrangement were pursued: (a) as a demonstration project; (b) for the purpose of testing a hypothesis of how to provide REV-related benefits to customers, perhaps through a novel tariff or third party partnership; and (c) where there is not a ready market provider for the same service. This model may be pursued further through a demonstration project filing if there is an appetite among project stakeholders for utility ownership of microgrid assets.

2. <u>Utility Ownership of Non-Generation Microgrid Assets Only</u>

Even if Con Edison does not own any of the DER assets within the Ossining 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 Con Edison 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 rules 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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[8] See Case 14-M-0101, "REV Demonstration Project Outline: Clean Virtual Power Plant," Consolidated Edison, July 1, 2015, and Case 14-M-0101, Letter from Scott Weiner, Deputy for Markets and Innovation, NYS Public Service Commission, to Consolidated Edison, August 3, 2015.

[9] Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan, Feb. 26, 2015, at 117.

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.[10]

New York's net metering policies may be revisited through the REV proceeding, and the Microgrid Working Group has particularly flagged for resolution the issue of how eligible and non-eligible net metering resources at a given site will be accounted for.

In the Ossining microgrid project, proposed PV generation assets may be eligible to receive net metering credit. Con Edison's net metering tariff may be found at Rider R: Tariff for Net-Metered Customers.[11]

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. Con Edison's buyback tariff can be found at Service Classification SC-11.[12]

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 Ossining 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.

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[10] NY PSL § 66-j.

[11] Available at http://www.coned.com/documents/elecPSC10/GR24.pdf#nameddest=riderr.

[12] Available at http://www.coned.com/documents/elecPSC10/SCs.pdf#nameddest=sc11.

Burrstone's algorithm makes hourly operational decisions that are automatically implemented by the Energy Management System.

C) Application of the Offset Tariff

Con Edison''s offset tariff can supplant the traditional standby tariff to allow customers connecting an efficient CHP system[13] between 2 and 20 MW on the high tension (utility) side of the meter to distribute power between a campus of proximate buildings all registered to a single customer account.[14] This tariff might currently apply to serving a series of buildings within the same microgrid that are all registered to the same customer account, such as the Ossining Police and Fire Departments, or the Sing Sing Compound.

Con Edison has agreed recently to convene a collaborative discussing removal of the single-customer limitation from the offset tariff. If this collaborative leads to an expansion of the offset tariff to multiple customer accounts, a wider group of customers within the Ossining project may benefit from the offset tariff.

D) Creation of New Tariff for Microgrid Service

Specially designed tariffs or service agreements may be adopted to support microgrids that rely on the utility distribution system to wheel power between microgrid users. Such a "wheeling charge," specialized tariff or other form of service agreement may be agreed to by the parties, and may potentially be approved by the Commission as a REV demonstration project. As articulated by the Commission:

> "Demonstrations should inform pricing and rate design modifications….Demonstrations should include opportunities for third parties to demonstrate how various rate designs, information sharing, adjusted standby tariffs, and other technologies can be used to benefit consumers, encourage customer participation, and achieve REV's efficiency and bill management objectives."[15]

This criteria may open the door for Con Edison to propose novel methods of billing microgrid customers for their use of the distribution system. In other settings, utilities have already considered or proposed REV-related projects that include reaching unique service agreements with microgrid customers.[16]

3. **Privately-Owned Microgrid Distribution**

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[13] As designated pursuant to the order of the Public Service Commission, dated January 23, 2004, in Case 02-E-0781.

[14] General Rule 20.2.1(B)(7), Leaf 157 (covering single-account offset arrangements), and General Rule 20.2.1(B)(8), Leaves 157.1-157.5

[15] Case 14-M-0101, "Memorandum and Resolution on Demonstration Projects," Dec. 12, 2014, at Appendix A.

[16] See, e.g., Case 14-E-0318, "Testimony of the Reforming the Energy Vision Panel," July 15, 2014, at 14.

Ossining 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 Ossining 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[17] (investigating the manufacture, distribution, and transmission of electricity; ordering improvements; and performing audits), rates,[18] safe and adequate service,[19] all aspects of the billing process, financial, record-keeping, and accounting requirements,[20] corporate finance and structure,[21] and more. This expansive purview of regulation may prove too administratively onerous for a small project like the Ossining 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

Ossining'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

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[17] PSL § 66.

[18] PSL § 65.

[19] PSL § 66.

[20] PSL § 66, 68(a).

[21] PSL § 69.

will be deemed a qualifying facility if it utilizes qualifying forms of generation,[22] is under 80 MW,[23] 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 Ossining 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 Ossining 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.[24] 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."[25] 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 Ossining 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.

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

[23] Id.

[24] 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).

[25] Id.

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.[26] 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 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.[27]

In the Ossining microgrid, the geographic footprint of private distribution facilities may or may not satisfy the "at or near" test developed by the Commission. The maximum distance between properties proposed to be incorporated in the microgrid appears to be approximately 4 miles, with the potential to extend beyond 5 depending on the route of private wire and whether it would incorporate further customers. Private distribution facilities would have to cross property lines, and several rights of way. Favorable declaratory rulings addressing facilities in comparable environments have not exceeded this distance, including *Burrstone* (approximately half a mile),[28] *Nissoquogue Cogen Partners* (1.5 miles),[29] and *Nassau District Energy Corporation* (1.7 miles).[30] Of these, the closest precedent factually 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 private distribution across the entire microgrid were proposed, it would not mirror the length for which the Commission has provided positive precedent. If, however, private distribution infrastructure were proposed for smaller segments of the microgrid, it may more closely adhere to the Commission's precedent.

In light of the above factors, the Ossining microgrid project may or may not 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 Ossining 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

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

[27] Id.

[28] 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).

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

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

the public interest.[31] 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.[32] The precedent of microgrids receiving lightened regulatory burden under this standard is very thin, however, and it is difficult to prognosticate how this standard would be applied to the Ossining project.

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

In its February 26th "Order Adopting Regulatory Framework and Implementation Plan,"[33] 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 Ossining 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.

Ossinging'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

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

[32] 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).

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

American Electric Power,[34] and the Borrego Springs microgrid owned by San Diego Gas & Electric.[35] These projects, which take place in jurisdictions where rules regarding utility ownership of generation are more permissive, face lower regulatory burdens than utility-owned microgrids in New York may face. However, at least one New York project has proceeded under a utility-owned model, and others have been proposed in rate case settings.

In the Town of Denning, NY, Central Hudson Gas & Electric (Central Hudson) developed a microgrid system to serve an electric load center located more than 14 miles from the distribution substation after an evaluation of the electric service reliability of the area found service to be unacceptable. The microgrid's internal DER consists of a 1,000-kVA diesel engine—owned and operated by Central Hudson—which is capable of serving the total peak load of the feeder. After the utility evaluated electric service reliability in the area of concern and determined it was below acceptable standards, Central Hudson developed a comprehensive corrective action plan to improve reliability that evaluated four different options with their respective costs. One option evaluated was the microgrid proposal and the other three options involved more traditional measures that included rebuilding miles of electric distribution lines. Due to its rugged and remote terrain, additional transmission and distribution investments were not comparably cost effective, as well as being an environmentally inferior option.[36]

In other settings, utilities have proposed microgrid ownership as part of pilot projects. Consolidated Edison, for example, agreed as part of its 2013 rate case to convene a collaborative geared towards developing a microgrid pilot. Central Hudson, in its 2014 rate filing, proposed a utility-owned microgrid pilot that has not moved forward yet.

Given the general prohibition on utility-owned generation, Con Edison would have to show that a microgrid is the cheapest alternative to distribution upgrades required to maintain adequate service, as in Denning, or propose a utility-owned microgrid as a demonstration or pilot, possibly in the REV proceeding. In the present case, Ossining does not appear to suffer service adequacy issues that would invoke the need to build a utility-owned microgrid purely for reliability purposes. It is likely that, if this project were to proceed as a utility-owned microgrid, it would need to seek a PSC approval as a demonstration project or pilot.

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 proposed developing "a service agreement for a specified term under which the cost for [microgrid] facilities would be recovered,"[37] but left open for collaborative discussions how this agreement

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

[35] 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.

[36] Central Hudson Gas & Electric EPTD 1208 Program Proposal. See also NYSERDA, Microgrids for Critical Infrastructure Resiliency in New York (2015) at 122.

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

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.[38]

In the Ossining project, existing utility distribution infrastructure may be employed, where the project exports power under a community net metering tariff, a combination of standard net metering and buyback tariffs, or any novel microgrid tariff proposed and approved for REV demonstration purposes. In this case, key considerations would include:

- Applicable tariff under which different levels of power export will occur
    - Any novel "microgrid wheeling charge" framework that compensates the utility for delivering power from one microgrid customer to the next and islanding the project during an outage.

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[38] 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.[39] 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 Ossining project.

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[39] 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. Town Law § 64, every town is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city.[40] "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.[41]

In the Ossining, the processes for granting a franchise for electric distribution wires is not specified. In other jurisdictions, municipal decision-makers will turn to comparable sections of code governing franchises for other services for guidance on the process and standards by which electric franchises will be awarded. In both the town and village of Ossining, regulations for cable communications may prove influential.[42] These provisions are substantively identical between the town and the village, and include:

- All franchises are nonexclusive.[43]
- Franchise fees shall be at least 5% of gross annual revenues, in addition to any other taxes owed the town.[44] The village will retain the right to audit the franchisee to ensure this fee is appropriately accounted for.[45]
- Franchises may be revoked or not renewed for cause, in which case ownership of certain fixed assets may vest in the grantor (town or village), which must pay fair market value.[46]
- Standards for rejecting franchises are not provided, though the Town and Village Boards both enjoy wide latitude to do so following public hearing.[47]

These and other cable provisions may be persuasive in the electrical franchising process, but it is difficult to predict what portions of these codes may be held to apply in the electrical context. Both the Town and Village Boards will have substantial latitude in reviewing the franchise application, conferred by both NY Town and Village Law, and may adhere to similar provisions in cable codes or set new precedents.

IV. Application of Other Local Codes

1. Zoning

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[40] N.Y. Town Law §64.

[41] 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)

[42] Village of Ossining Code §103.

[43] Village of Ossining Code §103-18.

[44] Village of Ossining Code §103-21.

[45] Id.

[46] Town of Ossining Code §70-23.

[47] Town of Ossining Code §70-49.

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

- Birdsall Fagan Police and Court Facility, 88 Spring St, Ossining, NY 10562: Village VC Village Center District
- Ossining Fire Department, 21 State St, Ossining, NY 10562: Village VC Village Center District
- Ossining High School, 29 S Highland Ave, Ossining, NY 10562: Village S75 One-Family Residence
- Sing Sing Prison, 354 Hunter St, Ossining, NY 10562: Village IR Institutional Redevelopment District
- Joseph G. Caputo Community Center, 95 Broadway, Ossining, NY 10562: Village VC Village Center District
- Torbank/Shaft 4 Water Tower, near Sunset Dr. and Ryder Rd., Ossining, NY 10562: Village S125 One Family Residence District
- John Paul Rodrigues Operations Center, 101 Route 9A # 2, Ossining, NY 10562: Village S125 One Family Residence District
- Anne M. Dorner Middle School, 100 Van Cortlandt Ave, Ossining, NY 10562: Town R15 One Family Residence District
- Indian Brook Water Filtration and Treatment Plant, Indian Brook Service Rd, Ossining, NY 10562: Town R30 One-Family Residence District
- Claremont School: Claremont Rd. and Van Cortlandt Ave, Ossining, NY 10562: Village S75 One Family Residence District

Generation as Permitted Use

Potential microgrid customers straddle between various zones in the Town and Village of Ossining, which are separate municipal bodies with distinct zoning codes. In each municipality, it will be essential to determine where and under what conditions electric generation will be permissible to site. In general, permitted use regulations in zoning codes are exclusionary by default: if a specific use is not allowed as either an expressly permitted use, accessory use, specially permitted use, or through a variance, it is prohibited by the code. In both the town and village of Ossining, various pathways may exist through which electric generation may be sited. The application of town and village code will be dealt with separately below.

In the Village of Ossining

In the Village of Ossining, “infrastructure and utilities uses” are alternately considered an expressly permitted or a specially permitted use, depending on the district in which they are sited, as well as on the intensity of the use. The Village Code defines “infrastructure and utilities uses” as:

> Public or private buildings, structures and lands used to provide infrastructure and utility services. Uses are divided into two subgroups based on potential impacts to surrounding areas, including the number of employees and/or visitors on site and the potential for noise and odor-related impacts.
>
> [1] General. Infrastructure services that need to be located in or near the neighborhood or use where the service is provided. Examples of general utilities include water and sewage pump stations, stormwater retention and

> detention facilities, telephone exchanges and surface transportation stops such as bus stops and park-and-ride facilities.
> [2] Intensive. Infrastructure services providing regional or community-wide service that normally entail the construction of new buildings or structures such as water towers, waste treatment plants, potable water treatment plants, solid waste facilities and electrical substations.

In the Village of Ossining, "general utility uses" are expressly permitted in the Village Center district, and specially permitted in Institutional Redevelopment and S125 One Family Residence districts.[48] "Intensive utility uses" are specially permitted in the Village Center District, Institutional Redevelopment, and S125 One Family Residence districts.

Different microgrid generation assets may qualify under either the general or intensive carve-outs of this section. The Village Code provides no further guidance on the distinction between "general" and "intensive" utility uses. However, since "intensive" utility uses will require the application of a special permit processes, it would presumptively be in the discretion of the Planning and Village Boards to determine what level of intensity is presented by various uses, as these Boards each exercise authority over the special permit process.[49] The special permit process is described in more detail in §270-54 of the Village Code.

The Village Code also refrains from further defining "utility uses," particularly to the question of whether a private SPE may provide utility services, or whether this provision is meant to apply only to the publicly regulated utility, Con Edison. The Planning and Village Boards presumptively retain authority to determine this question as well.

If microgrid assets are owned or operated by the Village of Ossining itself, they may also be expressly permitted in every relevant zone under the Use Tables' allowance for "municipal uses." Municipal uses are defined as:

> "Facilities owned or operated by the Village and not subject to the standards of this chapter, including **but not limited to** reservoirs; water supply reservations; parks and open space; playgrounds; recreational facilities; community centers; libraries; firehouses; police stations; government offices; government garages; and public parking areas."[50] (emphasis added)

While this definition does not explicitly incorporate electric generation assets, its broad sweep of application suggests that microgrid assets may be interpreted as a valid municipal use as well.

If a generation asset is not expressly or specially permitted, it may qualify as an accessory use, defined as a "use customarily incidental and subordinate to the main use on a lot, whether such accessory use is conducted in a principal or accessory building. An accessory use may not be accessory to another accessory use."[51] 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

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[48] See Village of Ossining Code §270 Attachment 1 and Attachment 3, Use Tables.

[49] Village of Ossining Code §270-54.

[50] Village of Ossining Code §270-4.

[51] Id.

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.

If generation assets are determined not to be expressly permitted, specially permitted, or a valid accessory use, they may only seek permission through the variance process, which is unlikely to succeed. The Zoning Board of Appeals in the Village of Ossining will only approve variances where:

(a) The applicant cannot realize a reasonable return, provided that lack of return is substantial as demonstrated by competent financial evidence;
(b) The alleged hardship relating to the property in question is unique and does not apply to a substantial portion of the district or neighborhood;
(c) The requested use variance, if granted, will not alter the essential character of the neighborhood; and
(d) The alleged hardship has not been self-created.[52]

These provisions are consistent with New York State precedent,[53] 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 the Town of Ossining

Prospective microgird customers in the Town of Ossining are limited to R15 and R30 One Family Residence districts. In these districts, certain public utility uses may be allowed by special permit. The code provides for special permitting for:

> "Public utility rights-of-way, as well as structures and other installations necessary to serve areas within the town, subject to such conditions as the Planning Board may impose in order to protect and promote the health, safety, appearance and general welfare of the community and the character of the neighborhood in which the proposed structure is to be constructed."[54]

Similar to provisions in the Village of Ossining's code, "public utility" is not defined in the code.[55] Whether the definition will be interpreted as inclusive of an SPE's electrical resources may be determined by the Planning board and Zoning Board of Appeals.

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[52] Village of Ossining Code §270-48.

[53] *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.

[54] Town of Ossining Code §200-7.

[55] Town of Ossining Code §200-53.

Also analogous to the Village of Ossining, all “buildings, structures and uses owned or operated by the Town of Ossining” will be expressly permitted in every relevant zone.[56]

Unlike in the Village of Ossining, valid accessory uses are expressly limited to those enumerated in the Code.[57] No specifically enumerated accessory use in R15 and R30 districts would apply to distributed generation assets.

If generation assets are determined not to be expressly permitted, specially permitted, or a valid accessory use, they may only seek permission through the variance process, which is unlikely to succeed. The Zoning Board of Appeals in the Town of Ossining will only approve variances where:

(a) The applicant cannot realize a reasonable return, provided that lack of return is substantial as demonstrated by competent financial evidence;
(b) The alleged hardship relating to the property in question is unique and does not apply to a substantial portion of the district or neighborhood;
(c) The requested use variance, if granted, will not alter the essential character of the neighborhood; and
(d) The alleged hardship has not been self-created.[58]

These provisions are consistent with New York State precedent,[59] 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.

2. Fire Code

The Village of Ossining incorporates by reference the New York State Uniform Fire Prevention and Building Code as well as all “other applicable laws and regulations of the state.”[60] It does not contain any additional substantive provisions relating to electrical generation or transmission.

In the Town of Ossining, by resolution adopted 8-14-1979, the Town accepted the applicability of the State Fire Prevention Code for the Town of Ossining, in accordance with § 392 of the Executive Law. It has rescinded its Fire Prevention Code entirely in the process.[61]

3. Building Code

The Village of Ossining incorporates by reference the New York State Uniform Fire Prevention and Building Code as well as all “other applicable laws and regulations of the state.”[62] It does not contain any additional substantive provisions relating to electrical generation or transmission.

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[56] Town of Ossining Code §270-7.

[57] Id.

[58] Town of Ossining Code §200-45.

[59] *See* fn. 50 above.

[60] Village of Ossining Code §91-1.

[61] Town of Ossining Code §97.

[62] Village of Ossining Code §91-1.

In the Town of Ossining, the applicability of the New York State Building Construction Code was accepted 3-8-1966 by L.L. No. 1-1966.[63] The Town's Building Construction Code makes no additional substantive provisions relating to electrical generation or transmission.

4. Electric Code

The Village of Ossining's Electric Code incorporates by reference the New York State Uniform Fire Prevention and Building Construction Code and the 1971 edition of the National Electrical Code as promulgated by the National Fire Protection Association.[64]

The Town Of Ossining's Electric Code incorporates by reference the National Electric Code,[65] with no substantive additions that would impact distributed generation or distribution.[66]

V. Applicable Tariffs

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

1. Standby Tariff

Customers operating private generating facilities to cover part of their load while receiving backup or supplementary power from the utility will be subject to Con Edison's standby tariff[67] unless they are otherwise exempt.[68] Under current standby rate design, Con Edison 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. In

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[63] Town of Ossining Code §63-1.

[64] Village of Ossining Code §114-4.

[65] See fn. 54, above.

[66] Town of Ossining Code §82-3.

[67] Located at http://www.coned.com/documents/elecPSC10/GR1-23.pdf#nameddest=gr20.

[68] In April 2015, the Commission expanded exemptions to standby rates, notably by permitting exemption for CHP system up to 15 MW. Exemptions also apply to fuel cells, wind, solar thermal, photovoltaic, biomass, tidal, geothermal, and methane waste-powered generation. See Case 14-E-0488, "Order continuing and Expanding the Standby Rate Exemption," (Apr. 20, 215).

2015, Con Edison and Staff came to a rate case settlement that will establishment a performance incentive, lowering the contract demand charge, for customers running generation reliably. Con Edison was authorized to file amendments to its electric tariff schedules designed to implement the Standby Service provisions effective on a temporary basis July 1, 2015.[69]

The actual level at which the contract demand charge is set can be established by the customer or Con Edison. 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 between 12 to 24 times (depending on the level of exceedance) the sum of the monthly demand charges for the demand in excess of the contract demand.

The daily as-used demand charge is designed to recover the costs of distribution infrastructure needed to meet the entire system's demand peaks. Therefore, the charge is assessed based upon the customer's daily maximum metered demand during peak-hour periods on the macrosystem.

Standby rates are under reexamination as part of the REV proceeding. Staff has noted that "the methodology for allocating costs that determine the contract demand and as-used demand components of standby rates should be reviewed in this new [REV] context."[70] The manner in which these rates change cannot be forecast at this time.

2. Community Net Metering

In July 2015, the Public Service Commission established a community net metering regime[71] that is currently pending implementation through tariff revisions in Con Edison's territory. Qualifying generation assets include those that would be eligible under net metering (See Section I(2)(A) above). Under community net metering, a project sponsor could size eligible generators far beyond the demand of a host utility account and distribute retail-value net metering credit to a set of "subscribing" customers in the same utility service territory. This may be a substantial value-added to the rate paid on qualifying generation assets for power exported to the utility.

Note that the Commission's Order required at least 10 subscribing customers in a qualifying community net metering project, which threshold is currently met by the project's proposed microgrid customers.

3. Residential/Non-Residential DG Gas Rate

A distributed generation rate is established in Con Edison's territory, applying where "separately metered gas service is used solely for the purpose of the operation of a Distributed Generation

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[69] Case 15-E-0050, "Order Adopting Terms of Joint Proposal to Extend Electric Rate Plan," (June 19, 2015).

[70] Case 14-M-0101, "Staff Whitepaper on Ratemaking and Utility Business Models," (July 28, 2015).

[71] Case 15-E-0082, "Order Establishing a Community Distributed Generation Program and Making Other Findings," (July 17, 2015).

Facility with a name plate rating less than 50 MegaWatts and having an Annual Load Factor equal to or greater than 50 percent."[72] 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.

3.1 Cost of Gas Service Upgrades

Microgrids that incorporate new natural gas-fired generators or CHP systems may require the delivery of substantially more natural gas to the site than was previously provided by the utility. If 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 Con Edison 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.[73] Section §230.2 outlines the "100 foot rule," which requires gas utilities to install up to 100 feet of main and service line extensions and related facilities at no cost to the applicants.[74] Utilities can bear the cost of extensions and additional facilities beyond 100 feet if the utility deems the expansion to be cost justified.[75] 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.[76] 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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[72] *See* Consolidated Edison's Rider H tariff, available at http://www.coned.com/documents/gas_tariff/pdf/0003(06)-General_Information.pdf#page=37.

[73] 16 NYCRR § 230.2(b).

[74] 16 NYCRR § 230.2 (c), (d), and (e).

[75] 16 NYCRR § 230.2 (f). Methods for determining cost-justified upgrades are set forth in each utility's tariff. For example, Con Edison analyzes whether the projected net revenue derived from the potential customer will cover the cost to install the service line beyond the 100 ft. maximum. If so, Con Edison will provide line upgrades beyond 100 feet at no cost to the customer.

[76] 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 REPORT

Site 32 – Village of Ossining

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Village of Ossining has proposed development of a microgrid that would enhance the resiliency of electric service for the following facilities in this Westchester County community:

- Indian Brook Water Treatment Plant;
- Pleasantville Road Pump House;
- Fire Department;
- Birdsall Fagan Police and Court Facility;
- John Paul Rodrigues Operation Center;
- Claremont Elementary School, Anne M. Dorner Middle School, Ossining High School, and the Joseph G. Caputo Community Center, all of which are designated as community shelters in the event of an emergency;
- Cablevision Hub & Dispatch Center (a commercial media dispatch center); and
- The Municipal Building, housing the Village's municipal offices.

The microgrid would incorporate ten PV solar arrays distributed among the participating facilities, ranging in capacity from 0.012 MW to 0.6 MW; total PV solar nameplate capacity would be 1.832 MW. In addition, a battery storage system and energy efficiency measures would be incorporated in each node of the microgrid; the total battery capacity included in the microgrid is 450 kWh.[77] The operating scenario submitted by the project's consultants indicates that these new resources together would produce approximately 2,460 MWh of electricity per year, roughly 40 percent of the amount required to meet the average annual demand of the facilities listed above. During a major outage, the project's consultants indicate that the microgrid system would supply 100 percent of average electricity use at the facilities served by the microgrid.[78] 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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[77] In addition to these resources, the microgrid will incorporate the emergency generators that currently serve the facilities listed above. These units, however, would only be relied upon in extreme circumstances and would not operate on a regular basis.

[78] As noted previously, the capacity of the new resources appears sufficient to supply 40 percent of average daily electricity use at facilities within the microgrid's island; the remainder would presumably come from the existing emergency generators incorporated in the microgrid.

METHODOLOGY AND ASSUMPTIONS

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

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

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.[79] 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).

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[79] 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.]

When facing a choice among investments in multiple projects, the "societal cost test" guides the decision toward the investment that produces the greatest net benefit.

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[80]

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.5 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.5 DAYS/YEAR
Net Benefits - Present Value	-$3,880,000	$124,000
Benefit-Cost Ratio	0.5	1.0
Internal Rate of Return	-4.7%	6.4%

Scenario 1

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

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[80] 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.

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

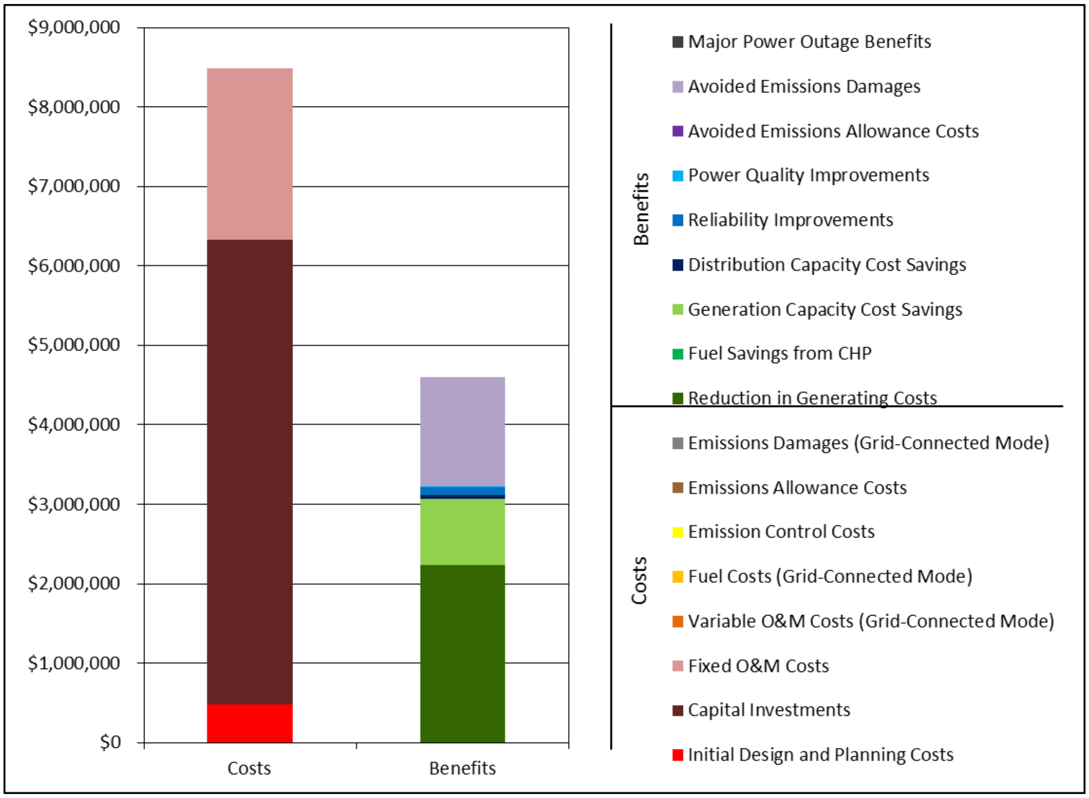

Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$5,860,000	$472,000
Fixed O&M	$2,160,000	$190,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$0	$0
Total Costs	**$8,490,000**	
Benefits		
Reduction in Generating Costs	$2,230,000	$197,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$834,000	$73,600
Distribution Capacity Cost Savings	$47,600	$4,200
Reliability Improvements	$99,100	$8,740
Power Quality Improvements	$21,000	$1,850
Avoided Emissions Allowance Costs	$924	$82
Avoided Emissions Damages	$1,370,000	$89,600
Major Power Outage Benefits	$0	$0
Total Benefits	**$4,600,000**	
Net Benefits	**-$3,880,000**	
Benefit/Cost Ratio	**0.5**	
Internal Rate of Return	**-4.7%**	

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.[81] The present value of the project's capital costs is estimated at approximately $5.86 million, including costs associated with installing the new PV arrays, battery storage, and associated microgrid infrastructure (controls, communication systems, information technology, etc.). The present value of the

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[81] The project's 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.

microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at $2.16 million, based on an annual cost of $190,000.

Variable Costs

The project team indicates that there are no variable O&M costs associated with the microgrid. In addition, because solar resources are its sole source of power, the system as designed would consume no fuel, emit no pollutants, and incur no costs related to these aspects of power production.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $2.23 million; this estimate takes into account both the electricity that the microgrid's PV arrays would produce and an anticipated reduction in annual electricity use at the facilities the microgrid would serve.[82] The reduction in demand for electricity from bulk energy suppliers would also reduce the emissions of air pollutants from these facilities, yielding emissions allowance cost savings with a present value of approximately $924 and avoided emissions damages with a present value of approximately $1.37 million.[83]

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.[84] Based on application of standard capacity factors for the PV arrays, 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 $834,000 over a 20-year operating period. Similarly, the project team estimates that the microgrid project would reduce the need for local distribution capacity by approximately 0.115 MW/year, yielding annual benefits of approximately $4,200. Over a 20-year period, the present value of these benefits is approximately $47,600.

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.

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

[83] 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.

[84] 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.

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 $8,740 per year, with a present value of $99,100 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:[85]

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.[86]

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

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

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. The Ossining team estimates that the facilities served by the microgrid would avoid an average of 0.156 such events annually. The model estimates the present value of this benefit to be approximately $21,000 over a 20-year operating period.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.5; i.e., the estimate of project benefits is approximately 50 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally

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[85] www.icecalculator.com.

[86] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Consolidated Edison.

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

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.[88,89]

The proposed microgrid project would serve a number of critical facilities during an extended outage. The project's consultants indicate that at present, all of these facilities except the Municipal Building are equipped with backup generators. If an extended outage occurred, the Municipal Building would rent a backup diesel generator (assuming rental units were available). Table 3 summarizes the estimated cost of operating these generators, assuming 24-hour operation; the estimate of daily operating costs includes the cost of fuel as well as other daily costs of operation. Table 3 also indicates the loss in service capabilities that is likely to occur while relying on these units, and the loss in service capabilities that would occur should these units fail. For purposes of evaluating the costs of a major power outage, the analysis assumes that there is a 15 percent chance that the backup generator at a given facility would fail. It also assumes that the supply of fuel necessary to operate backup generators would be maintained indefinitely.

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

FACILITY	ONGOING OPERATING COSTS ($/DAY)	PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE	
		WITH BACKUP POWER	WITHOUT BACKUP POWER
Joseph G. Caputo Community Center[1]	$277	0%	100%
John Paul Rodrigues Operation Center[1]	$111	0%	90%
Pleasantville Road Pump House[1]	$76	0%	100%
Indian Brook Water Treatment Plant[1]	$976	0%	100%
Fire Department[1]	$38[2]	0%	50%
Birdsall Fagan Police and Court Facility[1]	$60	0%	40%
Claremont Elementary School[1]	$114	0%	100%
Anne M. Dorner Middle School[1]	$129	0%	100%
Ossining High School[1]	$192	0%	100%
Municipal Building	$143[3]	0%	100%

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[88] 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.

[89] 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.

FACILITY	ONGOING OPERATING COSTS ($/DAY)	PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE	
		WITH BACKUP POWER	WITHOUT BACKUP POWER
Cablevision Hub & Dispatch Center[1]	$45	0%	100%

Notes:

[1] Existing backup generator.

[2] Running the trucks to keep their radios and other electrical equipment powered would entail additional costs of $1,500 per week.

[3] This facility would also incur a one-time cost of $500 to rent a portable generator.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities of interest. The analysis calculates the impact of a loss in the village's fire, police, water supply, and wastewater treatment services using standard FEMA methodologies. The impact of a loss in service at the remaining facilities is based on the following value of service estimates:

- For the Municipal Building, John Paul Rodrigues Operation Center, and the Cablevision Hub & Dispatch Center, a total value of approximately $141,000 per day. This figure was estimated using the ICE Calculator, assuming 24 hours of microgrid demand per day during an outage.[90]
- For the three public schools and the community center, which will act as emergency shelters during an extended outage, a total value of approximately $175,000 per day. This figure is based on an estimate of the facilities' shelter capacity (approximately 3,500 people across all four facilities) and a standard value from the Red Cross of $50 per person per day for food and shelter.[91,92]

Summary

Figure 2 and Table 3 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.5 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. It is worth

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[90] http://icecalculator.com/.

[91] We estimate the shelter's capacity based on the project team's estimate of square footage available and a standard value of 40 square feet per person for shelter (for more than 72 hours). The 40 square feet per person assumption is from: FEMA. 2010. Guidance on Planning for Integration of Functional Needs Support Services in General Population Shelters. Accessed March 17, 2016 at https://www.fema.gov/pdf/about/odic/fnss_guidance.pdf.

[92] The standard value from the Red Cross of $50 per person per day for food and shelter is from: American Red Cross. 2014. Fundraising Dollar Handles for Disaster Relief Operations. Revised March 2014 based on FY14 figures. Accessed March 17, 2016 at http://www.redcross.org/images/MEDIA_CustomProductCatalog/m30240126_FY14FundraisingDollarHandles.pdf
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noting that the bulk of the benefits of the proposed project are driven by the ability of the microgrid to supply reliable power for the water and wastewater facilities in the event of a major power outage.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 0.5 Days/Year; 7 Percent Discount Rate)

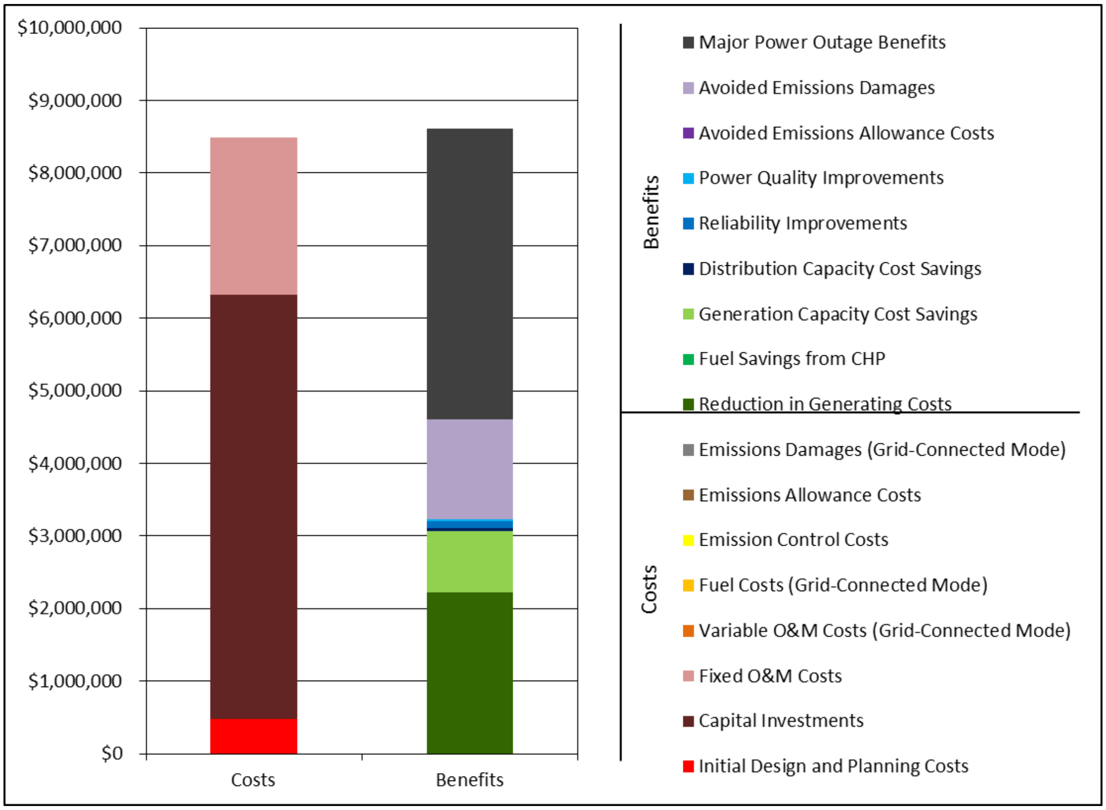

Table 4. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.5 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$5,860,000	$472,000
Fixed O&M	$2,160,000	$190,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$0	$0
Total Costs	**$8,490,000**	
Benefits		
Reduction in Generating Costs	$2,230,000	$197,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$834,000	$73,600
Distribution Capacity Cost Savings	$47,600	$4,200
Reliability Improvements	$99,100	$8,740
Power Quality Improvements	$21,000	$1,850
Avoided Emissions Allowance Costs	$924	$82
Avoided Emissions Damages	$1,370,000	$89,600
Major Power Outage Benefits	$4,010,000	$353,000
Total Benefits	**$8,610,000**	
Net Benefits	**$124,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.4%**	

APPENDIX E: 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
- PV- solar photovoltaics
- REV- Reforming the Energy Vision
- RFI- request for information
- RFP- request for proposals
- RTO- Regional Transmission Organizations
- SGIP- Smart Grid Interoperability Panel
- SOC- state of charge
- SPE- special purpose entity