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Notice

White Plains Community Microgrid

Final Report – NY Prize Stage 1: Feasibility Assessment

Submitted to:
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April 2016

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PROJECT TEAM

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PROJECT STAKEHOLDERS

- City of White Plains: Various facilities
- Westchester County: County Court
- U.S. Government: District Court
- New York State: Supreme Court Law Library
- White Plains Housing Authority
- Kensington Assisted Living Center
- White Plains Hospital and Dickstein Cancer Treatment Center
- Various small businesses

WHITE PLAINS COMMUNITY MICROGRID - KEY OVERVIEW METRICS

Team

Lead:	Hitachi, Inc.
Community Partner:	City of White Plains
Additional Consultants:	Pace University, GI Energy, Sustainable Westchester, Green Energy Corp

Utilities

Electric:	Con Edison, Inc.
Gas:	Con Edison, Inc.

Microgrid System Design

Size:	5,972 kW
Load Served:	44,124,170 kWh/yr

DER*	Quantity	Capacity
Combined Heat & Power:	6	4,572 kW
Photovoltaic:	9	1,300 kW
Existing Photovoltaic:	1	100 kW
Energy Storage Systems:	10	480 kWh
Existing Emergency Gen:	4	4,130 kW

Microgrid Financials*

Total Installed Cost:	$ 15,932,000
Net Installed Cost:	$ 13,745,000
Resiliency Savings:	$ 59,000/yr
GHG Offset:	$ 325,000/yr
Current Avg Electric Rate:	$ 0.0971/kWh
Potential Savings with Microgrid:	5% - 8%

Supporting Organizations

City of White Plains	White Plains Library
Con Edison	Calvary Baptist Church
Kensington Assisted Living Residence	White Plains Housing Authority
Westhab Shelter for Families	Post Maple 77
NY Power Authority	Lifting Up Westchester Homeless Shelter
White Plains Hospital	

Customer Types

Gov't Administrative:	5
Emergency Services:	1
Health Care:	1
Large Commercial:	3
Small Commercial:	1
Multi-Unit Residential:	2
Total:	**13**

Electric Demand & Consumption with Microgrid

Max kW	Avg kW	kWh / yr
10,362	5,038	44,128,828

Benefit Cost Analysis Outputs

	Scenario 1	Scenario 2
Days of Major Outage	0 days/yr	0.7 days/yr
Total Benefits**	$ 59,900,000	$ 68,600,000
Total Costs**	$ 68,500,000	$ 68,500,000
Net Benefits**	$ -11,500,000	$ 165,000
Benefit-Cost Ratio	0.8	1.0

***Net present values*

**Estimates based on financial modeling*

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 White Plains Community Microgrid. Hitachi Microgrids developed the microgrid design according to NYSERDA's requirements, and the specific needs and priorities of White Plains stakeholders. Hitachi used an iterative process that supports optimization of the design against cost, emissions, and resilience goals. Hitachi Microgrids also led the feasibility assessment in collaboration with the White Plains government. Various community organizations and partners, including the future customers of the White Plains Community Microgrid, lent additional support.

Community Overview

White Plains is the county seat of Westchester County. A city of about 58,000 residents, White Plains is also a commercial center for the county, and its daytime weekday population swells to over 250,000. The city is located 20 miles north of New York City, in the Westchester Opportunity Zone for NY Prize, and in an area in need of congestion reduction, as identified by Con Edison.

The White Plains Community Microgrid is designed to cover a group of very tightly clustered critical facilities in downtown White Plains. Instead of a the distributed, nodal approach that many community microgrids take, the White Plains microgrid will include all facilities in a single node, which will allow facilities to share DER and a single microgrid control system.

Community Requirements and Microgrid Capabilities

The White Plains Community Microgrid is designed to meet specific needs within the community. These include the need to ensure the safety of vulnerable populations, the need to harden infrastructure against storm damage, and the need to ensure continuity of emergency operations and services.

First, the microgrid is designed to protect the safety and welfare of the most vulnerable populations within the city. The location of the microgrid is a HUD Community Development Target Area. At the center of the microgrid design is the Brookfield Commons housing complex, administered by the White Plains Housing Authority. This complex is home to 1,800 low-income residents. These residents have limited ability to travel to alternative accommodations during an emergency. The microgrid will help to ensure a constant supply of heat and electricity to these homes, which will allow residents to shelter in place through more emergencies.

The microgrid is designed to protect residents served by facilities with some existing backup generation. In each of these cases, the facilities reported that backup generation is only sufficient to power a portion of their operation. The Kensington Assisted Living Residence includes 87 apartments and provides health care and other services to its elderly residents. When operating under existing backup power, facility staff report that they lose about 40% of their operational capacity. Likewise, the 292-bed White Plains hospital and the nearby Dickstein Cancer Center must cut back services during a power outage to support only critical operations. The microgrid will allow all of these facilities to remain operational at a very significant level during a power outage and will prevent any curtailing of patient or resident care.

The vulnerability of the populations described above is compounded by the city's location. Like its neighbors in Westchester County, White Plains is vulnerable to both coastal storm activity and hazardous snow and ice conditions. White Plains was hit hard by Hurricane Irene in 2011, Hurricane Sandy in 2012, and several recent severe snow events that left the city or portions of the city without power for days.

In addition to the 58,000 residents of White Plains, the facilities within the planned microgrid serve a large population across the region. Many of these facilities will have an important role to play in emergency situations, including the Police Department and court facility, the Westchester County Court and Federal Office facility, and the White Plains Hospital. Several others could serve as emergency shelters if there should be a need. The microgrid will ensure that when an emergency is associated with a power outage, the facilities involved in emergency response will remain fully powered and operational.

The White Plains 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. The site of the microgrid is within the Westchester Opportunity Zone for NY Prize and in an area in need of congestion reduction, as identified by Con Edison. In addition to bringing new distributed generation onto the grid, the microgrid will facilitate participation in Con Edison's demand response programs, which will help the utility to cost effectively meet peak demands.

Technical Design

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

The design addresses White Plains' critical facilities that are co-located in the community. As such, the microgrid is represented as a large campus.

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

The 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

Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
	Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW
Business as Usual	10,362	1	100	-	-	-	-	8	4,130
Microgrid	3,000	9	1,300	10	240/480	6	4,572	8	4,130

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

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

Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
10,362	5,038	44,128,828	3,677,402	148,268,917	12,355,743	92,865,546	7,738,796

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

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

Financial Feasibility

The project team developed a budget estimate for the White Plains 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 $15,932,000 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 $13,745,000. 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 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 $0.097/kWh. Based on the estimated energy savings, assumed project financing costs, and the 25 year contract term, the study supports a PPA electric rate with an electric cost that represents an average discount of approximately 5-8% for the facilities in this project – even for facilities currently purchasing power from the New York Power Authority.

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 White Plains Community Microgrid, the breakeven outage case is an average of 0.7 days of outage per year. The cost benefit results are presented in Table 3.

Executive Summary Table 3 – Cost Benefit Analysis Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 0.7 DAYS/YEAR
Net Benefits - Present Value	-$11,500,000	$165,000
Total Costs – Present Value	$68,500,000	$68,500,000
Benefit-Cost Ratio	0.8	1.0
Internal Rate of Return	-10.2%	6.1%

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

- Gas rates used in IEc's benefit-cost analysis were based on a state-wide average for commercial end-use customers. The rates used in White Plains financial feasibility analysis are based on Con Edison's distributed generation rate. This resulted in year 1 gas rates of $6.34 and $5.71, for the benefit-cost analysis and the financial feasibility analysis, respectively. If Con Edison's distributed generation rate were applied to the benefit-cost analysis, net benefits would be increased by $1,400,000.
- The financial feasibility assessment incorporates the tax benefits of the Federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit reduces the capital cost of the project by $2,186,000.
- Capital replacement costs used in the BCA were calculated as a full replacement costs, whereas the project team assumed a 'rebuild' cost that is not equal to the full cost of replacement. The rebuild cost for the White Plains Community Microgrid is $4,246,000 less than the full cost of replacement.
- The benefit-cost analysis derives a price for electricity based on average wholesale energy costs, whereas the financial feasibility assessment evaluates the savings to the community based on actual costs paid by community participants.
- The period of analysis in the benefit cost analysis is 20 years and the third party ownership model is based on a period of analysis of 25 years.

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

Conclusions and Next Steps

The NY Prize feasibility assessment indicates that the White Plains Community Microgrid is both technically and economically viable. In addition to protecting the city's ability to respond to emergencies, the microgrid will provide direct benefit to a number of particularly vulnerable populations within White Plains, all while lowering costs and the carbon footprint of microgrid customers. The project team believes that the proposed microgrid design will serve as a leading example for New York and will be beneficial and replicable to hundreds of other communities across the State and beyond.

The next steps that the White Plains Community will need to undertake are to finalize the ownership structure to be proposed, and identify a team of partners to engage in the detailed design phase of the project. Once these decisions are made, the project team will draft a proposal to NYSERDA to compete in Stage 2 of NY Prize. This Stage 2 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. 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.

White Plains 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 governance, medical needs, and elderly populations of White Plains. 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.

All of the critical facilities included in the White Plains Community Microgrid are located in one area, with each adjacent to another. This allows for the design of a single, contiguous microgrid with shared generation assets and a central control system both when the larger grid is operational and when it is down during an emergency.

The proposed microgrid will include government support services, several medical facilities, retail and parking, a library, as well as an elderly care facility and the housing authority.

The White Plains Community Microgrid consists of facilities and functions as presented in Table 1.

Table 1 – Overview of Microgrid Facilities

Facilities	Function
Police & City Court U.S. District Court Westchester County Court and Federal Offices Supreme Court Law Library	Governance
White Plains Housing Authority Kensington Assisted Living Center	Housing
White Plains Hospital Dickstein Cancer Treatment Center	Healthcare
White Plains Library	Public Services
BP Gas Station Eagle Service Station Greenside Market	Gasoline and Food Services
Galleria Parking Structure Hospital Parking Structure Longview Cromwell Parking Structure	Parking

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 the microgrid in key areas where it is cost effective for the overall project. While this greatly improves resiliency within the microgrid, the cost of the underground cabling limits the reach of the microgrid. The same general protection schemes are employed in the microgrid 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 point of common coupling (PCC) as described above.

The design team met with a Con Edison distribution engineering team to review utility infrastructure that impacts the microgrid design. This engagement did not include a specific quantification of the value of this system to Con Edison's local distribution system. The Con Edison engineers have provided some proposed distributed energy resources (DER) integration to the microgrid sites. Several sites have redundant Con Edison service connections to improve delivery of service due to local outages. In general, Con Edison has recommended interconnection of microgrid DER on the secondary side of the 13 kV transformers and guidance on the level of electric export as a percentage of the transformer rating. A sample of Con Edison input is presented in Figure 1.

The existing thermal infrastructure consists of a variety of systems. The sites that represent nearly all of the heat recovery opportunities are the Housing Authority Complex and the Hospital. The CHP connections to the hot water systems for these facilities will be installed in parallel with the existing boiler(s), and feed into the existing supply and return headers.

Table 2 - Microgrid Electrical and Thermal Infrastructure Plan

Infrastructure	Class	Associated Device	Comment / Description
460 volts, 3 phase, Underground Cabling	New	Selected Microgrid DER	Added for Microgrid DER that interconnect to multiple electric accounts
SCADA Switches	New	Points of Common Coupling	Enables sectionalizing of Con Edison circuit to support microgrid operations
13 kV / 460 V Transformers	Updated	Critical Facilities	Conversion from pole-top to pad mount as needed
Synchronizing Switches	New	CHP	Each CHP at a critical facility will require a synchronizing switch with protection to enable remote synchronization with the microgrid bus
M, C, P	New	All resources	Monitoring (sensing), Control, and Protection relays for proper management of resources in all modes
Automatic Transfer Switch	Existing	Emergency Generators	All emergency generation (diesel or gas) have automatic transfer switches installed in critical facilities. This will remain unchanged.
Hot Water Supply Connection	New	CHP & heating	Tie-in from CHP to facility thermal loop for the Housing Authority Complex and the Hospital
Hot Water Return Connection	New	CHP & heating	Tie-in from CHP to facility thermal loop for the Housing Authority Complex and the Hospital

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

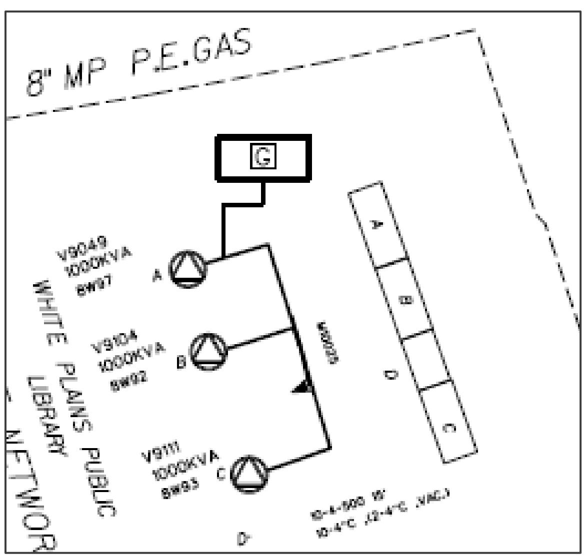


Table 3 – Operation of Critical Facilities During Power Outage

Business	Current Condition in Grid-Loss Scenario	Future Condition with Microgrid in Grid-Loss
BP Gas Station	This gas station does not have an emergency backup generator, and is forced to close when there is a power outage.	The microgrid will allow the gas station to operate during a power outage to support vehicle fueling operations.
Dickstein Cancer Center	The cancer center shares a 3,200 kW emergency diesel generator (EDG) with White Plains Hospital.	The Dickstein Cancer Center is a prestigious cancer treatment facility, and serves patients from all over the region. The microgrid will allow the facility to make use of the full portfolio of microgrid energy resources. This will allow the center to remain operational during a power outage, and will prevent curtailing of patient care. In an extended outage, the center would not be limited by the availability of diesel fuel to remain powered.
Eagle Service Station	This gas station does not have an emergency backup generator, and is forced to close when there is a power outage.	The microgrid will allow the gas station to operate during a power outage to support vehicle fueling operations..
Greenside Market	Greenside Market does not have an emergency backup generator. The lack of backup generation at the store puts all of the frozen and refrigerated food in stock at risk of spoilage, which could represent a significant loss for the store.	The microgrid will allow the grocery store to stay open during a power outage. Uninterrupted refrigeration will allow the store to protect their stock from spoilage. Continued operation at the store will also help assure the food supply for the local community.
The Kensington Assisted Living Residence	The senior center is served by a 180 kW emergency gas generator. When using emergency generation, staff at the center report that they lose 40% of their services.	The Kensington is a residential assisted living facility with 87 apartments. The microgrid will allow the facility to make use of the full portfolio of microgrid energy resources, and not just backup generation. This will allow the center to remain operational during a power outage at a higher capacity than with the current emergency generator only.
Police & Court	The White Plains Police Department and City Court facility is served by a 600 kW EDG. Staff at this facility reported a 50% loss in services when using emergency backup generation during a power outage.	The police department serves all of White Plains' 58,000 residents. The facility may serve as a command center during an emergency. The microgrid will allow the city's law enforcement function to function at a higher capacity than with the emergency generator only.
Supreme Court Law Library	This library does not have an emergency backup generator and is forced to close when there is a power outage.	The microgrid will allow the library to remain operational during a loss of grid power. During extended outages, the

Business	Current Condition in Grid-Loss Scenario	Future Condition with Microgrid in Grid-Loss
		library will function as a communication center to provide WiFi services and charging of batteries in personal communication devices.
US District Court	This federal court facility does not have an emergency backup generator and is forced to close when there is a power outage.	The microgrid will allow the business of this this federal court to continue during a power outage.
Westchester County Court & Federal Offices	This county court and federal office facility does not have an emergency backup generator and is forced to close when there is a power outage.	The microgrid will allow both the county court and federal offices in this facility to remain fully operational in a power outage, ensuring continuity in the governance services they support.
White Plains Hospital	The White Plains hospital is served by a total capacity of 3,200 kW EDG. During a power outage, hospital services must be cut back to support only critical operations.	The microgrid will allow the hospital to provide additional services beyond critical operations during a power outage. Patient care will be able to continue as normal, powered not just by the backup generator, but by the entire portfolio of microgrid energy resources.
White Plains Housing Authority	This housing authority does not have an emergency backup generator and residents are left without power and heat when there is a power outage.	The Brookfield Commons complex is home to 1,800 low-income residents. The microgrid will ensure that these residents have heat and electricity during a power outage. This will allow them to shelter in place during an emergency situation, rather than taking on the potentially difficult task of travelling to alternative accommodations.
White Plains Library	The library is served by a 150 kW emergency natural gas generator (EGG).	The existing EGG system has been incorporated into the microgrid design. The microgrid will allow the library to remain powered and open during a loss of grid power. During extended outages, the library will function as a communication center to provide WiFi services and charging of batteries in personal communication devices.

In addition to the potential facilities identified above, the White Plains 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 4 – Community Stakeholders to Benefit from the Microgrid

Organization	Benefits from White Plains Community Microgrid
Consolidated 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. Consolidated Edison (Con Edison) is implementing other resiliency upgrades to their system, and the microgrid complements these other efforts. This system will also help the utility meet its customer-sited renewable energy target under the New York's Renewable Portfolio Standard.
City of White Plains	As a city of roughly 58,000 people with a weekday daytime population estimated at 250,000, White Plains is a critical urban center for Westchester County. Having a pocket of energy resilience in the city will improve the city's ability to support its entire population.
Lifting Up Westchester	As an organization with a mission to help Westchester's poor and homeless populations, Lifting Up Westchester would be able to leverage facilities within the microgrid to help protect the most vulnerable members of White Plains during an extended power outage event due to a storm.

KEY FEATURES OF THE MICROGRID

Community Microgrid Controller

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

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

The White Plains design follows a campus microgrid approach except that there are multiple customers within the microgrid. Specifically, the solution includes local controllers within the microgrid part as well as a hosted controller in the Microgrid NOC that can monitor and manage the microgrid resources at a higher level.

In the grid-connected mode, the primary operations will focus on maximizing economic benefits and minimizing emissions across 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.

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**: 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 will be responsible for setting the voltage source and load following resource.
4. **Unintentional islanding**: The designed PCC structure, coupled with additional analysis compliant with IEEE 1547.4, enables the utility-controlled breaker or switch to immediately open (frequency = 59.3 Hz) on loss of the grid. The microgrid managed synchronizing breaker will remain closed for a few more milliseconds until microgrid frequency reaches 57.0 Hz. Since the inverters and generator controls are keying off the synchronizing breaker, these few additional milliseconds enable the energy storage and power electronics to better manage the transient as the microgrid resources pick up the portion of the load served by the utility grid just before the grid was lost. When, or if, the frequency dips to 57.0 Hz and the synchronizing breaker opens, the microgrid will move into island mode. The microgrid controller will adjust all microgrid resources for the new state and island performance objectives.
5. **Islanding to grid-connected transition**: As with intentional islanding, the utility operator will provide the appropriate permission to close in the PCC. The local microgrid controller will support the reconfiguration of each dispatchable resource.

6. **Energy management**: The microgrid design incorporates a portfolio of resources. The EPRI Use Case takes a traditional energy management approach– economic dispatch, short-term dispatch, optimal power flow, and other processes typical in utility control room environments. The microgrid controller will have corresponding applications that manage a set of controllable generation and load assets. Within that portfolio, the system will also optimize the microgrid based on load forecast, ancillary services events, changes in configuration, outage of specific equipment, or any other kind of change to determine the optimal use of assets 48 hours ahead.
7. **Microgrid protection**: The microgrid controller will ensure two primary conditions. The first is that each protection device is properly configured for the current state of the microgrid, either islanded or grid-connected. The second condition is that after a transition, the microgrid controller will switch settings or test that the settings have changed appropriately. If the test is false in either condition, the controller will initiate a shutdown of each resource and give the appropriate alarm.
8. **Ancillary services**: The controller will provide fleet control of the nested microgrid parts. Specifically, the utility operation will have the ability to request and/or schedule balance up and balance down objectives for the fleet. The cloud-based controller will take the responsibility to parcel out the objectives for each microgrid part based on the available capacity.
9. **Black start**: The local microgrid controller will provide a workflow process for restarting the system. Each microgrid part will have a unique sequence of operations for predetermined use cases. One objective will be to provide this function both locally and remotely to meet the reliability requirements of the overall design.
10. **User interface and data management**: The solution provides local controllers in each microgrid part as well as a hosted controller that can operate each microgrid part separately or collectively. The primary actors are the utility operator, local energy managers, maintenance personnel, and analyst. The user experience for each actor will be guided by a rich dashboard for primary function in the system around Operations, Stability, Ancillary Services, and Administration.

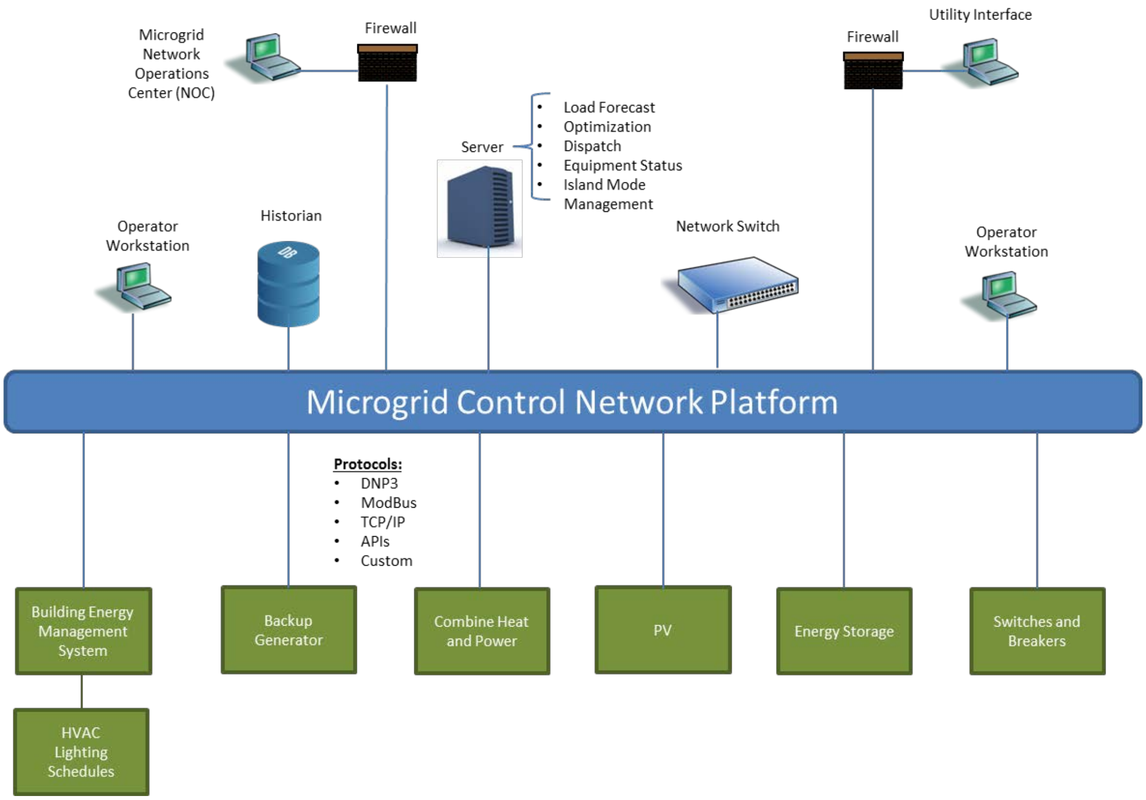
In addition, the microgrid controller will:

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

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

A microgrid controller design needs to be reliable and have redundancy comparable to the other microgrid resources. A standard controller approach such as central controller or 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 Figure 2.

Figure 2 – Conceptual Microgrid Controller Topology



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

The microgrid 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 for communications, as it is currently the most prominent communications protocol within the DER and inverter community. Communications with the utility distribution management systems will use DNP3, as that is the prominent protocol used by the utility industry.

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

Communications – Microgrid and Utility

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

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

The microgrid control system will be local to the microgrid in a secure, conditioned space, (e.g., electrical room) in one of the critical facilities. 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 and do not require off-board communications to function.

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

DISTRIBUTED ENERGY RESOURCES CHARACTERIZATION

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

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

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

The microgrid will take advantage of DER to remain in operation when the utility grid is not available. The microgrid controller will monitor island mode frequency and voltage and adjust equipment operation accordingly to maintain circuit stability. CHP units will be co-located with the thermal loads of targeted buildings. Solar PV arrays will be located opportunistically on suitable rooftops, in parking areas, and in locations where opportunities for ground-mount arrays exist. Energy storage units will be sited near the solar PV arrays, with preference for indoor locations. 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).

The EEMs that are planned for the White Plains microgrid have been taken into account for the final sizing of the microgrid portfolio of resources. This ensures that the microgrid resources are not oversized. Some of the EEMs selected for this project include the installation of LED lighting, premium efficiency motors, variable speed drives, and advanced building controls.

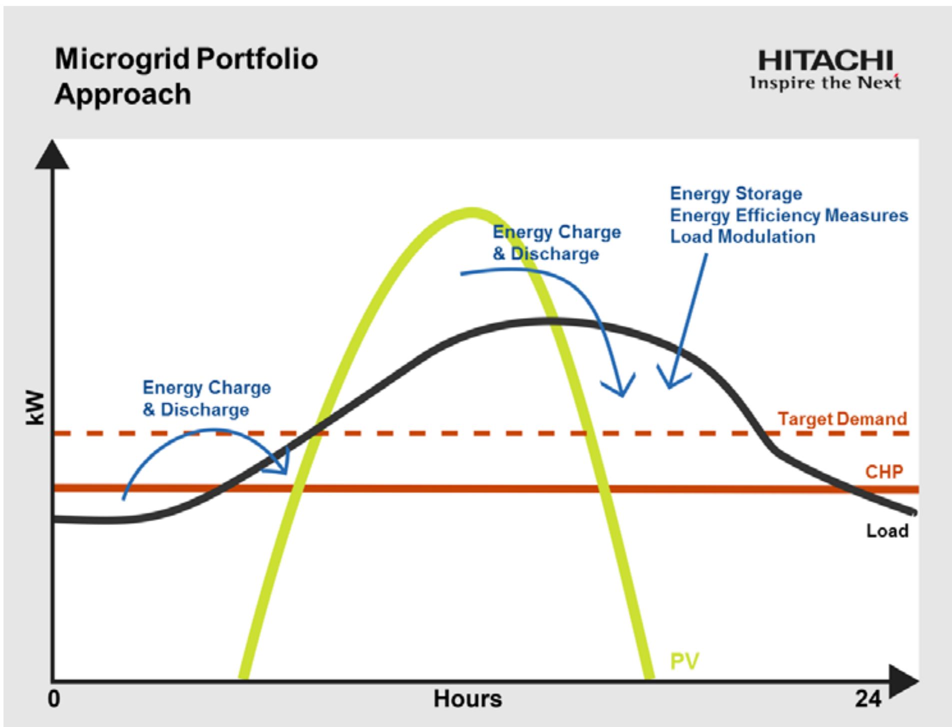
To support steady-state frequency requirements, as well as the ANSI 84.1-2006 standard voltage requirements and to support the customer power quality requirements at PCC, the microgrid controller will actively manage the dispatch of generation resources; actively manage the charge and discharge of energy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

Normal and Emergency Operations

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

Under this strategy, base-load CHP will be designed to run at design output for a majority of the hours per year. To meet the load that varies above the base load, resources such as PV and energy storage will be integrated into the system. Energy storage systems are specified based on their capability to change their output rapidly and address the ramp rate issue to support load following, and buffering the differences between CHP, electrical load, and PV throughout the day. This concept is presented in Figure 3.

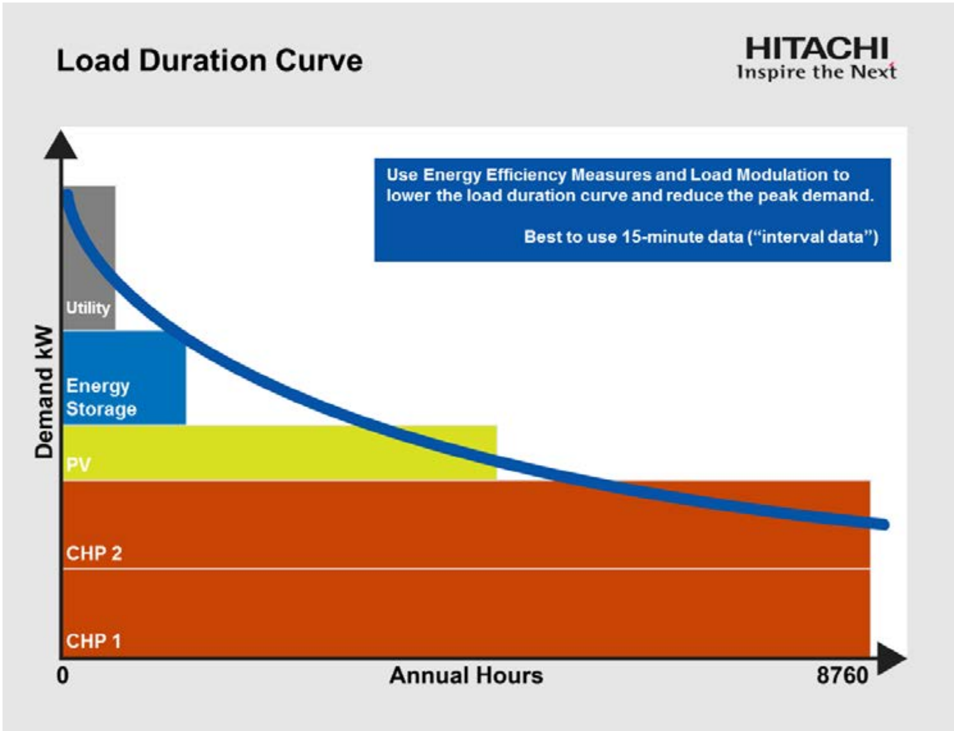
Figure 3 – Microgrid Portfolio Approach



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

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

Figure 4 – Load Duration Curve



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

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

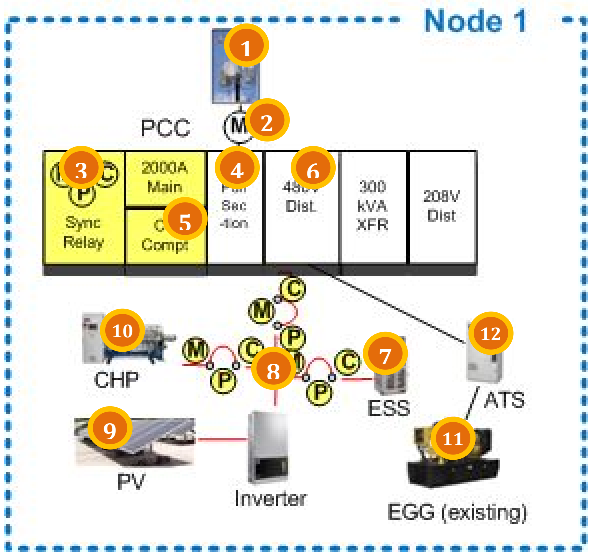
- Unplanned Transition*:* In an unplanned transition, an unanticipated outage takes place such as the loss of a transformer or a car hitting a distribution power pole. Depending on the microgrid resources operating at the time, an outage may take place that requires the microgrid to establish itself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

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

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

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

Figure 5 – One-Line Diagram Explanation



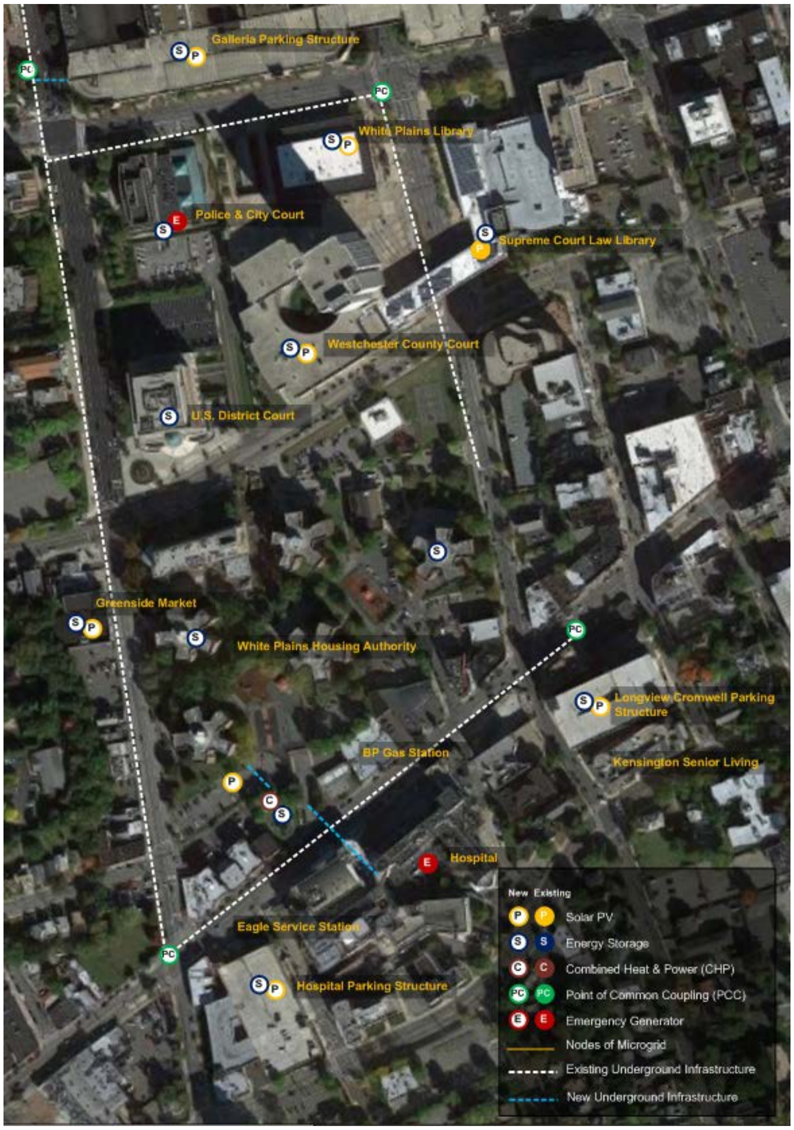
1. Transformer to the critical facility
2. Utility meter
3. Synchronizing relay controls / main breaker with monitoring (M), protection relays (P), and controls (C)
4. Main disconnect (pull section)
5. Instrument current transformer compartment
6. Main 480V 3-phase distribution panel; step-down transformer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

The following pages highlight the layout design and one-line diagram subsections, as well as a brief explanation of included energy resources.

Geospatial Diagrams and One-Line Subsections

Microgrid System Configuration: Overview

<u>Geospatial Diagram</u>



<u>Description</u>

The microgrid includes parking structures, police and court facilities, a hospital, library, government administration buildings, a gas station and auto shop, a grocery store, a hospital and cancer center, and a senior living center.

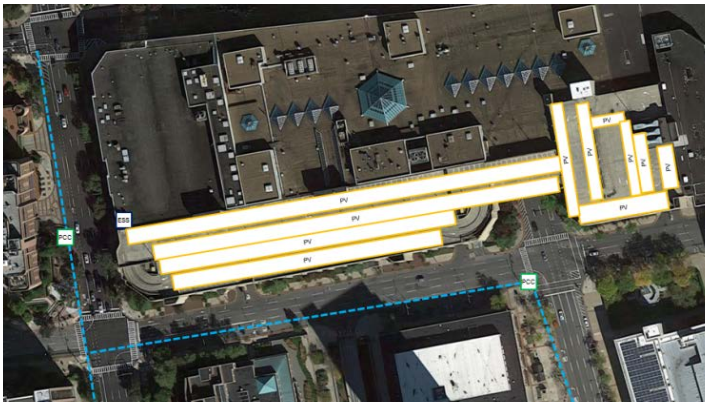
The microgrid covers a large area and includes many new energy generation and storage resources. Existing underground infrastructure will be leveraged to connect new DER to the included facilities, and 377 feet of new underground infrastructure will be installed:

- 230 ft of new infrastructure will connect the new CHP resources to the hospital
- 98 ft of new infrastructure will connect the new CHP resources to the housing complex
- 49 ft of new infrastructure will connect the Galleria parking structure to the existing underground infrastructure

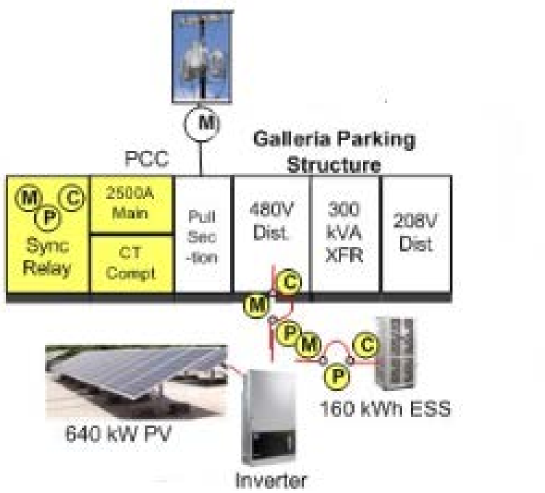
The placement and capacity of resources at key facilities is described in the pages that follow.

System Configuration: Galleria Parking Structure

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix for full diagram

Facility

- Galleria Parking Structure

Description

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

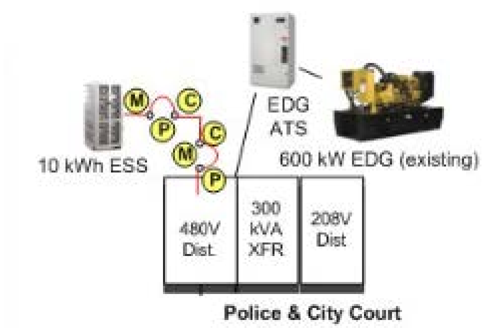
- **PV (640 kW):** The Galleria parking structure serves as the largest solar generation site in the microgrid, with 980 kW of covered parking PV installed.

- **ESS (160 kWh):** An ESS unit will be placed inside the parking structure near the PV inverters.

System Configuration: Police and City Court

Geospatial Diagram

One-Line Diagram Excerpt*



*See appendix for full diagram

Facility

- Police and City Court

Description

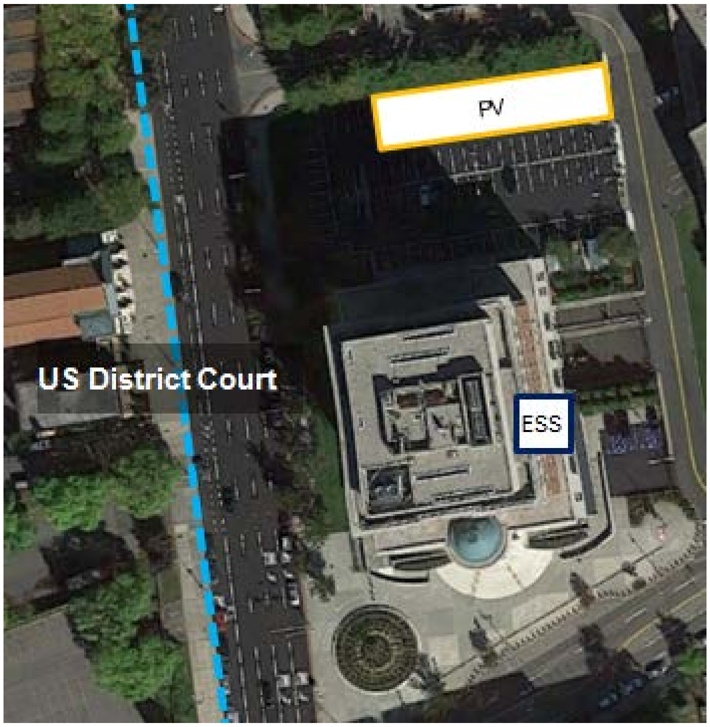
This facility includes an existing emergency diesel generator (600 kW).

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

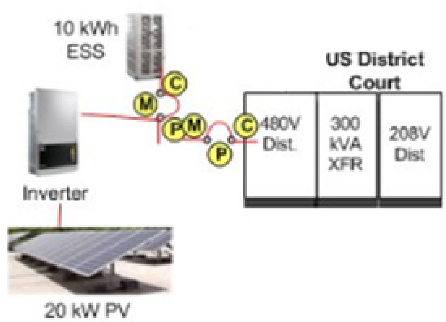
- **ESS (10 kWh):** An ESS unit will be placed inside the facility near the electrical room

System Configuration: U.S. District Court

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix for full diagram

Facility

- U.S. District Court

Description

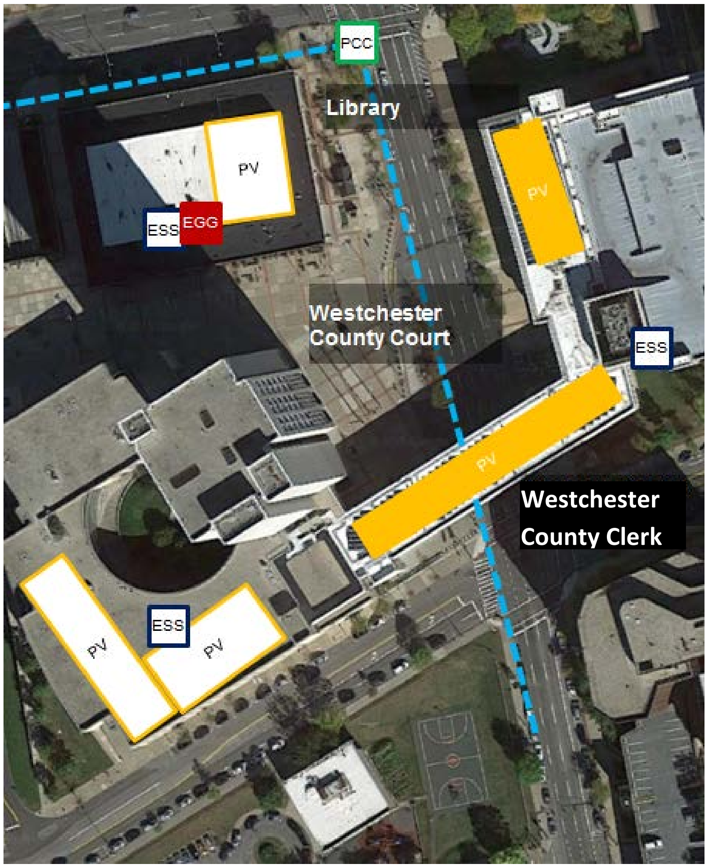
As part of the microgrid, the following will be installed:

- **ESS (10 kWh):** An ESS unit will be placed inside the facility near an electrical room.

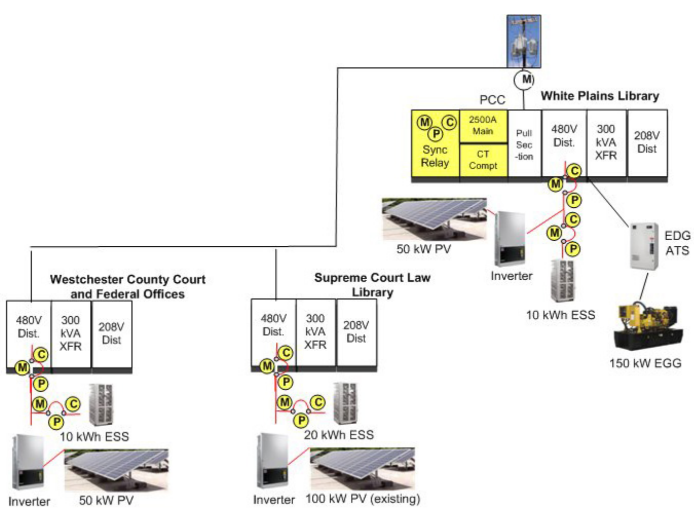
- **PV (20 kWh):** Covered-parking PV will be installed north of the facility.

System Configuration: Supreme Court Law Library, Westchester County Court, and White Plains Library

Geospatial Diagram



One-Line Diagram Excerpt*



*See appendix for full diagram

Facility

- Supreme Court Law Library
- Westchester County Court
- White Plains Library

Description

The microgrid includes 100 kW of existing PV at the Supreme Court Law Library, and a 150 kW natural gas emergency generator at the White Plains Library.

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

Westchester County Clerk's Office

- **ESS (20 kWh):** An ESS unit will be placed inside the building near an electrical room

Westchester County Court

- **PV (50 kWh):** Rooftop PV will be installed along the southwest rooftops

- **ESS (10 kWh):** An ESS unit will be placed inside the building near an electrical room

White Plains Library

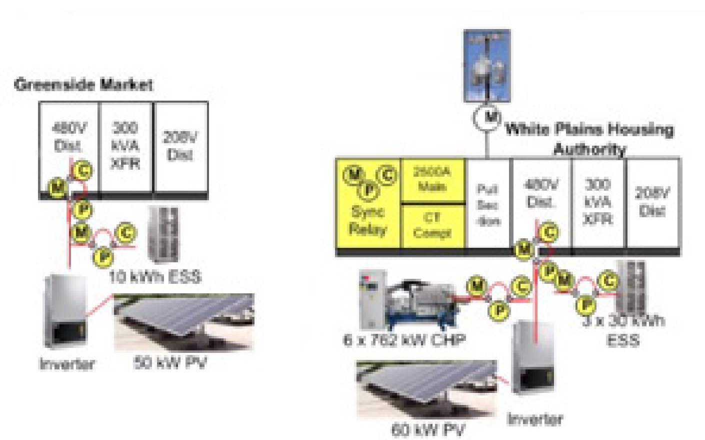
- **PV (50 kWh):** Rooftop PV will be installed on the eastern half of the facility

- **ESS (10 kWh):** An ESS unit will be placed inside the building near the PV inverters

System Configuration: White Plains Housing Authority, BP Gas Station, Greenside Market Grocery

Geospatial Diagram

One-Line Diagram Except*



*See appendix for full diagram

Facility

- White Plains Housing Authority
- BP Gas Station
- Greenside Market Grocery

Description

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

White Plains Housing Authority:

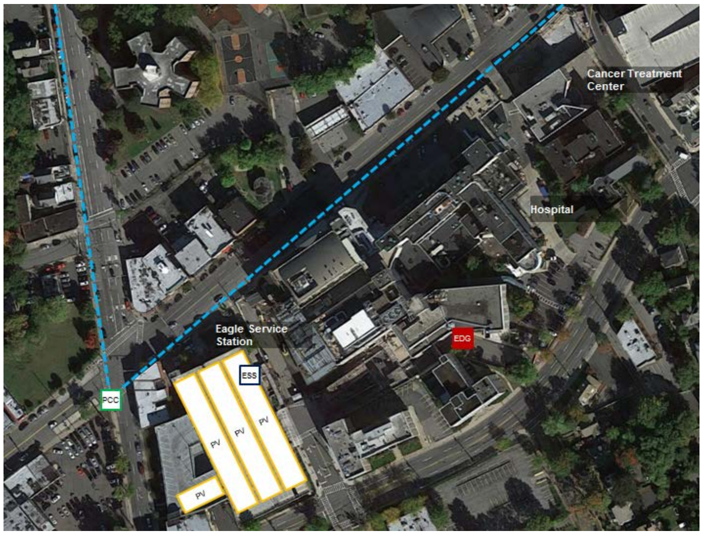
- **PV (60 kW):** covered parking PV will be installed at the South lot
- **ESS (90 kWh):** 3 ESS units will be installed: one in each of two of the housing authority buildings, and a third co-located with the new central energy facility
- **CHP (4,572 kW):** a large CHP installation consisting of six 762 kW units will be installed at a new central energy facility within the complex. Heat recovered from the CHP units will be utilized by the housing complex and the hospital across the street

Greenside Market Grocery:

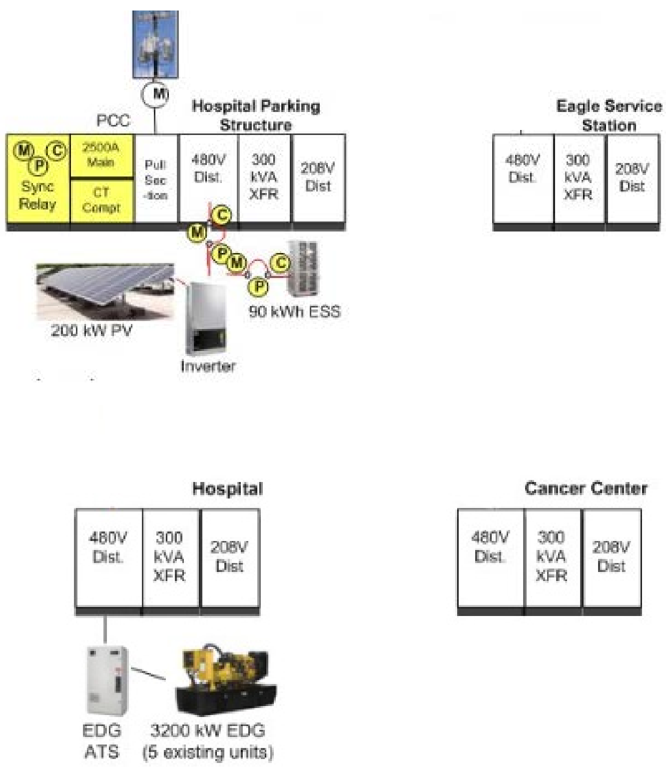
- **PV (50 kW):** Rooftop PV will be installed along most of the available rooftop
- **ESS (10 kWh):** An ESS unit will be installed inside the facility near the PV inverters

System Configuration: White Plains Hospital, Dickstein Cancer Treatment Center, Eagle Service Station

Geospatial Diagram



One-Line Diagram Except*



*See appendix for full diagram

Facility

- White Plains Hospital
- Hospital Parking Structure
- Dickstein Cancer Treatment Center
- Eagle Service Station

Description

The microgrid includes an existing emergency diesel generator (3,200 kW) at White Plains Hospital.

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

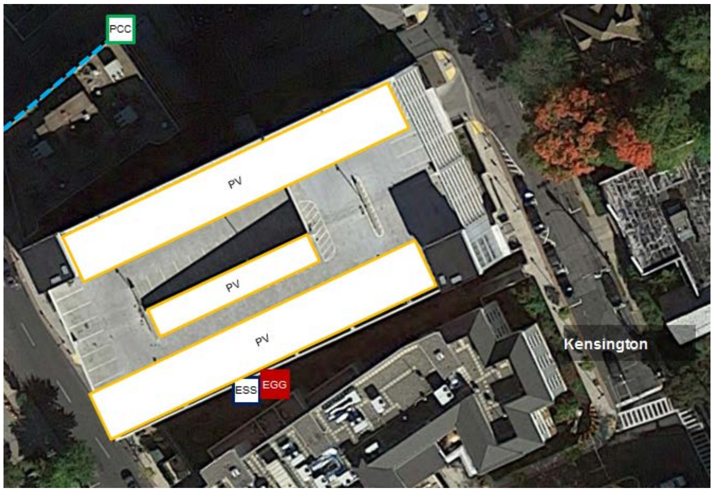
Hospital Parking Structure

- **PV (200 kW):** Covered parking PV will be installed on the top level of the parking structure

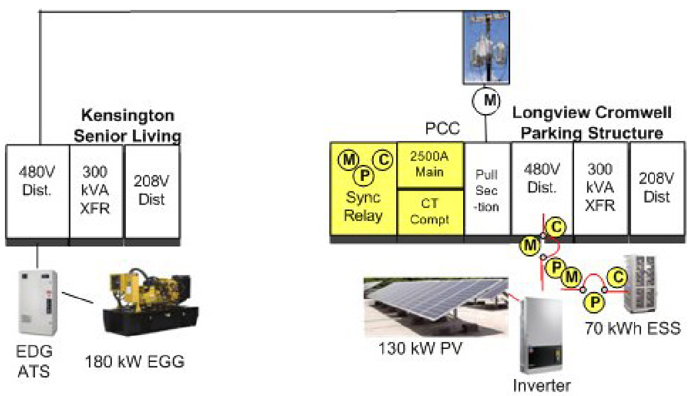
- **ESS (90 kWh):** An ESS unit will be installed inside the parking structure near the PV inverters

System Configuration: Longview Cromwell Garage, Kensington Assisted Living Center

Geospatial Diagram



One-Line Diagram Except*



*See appendix for full diagram

Facility

- Longview Cromwell Parking Garage
- Kensington Assisted Living Center

Description

The microgrid includes an existing emergency natural gas generator (180 kW) at the Kensington Assisted Living Center.

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

Longview Cromwell Parking Garage:

- **PV (130 kW):** Covered parking PV will be installed on the top level of the parking structure
- **ESS (70 kWh):** An ESS unit will be installed inside the parking structure near the PV inverters

Modeling Methodology

The microgrid was modeled with HOMER Pro software, using Hitachi's Energy First Portfolio Approach. 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

Table 5 presents an overview of the energy operations of the microgrid for annual and monthly average values. The microgrid will have a maximum demand of 10,362 kW and an average demand of 5,038 kW. The microgrid will deliver approximately 44 million kWh per year. The thermal loads in the microgrid will be approximately 148,300,000 kBTU per year, of which approximately 92,900,000 kBTU/year will be recovered from the CHP systems and reused to support on-site thermal loads at the housing authority and hospital facilities.

Table 5 –Microgrid Energy Overview: Grid Connected Operation

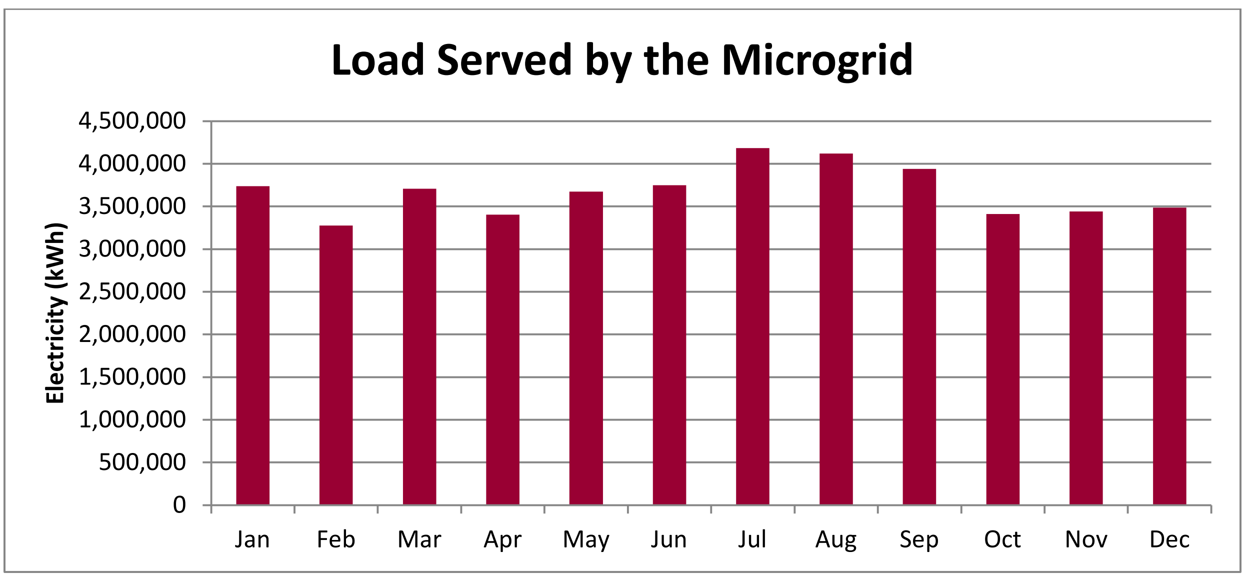
Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
10,362	5,038	44,128,828	3,677,402	148,268,917	12,355,743	92,865,546	7,738,796

The monthly energy delivery is presented in Table 6 and presented graphically in Figure 6.

Table 6 –Monthly Grid Connected Operation

Month	Electricity Load (kWh)
Jan	3,736,300
Feb	3,275,957
Mar	3,707,794
Apr	3,405,331
May	3,672,467
Jun	3,749,173
Jul	4,182,712
Aug	4,120,795
Sep	3,938,764
Oct	3,412,987
Nov	3,441,205
Dec	3,485,343
Total	**44,128,828**

Figure 6 - Monthly Grid Connected Operation



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

The reliability of the White Plains Community Microgrid will be ensured with the following measures:

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

These techniques are employed in the White Plains Community Microgrid design so that equipment loss is mitigated or accommodated in the microgrid for this community, under grid-connected and islanded modes of operation. Table 7 summarizes the microgrid resources in terms of number of devices and the total installed capacity by technology.

Table 7 – Microgrid Resources Comparison

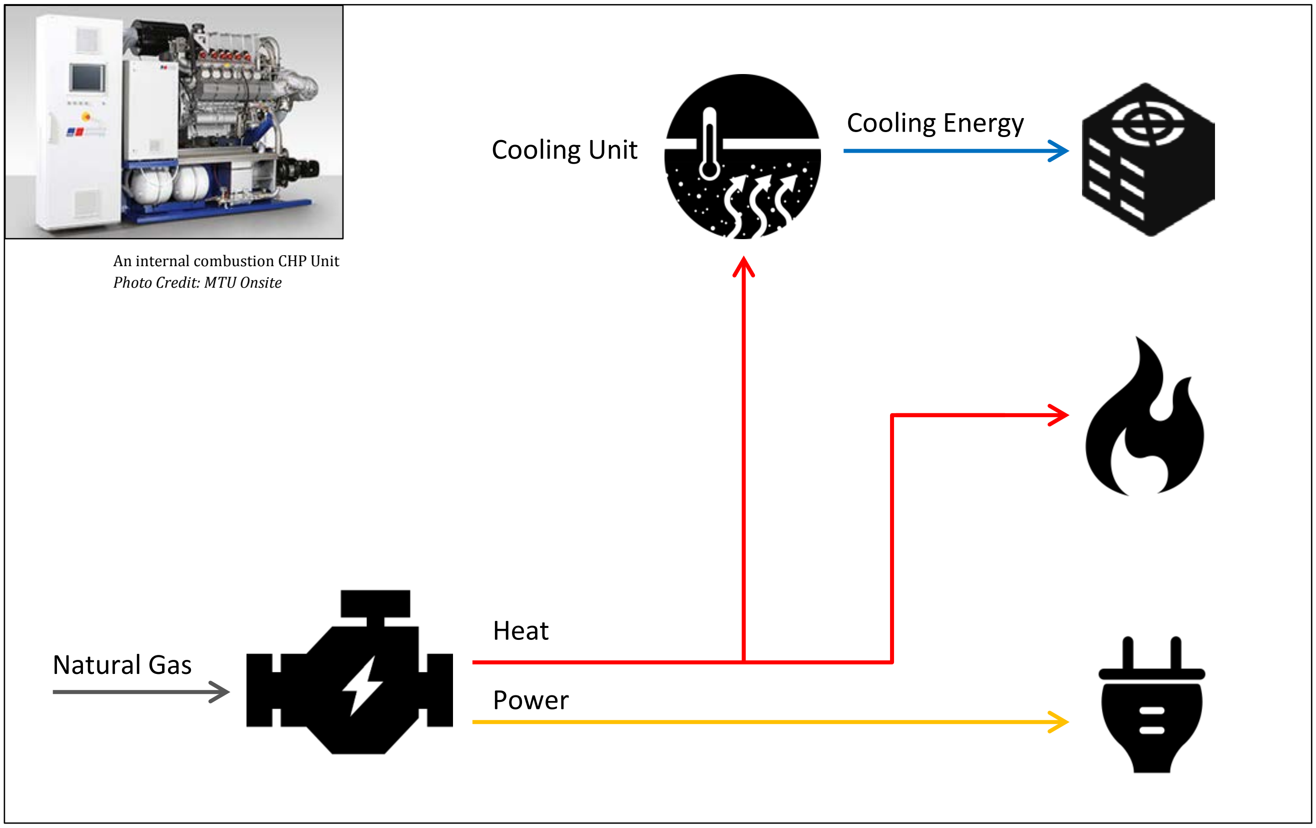
Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
	Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW
Business as Usual	10,362	1	100	-	-	-	-	8	4,130
Microgrid	3,000	9	1,300	10	240/480	6	4572	8	4,130

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

CHP

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

Figure 7 – CHP System Overview



An internal combustion CHP Unit
Photo Credit: MTU Onsite

Benefits of CHP

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

CHP Approach

- Co-locate generators near thermal loads on the customer-side of the meter
- Design for base load operation, and to maximize heat recovery when grid connected

- Support microgrid operations when the electric grid is not available along with PV, energy storage, and building load control
- Design to serve specific winter Heat Recovery Loads, such as a boiler plant, space heating, DHW, and pool heating
- Design to serve specific summer Heat Recovery Loads, including space cooling, DHW, and pool heating

CHP in the Microgrid

The size and location of the planned CHP units is presented in the layout diagram and single-line diagram presented in the Appendix. There are six CHP units in the design, with a total capacity of 4,572 kW. The tables and figures below describe the annual operation of the CHP fleet in the White Plains microgrid.

Table 8 - Microgrid CHP Electric Production

Month	Electric Production (kWh)
Jan	3,230,194
Feb	2,849,271
Mar	3,156,351
Apr	2,930,881
May	3,031,432
Jun	2,967,848
Jul	3,221,106
Aug	3,199,686
Sep	3,006,001
Oct	2,895,095
Nov	2,924,299
Dec	2,668,879
Total	**36,081,044**

Figure 8 – Microgrid CHP Electric Production

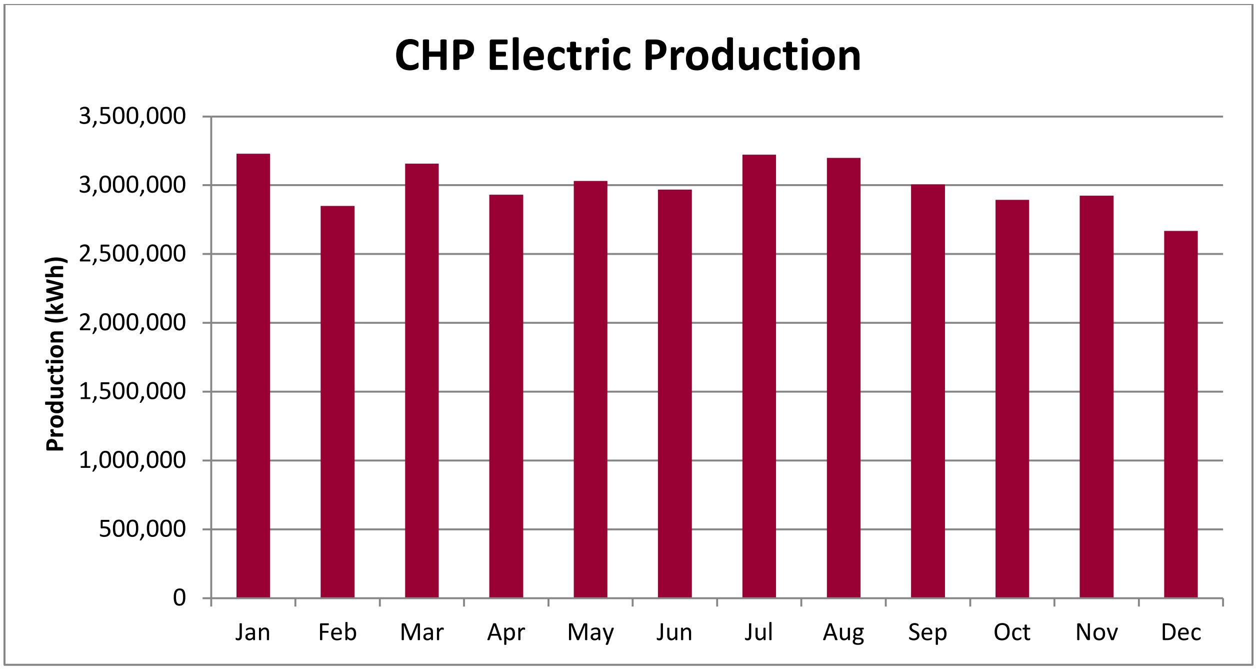


Table 9 - Microgrid CHP Heat Recovery

Month	Heat Recovery (kBTU)
Jan	10,236,075
Feb	9,019,345
Mar	10,007,505
Apr	8,804,734
May	6,565,761
Jun	5,288,900
Jul	5,288,026
Aug	5,163,925
Sep	6,096,437
Oct	8,708,162
Nov	9,221,181
Dec	8,465,496
Total	**92,865,546**

Figure 9 – Microgrid CHP Heat Recovery

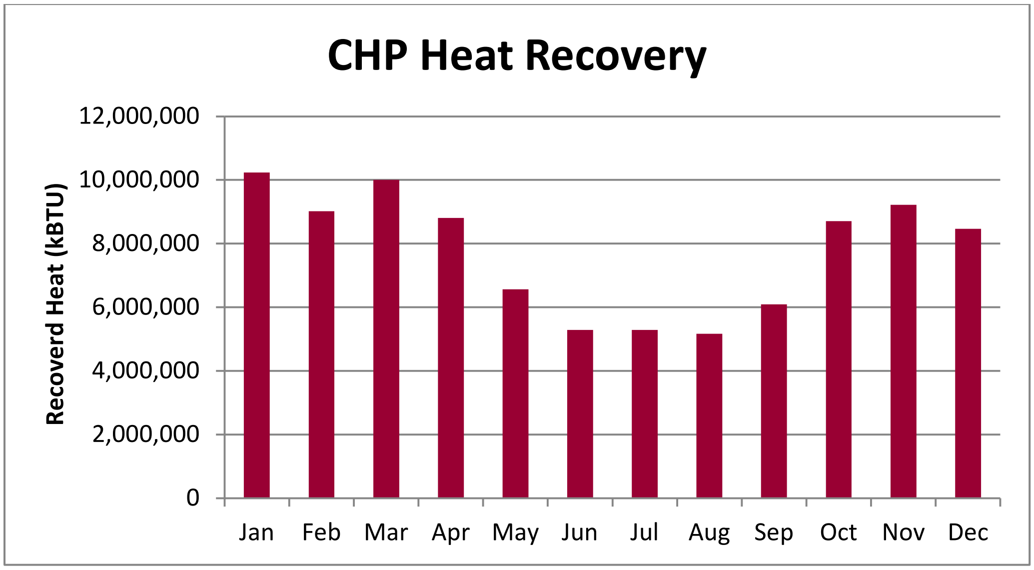
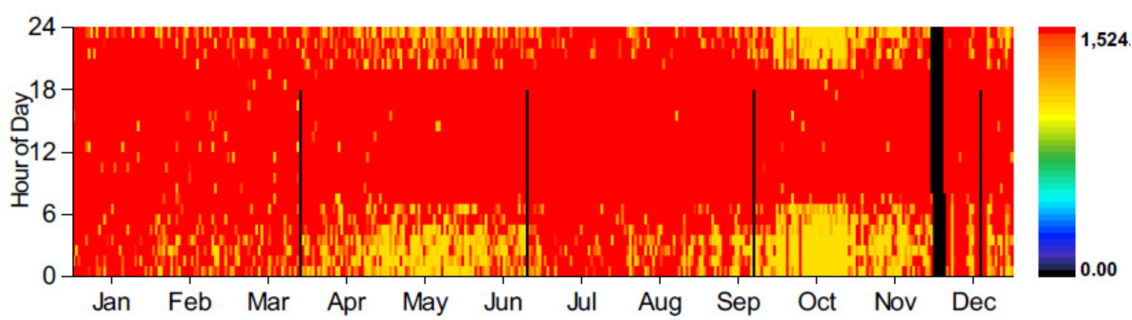


Figure 10 presents the hourly operation of the CHP in the form of a heat map. This representation demonstrates that the CHP unit is operating near full capacity for a majority of hours (red), then does some electric load following during the other hours (orange) but is loaded at an overall high level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

Figure 10 – CHP Operational Summary

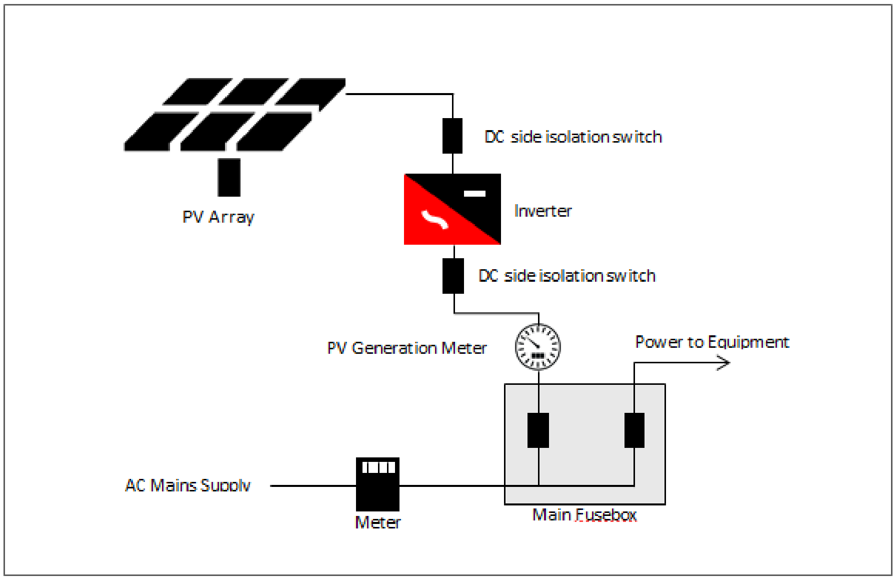
CHP Output



Solar Photovoltaics

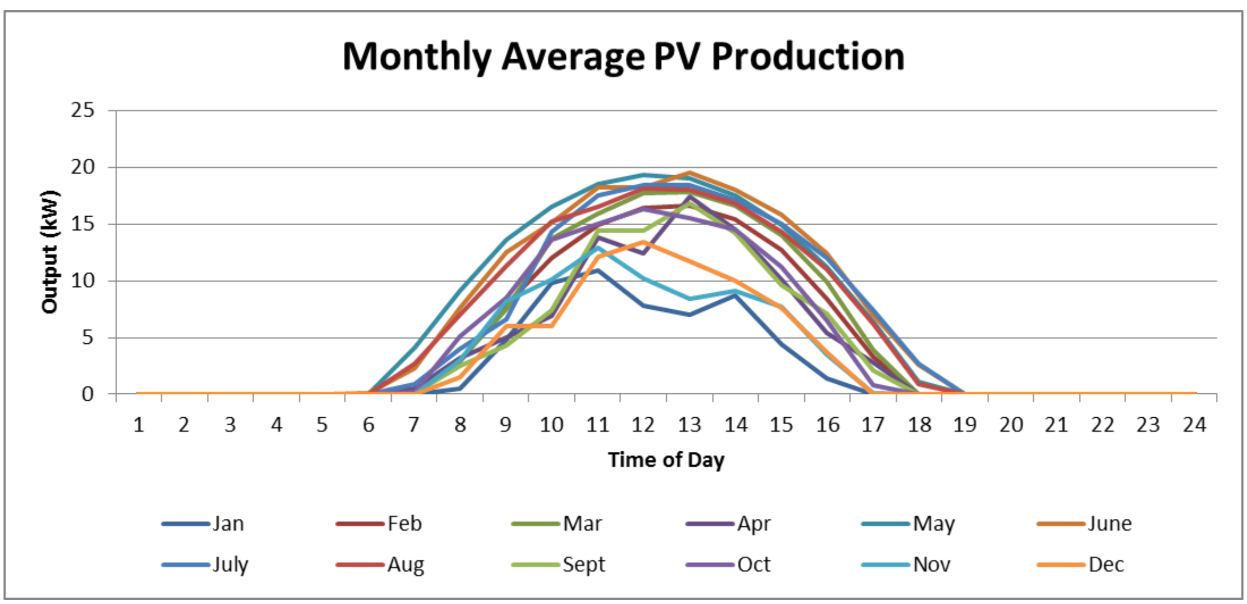
The solar PV will be rooftop, parking lot, or ground mounted using hail-rated solar panels. PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by photons and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

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



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

Figure 12 – Typical PV Daily Generation Profiles



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

Figure 13 – PV Installation Options.

Benefits of PV

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

PV Approach

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

PV in the Microgrid

The size and locations of the planned PV systems is presented in the layout diagram and single-line diagram in the Appendix. Table 10 summarizes the PV components of the microgrid.

Table 10 - Microgrid PV Resources

PV	
# of Inverters	Total kW
9	1,300

The below table and figures below presents the monthly operation of the PV fleet.

Table 11 – Microgrid PV Fleet Electric Production

Month	Electric Production (kWh)
Jan	119,292
Feb	130,108
Mar	177,779
Apr	161,021
May	169,213
Jun	162,083
Jul	157,879
Aug	157,571
Sep	156,978
Oct	144,158
Nov	111,858
Dec	108,041
Total	**1,757,280**

Figure 14 – Microgrid PV Fleet Electric Production

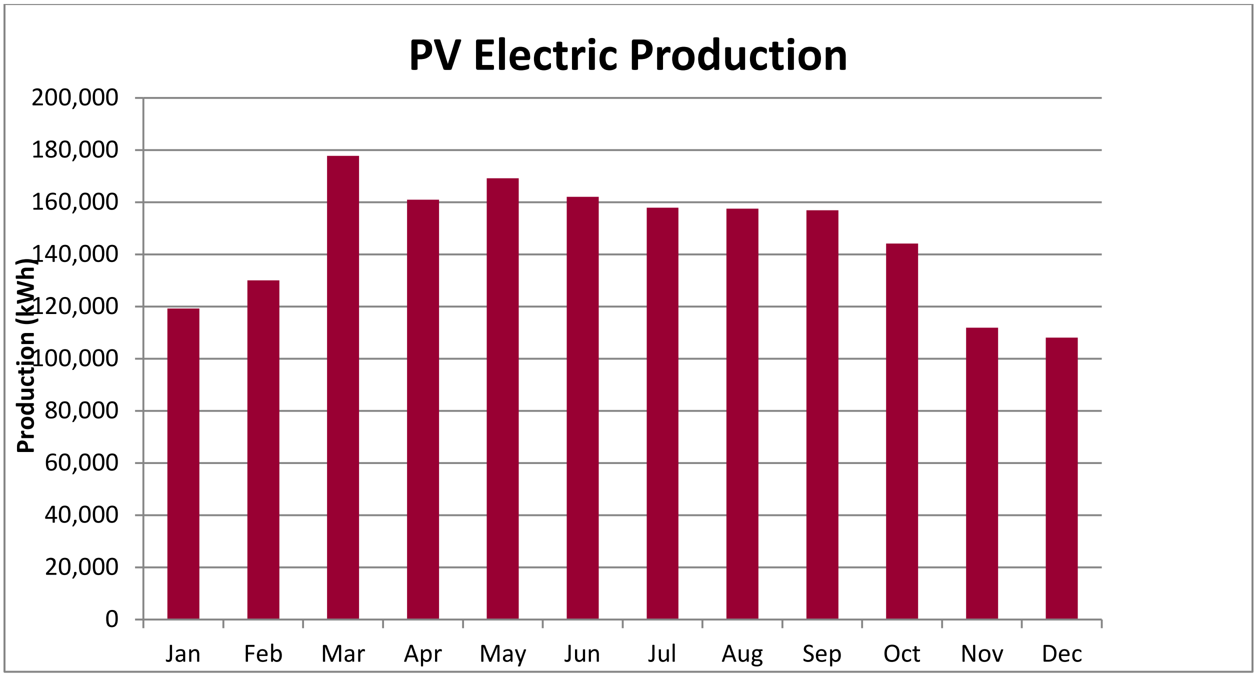
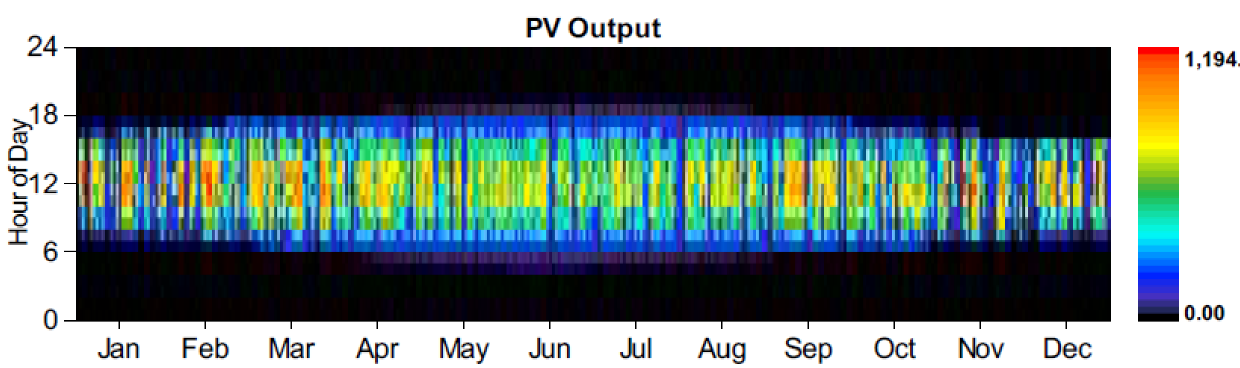


Figure 15 presents the hourly operation of the PV in the form of a heat map. This representation demonstrates how the PV units operate during hours of sunshine with maximum production in the middle of the day, ramping up in the mornings and ramping down in the afternoon hours. This also illustrates the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

Figure 15 – 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 White Plains microgrid is Li-ion batteries, which have a fast reaction response to changes in load, a fairly small footprint, and a relatively high round trip efficiency. Li-ion batteries have some unique operational characteristics:

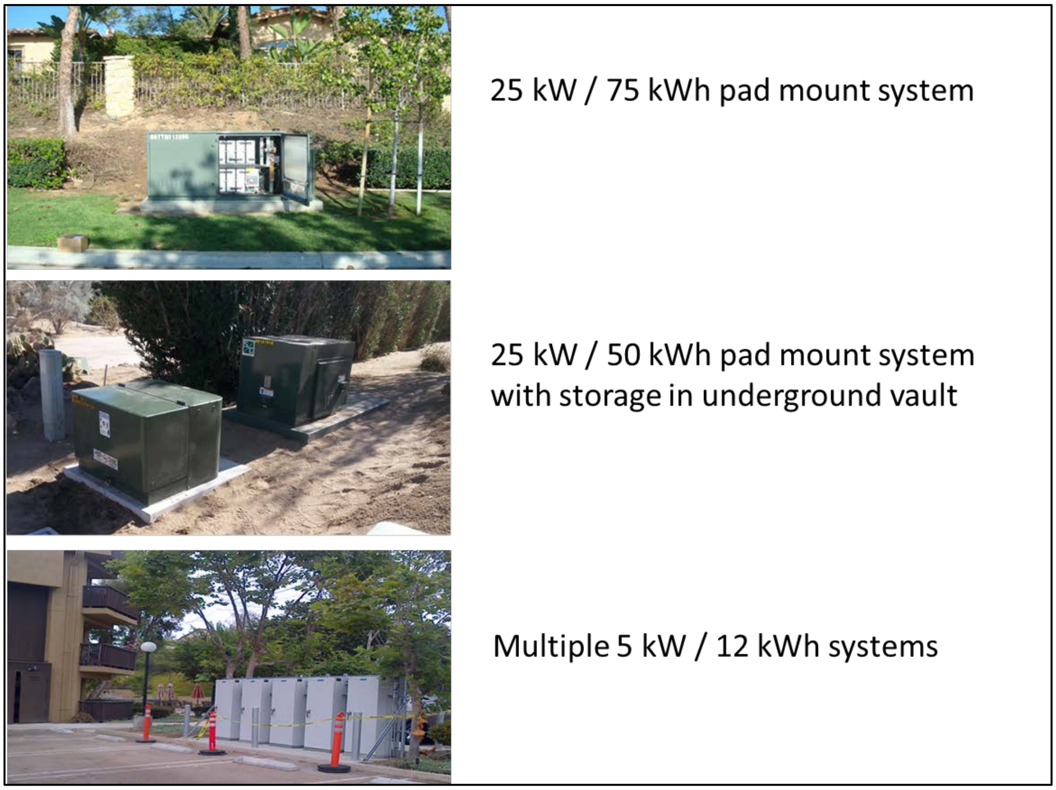
- The usable energy capacity is between a 15% and 95% state of charge (SOC)
- The life of the batteries are impacted by temperature and charge rate
- Most systems are capable of approximately 3,000 deep discharge cycles (+/- 80% SOC cycles)
- Most systems are capable of more than 100,000 shallow discharge cycles (+/- 15% SOC cycles)
- The batteries are at a high risk of failure if the system is discharged to a zero percent sate of charge
- The systems typically have different rates (kW) for charge and discharge
- Most Li-ion systems have accurate methods of determining the system SOC
- Typical power electronic systems provide multiple modes of operation
- Systems are typically capable of four quadrant operation

Benefits of Energy Storage

- Reduces utility costs and improves economic competitiveness
- Increases power reliability and self-sufficiency
- Reduces GHG emissions and other pollutants
- Reduces demand for imported energy supplies
- Supports system with a high level of renewable energy penetration
- Based on a suite of proven, commercially available technologies for a variety of applications
- Competitive market for hardware and installation services
- Provides multiple functions and benefits to the microgrid:
  - Peak Load Management
  - Load Shifting
  - Frequency Regulation
  - Reactive Power Support
  - PV Support
  - Demand Response
  - Energy Arbitrage
  - Backup Power

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

Figure 16 – Example ESS Installations



Energy Storage Approach

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

ESS in the Microgrid

The size and location of the planned ESS systems is presented in the layout diagram and single-line diagram presented in the Appendix. Table 12 summarizes the ESS components of the microgrid.

Table 12 - Microgrid ESS Resources

Battery Energy Storage		
Qty	kW	kWh
10	240	480

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 is presented in Table 13, which shows both the charge and discharge modes of operation. The net value is positive which takes into account the operational losses for the systems.

Table 13 – Microgrid ESS Operation

Month	Charge	Discharge	Net
		(kWh)	
Jan	1,683	1,157	526
Feb	817	751	65
Mar	965	888	77
Apr	532	489	43
May	1,945	1,790	156
Jun	9,422	8,668	754
Jul	15,607	14,358	1,249
Aug	20,105	18,497	1,608
Sep	18,322	16,857	1,466
Oct	3,987	3,668	319
Nov	3,101	2,852	248
Dec	10,685	9,830	855
Total	**87,172**	**79,807**	**7,365**

Figure 17 – Microgrid ESS Operation

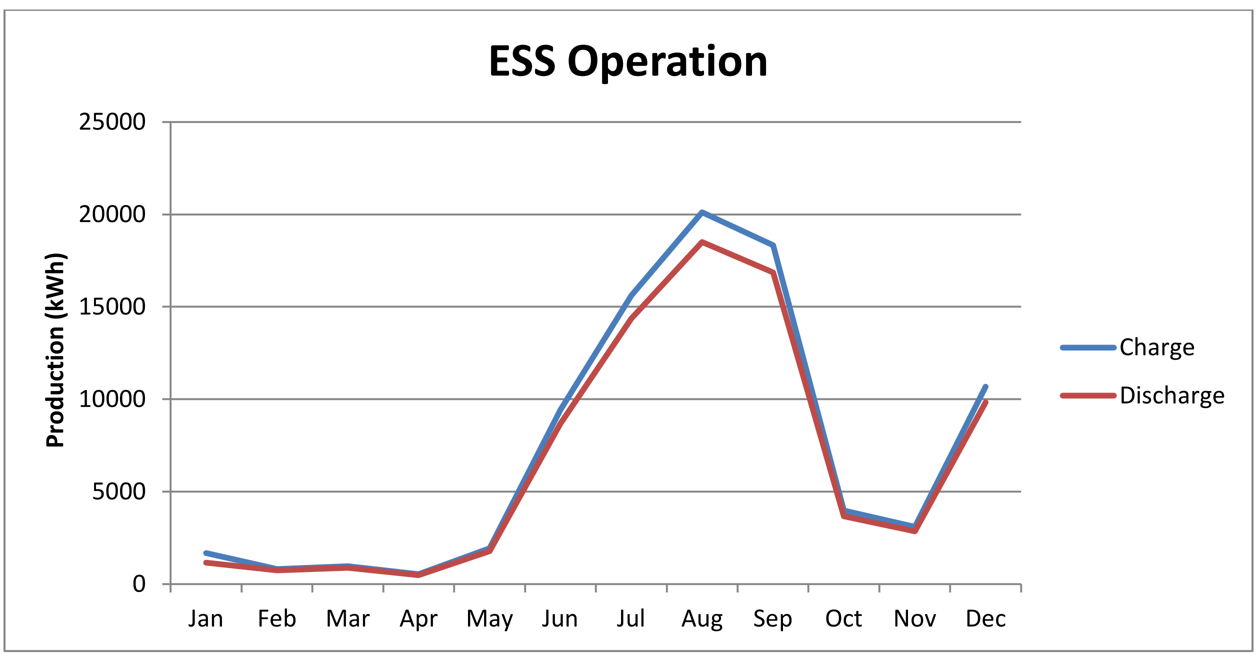
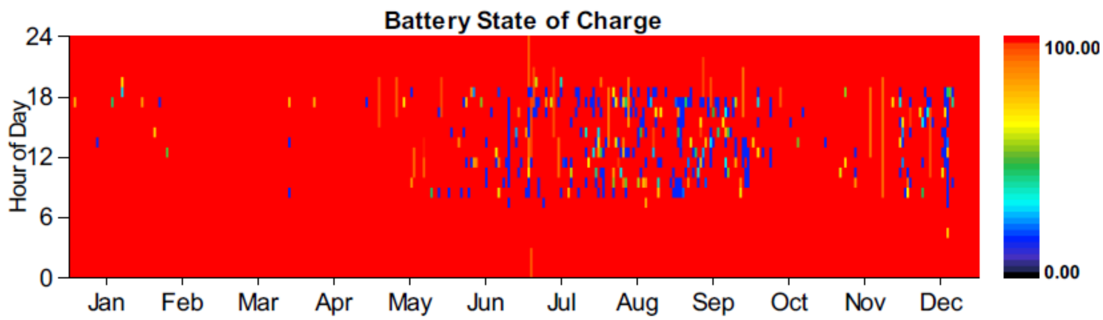


Figure 18 presents the hourly operation of the ESS in the form of a heat map. This representation demonstrates how the ESS units operate. Typically, the units are charged to a high SOC in the middle of the day. The blue areas at the end of the day indicate a lower state of charge representing operation that the units are most active during the typical facility hours of operation and the utility on peak period. The ESS units operate in a variety of modes to support the various operational and economic objectives. The operations represent PV intermittency support, PV load shifting, and peak shaving (to manage utility imports).

Figure 18 – ESS Operational Summary



Island Mode Modeling Results

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

The design strategy for the White Plains 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. The microgrid 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 14.

Table 14 –Microgrid Energy Overview: Island Mode Operation

Season	Electric Demand		Electric Consumption	Thermal Load	Thermal Recovery
	Max (kW)	Avg (kW)	kWh/week	kBTU/week	kBTU/week
Winter	7,827	5,450	915,679	5,891,692	2,594,430
Summer	6,307	5,152	865,578	1,358,883	1,357,021

Emissions Abatement

The White Plains community microgrid will reduce greenhouse gas emissions in two ways. Electricity drawn from the utility will be replaced by on-site generation with a favorable emissions profile, and heat recovery from the CHP units will reduce usage of on-site heating technologies. The net effect is a reduction in emissions attributable to electricity usage and heating in the community. The net effect for CO_2 emissions is detailed in the table below.

Table 15 – Microgrid Emissions Offset

Emissions Source	CO2 Emissions (metric tons)	CO2 Emissions (car equivalents; operating continuously)	CO2 Emissions (car equivalents; driven 15,000 miles per year)
Macrogrid under Current Conditions	23,830	214.3	3753
Macrogrid (after Microgrid)	3,453	31.0	544
CHP (in Microgird)	13,004	116.9	2048
Total Microgrid Case	16,457	148.0	2592
Emissions Reduction from Generation	7,373	66.3	1161
Emissions Reduction from Thermal Offset	6,844	61.5	1078
Total Emissions Reduction	14,217	127.8	2239
Local Emissions Increase (CHP less Thermal Offset)	6,160	55	970

Further emissions reductions will also be realized by offsetting sulfer dioxides, nitrogen oxides, and particulate matter. The IEc analysis values the reduction in all emissions at $325,000/year.

FINANCIAL FEASIBILITY

The proposed microgrid design has been developed based on the following key elements:

- The critical nature of the identified facilities to support community operations in the event a major electric outage,
- The electrical and natural gas infrastructure in the community,
- Each facility's energy requirements,

- Each facility's energy systems and infrastructure,
- Improved resiliency to withstand extended power outages,
- Increased reliance on renewable energy,
- Improved emissions footprint, and
- Supply of energy at a competitive cost

The design incorporates the installation of new distributed energy resources (DER) including CHP, PV, and energy storage. Other microgrid resources include the conventional electric grid, energy efficiency measures, and load control strategies. The overall system sizing provides for meeting the baseline energy requirements of the facility with the grid, DER, and energy efficiency. The proposed design will deliver 37.8 million kilowatt-hours of energy per year from the microgrid on-site distributed energy resources.

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.

Hitachi's financial analysis used proprietary Hitachi software called EconoSCOPE™ to model project costs and benefits. This software utilizes outputs from Hitachi's technical design models and provides details of potential project costs and revenue streams (including PPA rates) with greater resolution than any other tool the project team could identify in the U.S. The tool was designed and is supported by a development team at Hitachi's Matsudo Research Center in Japan where Hitachi has developed and financed hundreds of energy projects including renewable energy, distributed generation, and microgrids. The EconoSCOPE™ model has directly supported decision-making for 95 large-scale energy generation and infrastructure projects.

At this feasibility stage of the project, a high-level project budget was developed and incorporated into the technical model to ensure that the design meets both the technical and economic elements 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 $15,932,000 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 $13,745,000. 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 feasibility business model financial results support an average PPA electric rate 5% - 8% lower than the current weighted electric rate of $0.097/kWh for the key critical facilities included in the proposed Microgrid. Using this system design and revenue target, the proposed Microgrid Special

Purpose Entity (SPE) would also generate an internal rate of return (IRR) that is attractive for project financing to be arranged with no costs to the community.

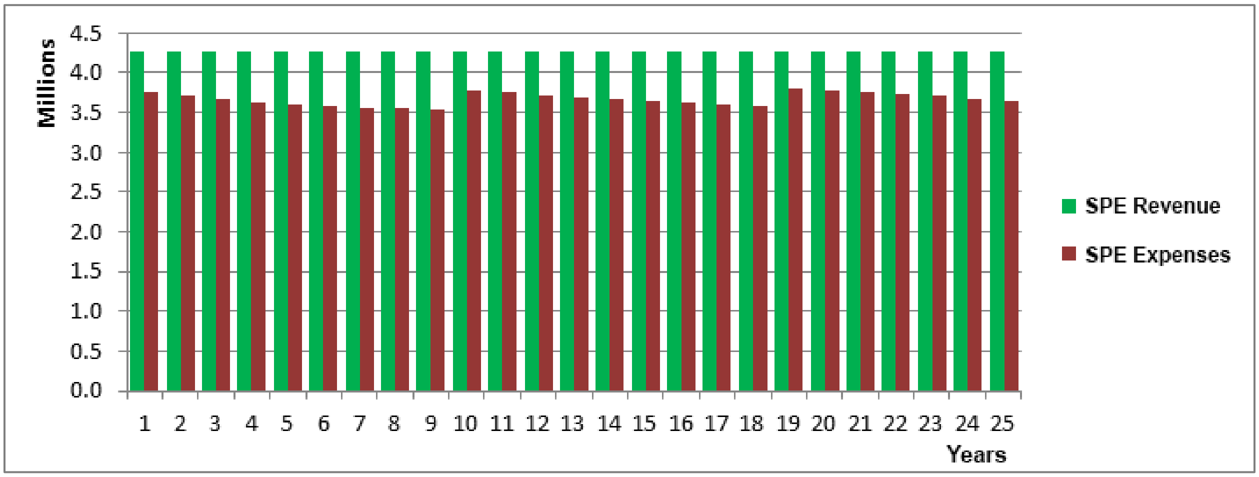
The microgrid creates additional measurable benefits to the community in the form of resilience savings (reduction in loss of operations during an outage) and greenhouse gas reductions. The Hitachi project team's analysis supports an estimated reduction in carbon dioxide emissions of 14,217 metric tons per year. The resilience analysis shows a resilience benefit of $59,000 per year. A summary of the estimated microgrid costs and benefits are presented in the table below.

Table 16 – Summary Costs and Benefits

Installed Costs	
Total Installed Cost:	$ 15,932,000
Federal Investment Tax Credit	$ 2,187,000
Net Installed Cost:	$ 13,745,000
Annual Community Energy Savings	
Current Avg Electric Rate:	$ 0.0971/kWh
Potential Savings with Microgrid:	5% - 8%
Load Served by Microgrid DER:	37,838,324 kWh
Potential Year 1 Energy Savings:	$184,000 - $294,000
Additional Benefits	
Resiliency Savings:	$ 59,000/yr
CO2 Offset:	14,217 metric tons/yr

Under this proposed model, the SPE is expected to generate first-year revenue of $3,746,000 and first-year expenses of $3,429,000. The graph below shows the estimated 25-year revenues and expenses in year 1 dollars (assumes that the expenses and revenues increase at the rate of inflation). The chart assumes a PPA rate with an average discount of 6.5% (taking the average of the 5% - 8% feasible discount in blended electric rate quoted above) over the current weighted average rate paid by Microgrid participants of $0.0971/kWh. Most of the change from year to year is due to the timing of asset overhauls and replacements.

Figure 19 – Summary Costs and Benefits



From the chart in Figure 19, it is clear that the return on investment is relatively small (the difference between the green and red bars), but this is a result of providing the critical facilities stakeholders with a discount off their current all-in electricity rate. Ultimately, the PPA revenue (height of the green bar) is a balance of an acceptable year one discount below the current all-in electricity rate and an acceptable IRR for the Microgrid SPE financiers.

The project team evaluated several available financial incentives when performing the financial analysis for the White Plains 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 and 10% tax credit for CHP systems. In December, the ITC was extended for three years, with a ramp-down through 2022.
- **NYSERDA Incentives**: There are many incentive programs available from NYSERDA that are likely apply to the 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.

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

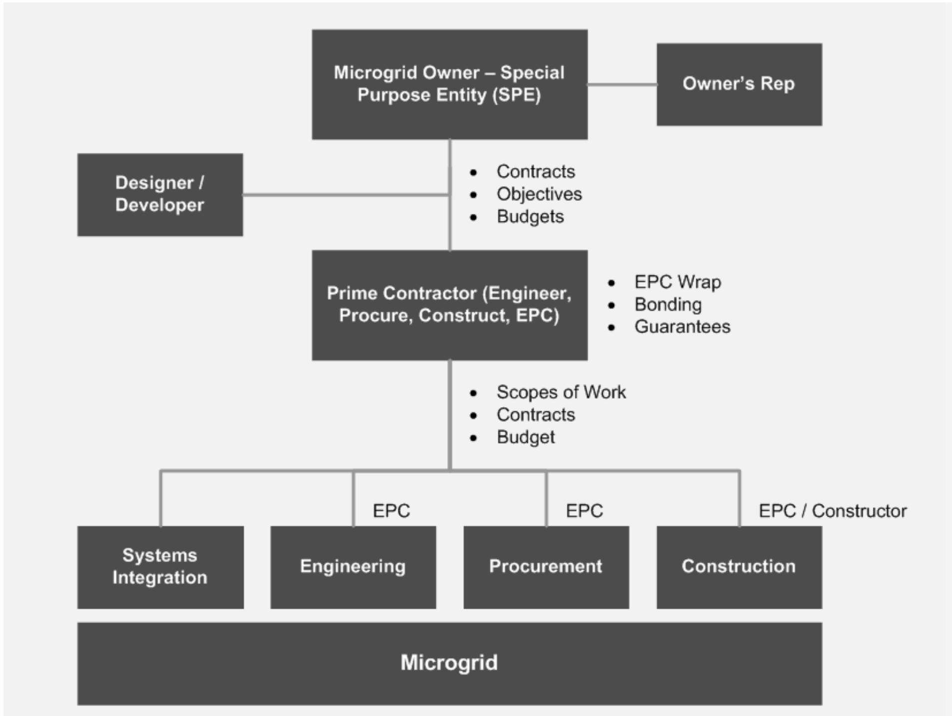
- **New York Power Authority – Energy Services Program for Public Utilities**: This program provides various rebates on energy efficient equipment.
- **Federal Energy-Efficient Commercial Buildings Tax Deduction**: This deduction provides $0.30-$1.80 per square foot, depending on technology and amount of energy reduction for buildings that become certified as meeting specific energy reduction targets as a result of improvements in interior lighting; building envelope; or heating, cooling, ventilation, or hot water systems.
- **Con Edison (Gas) - Commercial and Industrial Energy Efficiency Program**: This program provides 50% of the cost of energy efficiency studies and various rebates for gas-saving efficiency measures.
- **Con Edison (Electric) - Multifamily Energy Efficiency Incentives Program**: This program provides various incentives for efficiency improvements of electric equipment at multi-family facilities.
- **NYPA – Energy Services Program for Public Utilities**: This program provides various rebates on energy efficient equipment.

Third Party Ownership

Under the proposed business model, a third party special purpose entity (SPE) would fund all development and construction of the microgrid, own and operate the assets, and sell the energy generated from the microgrid to community customers through PPAs.

The SPE will engage the design team to finalize the construction drawings and utility interconnection agreements. The SPE will engage an engineering, procurement, and construction firm to build the microgrid, and will be financially responsible for all engineering, procurement, and construction for the system. The SPE will also be financially responsible for integrating the controls and communications systems. This process is presented in the Figure 20 below.

Figure 20: Microgrid Development Relationships



To ensure proper operation of individual microgrid resources, an energy performance contractor (selected through a partnership or solicitation, and hired by the SPE) will conduct site acceptance tests that validate the operation and performance of the new equipment. Once the system construction and integration are complete, the SPE will engage a third party commissioning agent that will test the microgrid as a system to ensure that the controls, communication and sequence of operation function to meet the requirements as defined in the specified use cases and the final design. After the fully commissioned system is accepted and transferred to the SPE, the SPE will own and operate the microgrid for a period of 25 years. If selected for Stage 2, the team would evaluate how shorter PPA periods would affect the energy price and discuss those options with potential system participants.

The operation of the microgrid will leverage the autonomous functionality of the microgrid controller, and minimize the need for on site operators. The controller will operate the microgrid to maximize economic benefits, minimize emissions, and maximize reliability of service in the event of a fault on the grid. In addition, the microgrid controller will monitor the performance, operation and alarms of the distributed resources. In the event of an alarm, the SPE will be notified through the network operations center, and dispatch a service technician who will be engaged through a service contract. The microgrid controller will also track the hours of operation of each microgrid resource, and will employ a predictive maintenance strategy to schedule maintenance before any failure occurs, and at a time that will have the least impact on the overall operation of the microgrid. As the microgrid operates, a history of performance, trending and signature analyses will develop, adding to the microgrid's ability to anticipate failures.

The project team conducted a thorough econometric analysis of the proposed White Plains 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 White Plains Community Microgrid project, and found that the financial case for this project is strong. Financial institutions do not yet allow for recognition of incentives in their evaluations of project attractiveness. Therefore, the project team did not include them in the underlying economic analysis at this time. During the detailed design phase, financial incentives will be evaluated as part of the entire system costs.

The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately$0.097/kWh. Based on the estimated energy savings, assumed project financing costs, and the 25 year contract term, the study supports a PPA electric rate with an electric cost that represents an average year 1 discount of approximately 5-8% for the facilities in this project.

SWOT Analysis

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

Strengths

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

Weaknesses

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

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

Opportunities

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

Threats

- Municipal ordinances, public utility rules and requirements, and state regulations may cause constraints, including:
    - Debt limitations in state and local codes and ordinances
    - Limits on contracting authority in city codes and state statutes
    - Budgeting, public purpose, and credit-lending issues
    - Limits on authority to grant site interests and buy electricity
- The PPA will be dependent on the long-term viability of the SPE. During the 15-25 year term of the PPA, the SPE could face difficulties and dissolve, requiring a change in ownership.
- The microgrid arrangement may trigger interconnection agreements and fees from electrical distribution utility.
- Regulatory changes may burden the PPA arrangement.
- Price adjustments due to fuel cost fluctuations may threaten the value proposition for the SPE.

Benefit Cost Analysis

NYSERDA contracted with IEc to conduct a benefit-cost analysis. The project team provided detailed information to IEc to support this analysis. IEc ran two scenarios for this proposed microgrid. The first scenario modeled no power outages, and evaluated the grid connected mode of operation. The second scenario modeled the number of days (or partial days) 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 White Plains Community Microgrid, the breakeven outage case is an average of 0.7 days of outage per year. The cost benefit results are presented in the tables that follow. The analyses indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.7 days per year (Scenario 2).

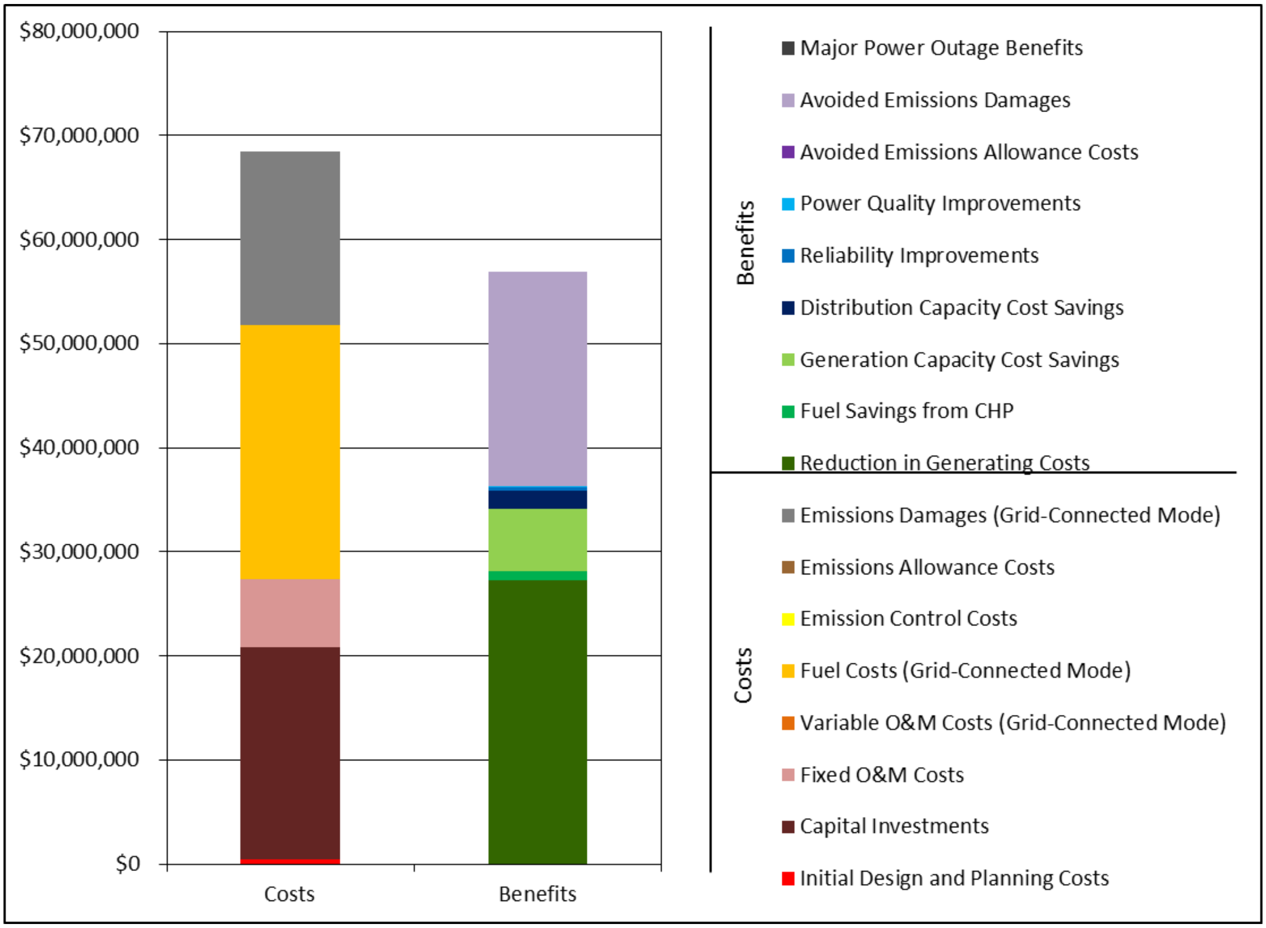
Table 17 – Cost Benefit Analysis Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 0.7 DAYS/YEAR
Net Benefits - Present Value	-$11,500,000	$165,000
Total Costs – Present Value	$68,500,000	$68,500,000
Benefit-Cost Ratio	0.8	1.0
Internal Rate of Return	-10.2%	6.1%

Table 18 – Cost Benefit Analysis Scenario 1
(No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$20,400,000	$1,610,000
Fixed O&M	$6,520,000	$576,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$24,400,000	$2,150,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$16,600,000	$1,090,000
Total Costs	**$68,500,000**	
Benefits		
Reduction in Generating Costs	$27,200,000	$2,400,000
Fuel Savings from CHP	$879,000	$77,600
Generation Capacity Cost Savings	$6,000,000	$529,000
Distribution Capacity Cost Savings	$1,790,000	$158,000
Reliability Improvements	$278,000	$24,600
Power Quality Improvements	$130,000	$11,500
Avoided Emissions Allowance Costs	$13,400	$1,180
Avoided Emissions Damages	$20,600,000	$1,350,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$56,900,000**	
Net Benefits	**-$11,500,000**	
Benefit/Cost Ratio	**0.8**	
Internal Rate of Return	**-10.2%**	

Figure 21 – Cost Benefit Analysis Scenario 1
(No Major Power Outages; 7 Percent Discount Rate)

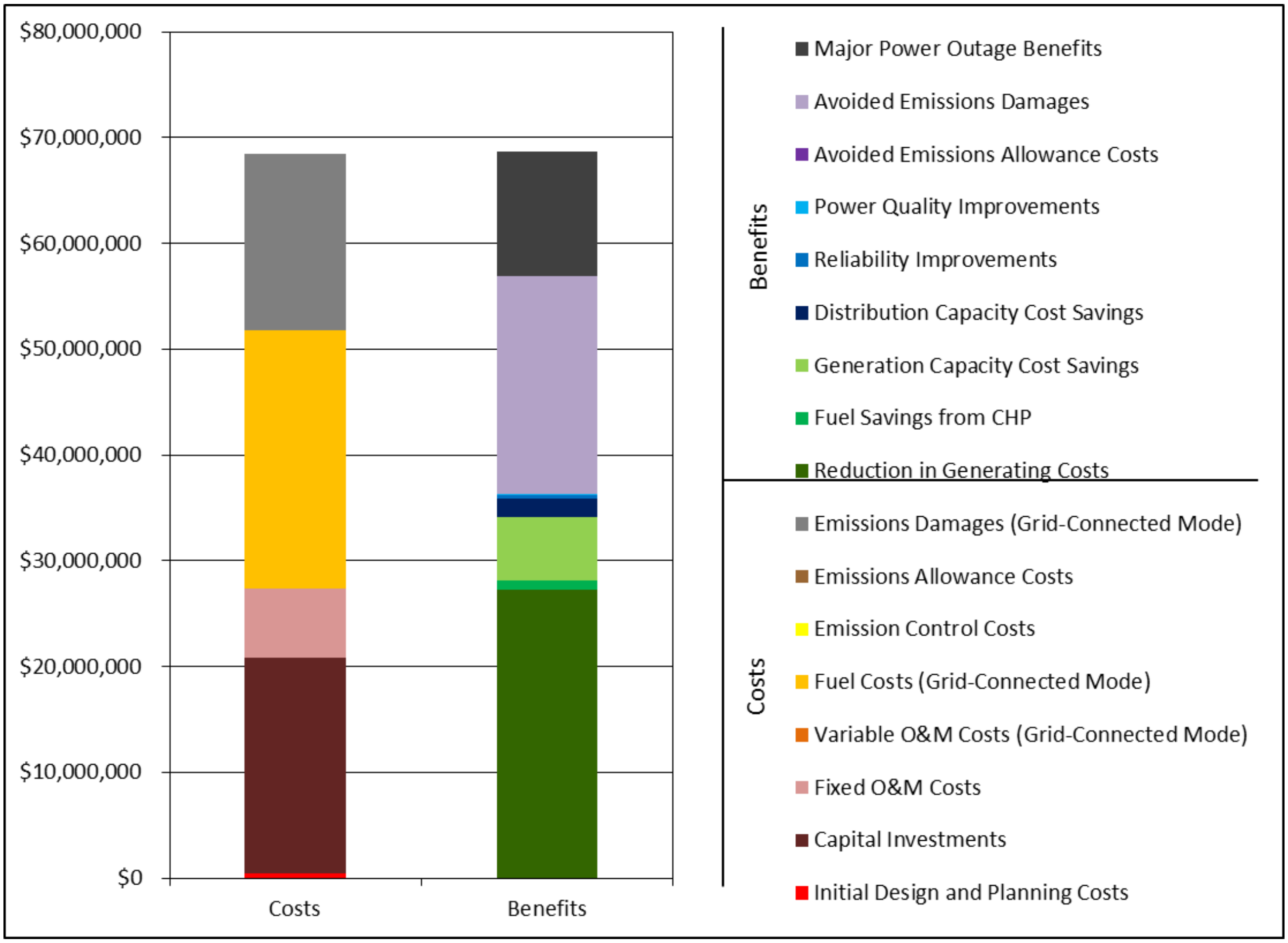


The major drivers of costs are the capital investments and fuel, where the major benefits are reduction in generation costs and avoided emissions damages.

Table 19 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 0.7 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$20,400,000	$1,610,000
Fixed O&M	$6,520,000	$576,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$24,400,000	$2,150,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$16,600,000	$1,090,000
Total Costs	**$68,500,000**	
Benefits		
Reduction in Generating Costs	$27,200,000	$2,400,000
Fuel Savings from CHP	$879,000	$77,600
Generation Capacity Cost Savings	$6,000,000	$529,000
Distribution Capacity Cost Savings	$1,790,000	$158,000
Reliability Improvements	$278,000	$24,600
Power Quality Improvements	$130,000	$11,500
Avoided Emissions Allowance Costs	$13,400	$1,180
Avoided Emissions Damages	$20,600,000	$1,350,000
Major Power Outage Benefits	$11,700,000	$1,030,000
Total Benefits	**$68,600,000**	
Net Benefits	**$165,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.1%**	

Figure 22 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 0.7 Days/Year; 7 Percent Discount Rate)



The benefits from the 0.7 outages result in $11,700,000 during the life of the microgrid. The entirety of the IEc analysis can be found in Appendix D of this report.

Model Comparisons

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

- Gas rates used in IEc's benefit-cost analysis were based on a state-wide average for commercial end-use customers. The rates used in White Plains financial feasibility analysis are based on Con Edison's distributed generation rate. This resulted in year 1 gas rates of $6.34 and $5.71, for the benefit-cost analysis and the financial feasibility analysis, respectively. If Con Edison's distributed generation rate were applied to the benefit-cost analysis, net benefits would be increased by $1,400,000.

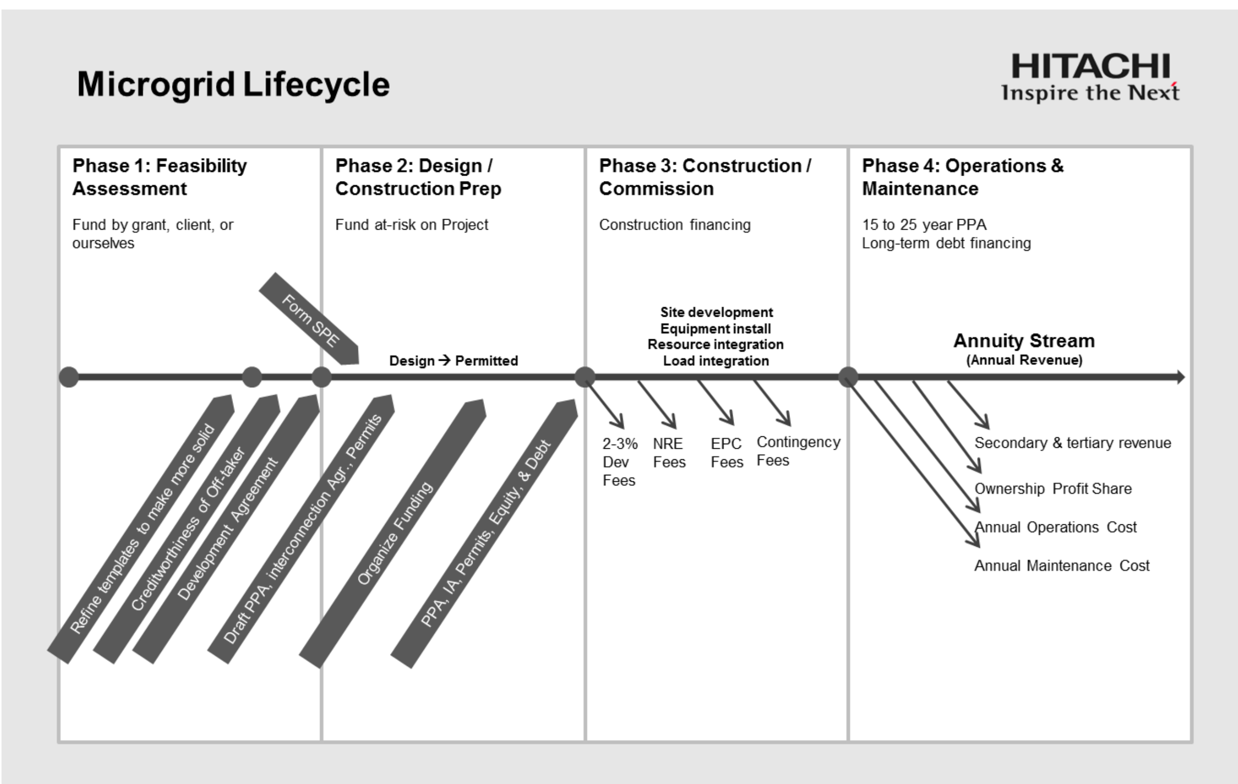
- The financial feasibility assessment incorporates the tax benefits of the Federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit reduces the capital cost of the project by $2,186,000.
- Capital replacement costs used in the BCA were calculated as a full replacement costs, whereas the project team assumed a 'rebuild' cost that is not equal to the full cost of replacement. The rebuild cost for the White Plains Community Microgrid is $4,246,000 less than the full cost of replacement.
- The benefit-cost analysis derives a price for electricity based on average wholesale energy costs, whereas the financial feasibility assessment evaluates the savings to the community based on actual costs paid by community participants.
- The period of analysis in the benefit cost analysis is 20 years and the third party ownership model is based on a period of analysis of 25 years.

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

Development, Construction, and Operating Approach

Once the design phase of a microgrid project is complete, the project must be brought to life by a well-designed and effectively supported development approach. The Hitachi Microgrid Lifecycle process closely matches the NY Prize process shown in Figure 23:

Figure 23: Hitachi Microgrid Lifecycle



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

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

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

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

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

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

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

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

Operation of the microgrid will include several key components:

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

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

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

Financial Operations: The SPE will bill system off-takers monthly for energy from system resources. Hitachi's approach to the PPA simplifies this process, billing consumed $/kWh monthly instead of the 18+ billing determinants in a typical utility electric bill. Depending on how the SPE is established with the community, the customer may still be billed by the utility. To simplify bill management for the customers of the microgrid, the utility bill may become a pass-through within the microgrid billing.

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

PROJECT TEAM

The success of this project relies on a strong team to take it from a feasibility study to an operational system. This White Plains Community Microgrid team has engaged with nearly all of the major community stakeholders. Local government representatives from White Plains have been heavily involved with this project from the beginning, and have signaled White Plains' clear interest in participating in a microgrid that can deliver resilient, cost effective energy. The community has not stated interest in any kind of public-private partnership at this time, but the project team will continue to consider the potential benefits of such an approach as the project is designed. This may take the form of partial ownership of the SPE by one or more local government agencies.

Other stakeholders have been kept informed throughout the process and have assisted the study by supporting site audits, providing facility information, and participation in regular status calls. This Stage 1 analysis of the White Plains Community Microgrid required the use of estimates around energy usage and efficiency opportunities for multiple large facilities, including the U.S. District Court and Westchester County Courthouse. While the basic office-space nature of these buildings allows for a high level of confidence in these estimates, the participation and engagement of these stakeholders will be absolutely critical for Stage 2. The Project Team has directly engaged decision-makers at Westchester County and received verbal support for the project moving forward. As this project enters the next phase, the project team will hold face-to-face meetings with participants to review the results of the feasibility study and touch base on their interest in participating in the microgrid once it becomes live.

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.

Project Leader: Hitachi Microgrid Solutions has expressed a desire to support the full-system design of the proposed microgrid as the project moves to the next stage. This group has extensive experience in microgrid design and operation. Hitachi also has access to the capital, at a competitive rate, needed to finance the system and set up an SPE to operate the equipment and manage PPAs. The team has designed over 50 microgrids and overseen the construction of several microgrids. The Hitachi Microgrid Solutions Business will also leverage its close partnership with other Hitachi Companies to support faster microgrid development and deployment. These include:

- Hitachi America, Ltd. – Established in 1959 and headquartered in Tarrytown, NY, Hitachi America, Ltd. is a major infrastructure and technology services company in North America with offerings in electronics, power and industrial equipment and services, and infrastructural systems.

- Hitachi Capital Corporation – Established in 1969, Hitachi Capital provides financing to various Hitachi Group Companies and the commercial business sector worldwide. Hitachi Capital's Energy Projects Division is one of its largest and fastest growing groups and it currently owns and finances projects through PPAs all over the world.

Together, this team has the financial strength to ensure that this project can be completed and sustained over time. Hitachi has more than 100 years of experience in product and service innovation and quality engineering. In 2012, the company had $96.2 billion in revenue and spent $3.7 billion on research and development. The company's 326,240 employees are all directed toward advancing Social Innovation – the idea that Hitachi's technological innovation should be leveraged for environmental and social good. . This goal is directly supported by Hitachi's expanding Microgrid Solutions Business. Hitachi Capital, a potential financier of the White Plains Community Microgrid, has over 5,000 employees and has made investments exceeding $17 billion to support Hitachi's Social Innovation projects.

Hitachi's expertise alone will not be enough to ensure project success. There are several critical roles that must be filled when designing a complex community scale microgrid. These include:

Project Financiers: Hitachi Capital has indicated interest in serving as an equity investor in the SPE, and could arrange for the related project financing. Hitachi Capital has a division dedicated specifically to energy project finance, and has financed more than 200 renewable and distributed energy projects at highly competitive rates. Other project investors have also contacted the team about the opportunity to invest in this project.

Microgrid Control Provider: Effective control and optimization are critical features in any microgrid. The Hitachi Microgrid Team is currently reviewing the results of their industry-wide RFI for microgrid control technologies. The team will utilize this ongoing analysis to determine the best system for the White Plains Community Microgrid during the detailed design phase. The team will develop a competitive RFP process to identify and select the controller partner with the most attractive combination of experience, skillsets, and price.

EPC Contractor: The EPC will be responsible for detailed engineering drawings of the system, purchasing the equipment specified in the design, and overseeing construction and commissioning of the microgrid system itself. The Hitachi Microgrid Solutions Business has long-term and strong relationships with many EPCs in New York and has had discussions with several regarding White Plains' microgrid project. A final evaluation and selection will be made during the proposal process for Stage 2.

CHP Design Firm: To ensure optimal design and placement of the generation and heat sources in the microgrid, the Hitachi Microgrid Team will leverage a firm that specializes in CHP applications. The team is currently in discussions with multiple CHP design and installation firms to determine which one would be an ideal partner to execute the CHP portion of microgrid projects in the State of New York. The team will develop a competitive RFP process to identify and select the CHP firm with the most attractive combination of experience, skillsets, and price.

PV System Design Firm: To ensure that PV generation systems in the microgrid are designed and placed for optimal performance, the Team will partner with a firm that specializes in PV applications. The Team is currently in discussions with multiple PV design firms to identify potential partners for the White Plains project. The team will develop a competitive RFP process to identify and select the PV firm with the most attractive combination of experience, skillsets, and price.

O&M Firm: Once a system is installed, operations and maintenance on the equipment will be critical to ensure both the resilience and profitability of the system. The SPE that owns the system will need to retain the services of an O&M firm with qualified team members close to the White Plains. The team will again develop a competitive RFP process to identify and select the team with the most attractive combination of experience, skillsets, and price. All microgrid resources will be monitored on an ongoing basis to ensure efficient operation, plan maintenance activities, troubleshoot issues, and respond to equipment alarms.

Legal and Regulatory Advisors: Hitachi's Microgrid Business is served by Crowell & Moring outside counsel. Crowell & Morning has a dedicated energy practice with more than 50 attorneys and a significant presence in New York. Further credentials can be provided on request.

LEGAL VIABILITY

The project team has developed a model for the legal organization of the White Plains 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. As the lead developer of the Stage 1 feasibility study, Hitachi is in a unique position to understand the commercial proposition and opportunity of the White Plains Community Microgrid and how to make the project a success.

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:

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

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

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

Utility Cooperation: The negotiation of interconnection agreements with local utilities can cause significant delays and lead to new costs when the proposed microgrid concepts are unfamiliar to the utility's staff and engineering contractors. To date, Con Edison has demonstrated support and cooperation with the approach and has not identified any deal killers so far. They will provide more detailed input to the design and interface requirements in the detailed engineering stage following this study. Through continued collaboration and sharing of design details, White Plains can expect this risk to be fairly small in the next phase.

Regulatory Issues

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

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

The use of the pre-existing ConEd underground circuits that lay along East Post Road, Lexington Avenue, Martine Avenue, and Dr. Martin Luther King Blvd, is not a simple jurisdictional issue, but it is workable through appropriate negotiation with the City of White Plains and ConEd. The advantage of using the pre-existing underground circuits for resilience of the critical facilities in the project area is clear.

The largest load, White Plains Hospital, is not currently served by underground cabling. It has three overhead line circuit feeds from Maple Avenue; this does not meet resilience criteria. The microgrid solution would supply ~85% of the electric consumption for the Hospital from the Microgrid CHP plant on the north side of East Post Road directly to the Hospital via underground cabling under the street.

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

The second largest load, White Plains Housing Authority, would be supplied directly from the Microgrid CHP plant on the north side of East Post Road, which is contiguous with the White Plains Housing Authority property.

The use of the pre-existing ConEd underground circuits mentioned above would be used to serve the remaining critical facilities (city, county, state, and federal) and essential facilities (grocery, pharmacies, and gas stations) important to a functioning community in the face of a major storm and extended grid outage. Since the ConEd franchise rights are granted by the City of White Plains, waivers and exemptions to the franchise rights are the purview of the City of White Plains. This is totally consistent with the NY REV proceedings and expectations because such a community resilience microgrid is in the public interest as judged by the City of White Plains.

In the proposed design, there would be switching added to the underground circuits at the various points of common coupling (PCC) to enable the project area to be islanded during a major storm and extended grid outage. This would provide the City of White Plains with the ability to continue critical operations and services to the city and broader region in the face of a major storm and extended grid outage. This additional switching, monitoring, protection, and control costs are included in the Microgrid project costs.

The expectation by the stakeholders and Microgrid SPE is that in exchange for the improvement to these underground circuits, and added resilience for the community, as well as the added local generation that would defer T&D capital upgrades by ConEd in this area for decades, there is no need to charge the full freight of the delivery charges for these critical and essential facilities. With local generation, only a very local, and very small portion of the distribution system is utilized, thus only a very local, and very small portion of the delivery charge would be appropriate.]

Privacy

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

CONCLUSIONS AND NEXT STEPS

The White Plains Community Microgrid is designed to meet specific needs within the community. These include the need to ensure the safety of vulnerable populations, the need to harden infrastructure against storm damage, and the need to ensure continuity of emergency operations and services. The microgrid will provide a highly reliable supply of energy to facilities in White Plains that are critical to all the city's citizens, but especially those most at risk. The hospital, retirement home, and large public housing complex are all home to populations for whom evacuation or relocation in an emergency would be difficult or impossible. Many other facilities included in the microgrid design will play an essential role in emergency response or public safety.

The microgrid will ensure that the missions that all of these facilities support are able to continue uninterrupted, even when the rest of the power grid is down.

The White Plains community is particularly well suited to microgrid development, due to the tight clustering of critical facilities in downtown White Plains. Instead of a distributed, nodal approach that many community microgrids take, the White Plains microgrid will include all facilities in a single node, which will allow facilities to share DER and a single microgrid control system, and help control costs.

In part because of this structural advantage, the White Plains Community Microgrid will be able to provide resilience to critical facilities and add new renewables to the grid while simultaneously lowering customers' monthly energy costs.

This feasibility analysis identified third-party ownership as the most likely and practical model for the development of the White Plains Community Microgrid. This ownership model will allow the White Plains community to reap the benefits of the microgrid without having to pay for its design, development, or construction. Based on this preliminary analysis, the third party SPE will be able to generate revenue from PPAs while still offering customers a lower cost of energy.

The project team believes that the proposed microgrid design will serve as a leading example for New York and will be beneficial and replicable to hundreds of other communities across the State and beyond. Key findings from the feasibility assessment include the following:

1. ***Engaged Stakeholders*****:** The Community Microgrid is built around a set of facilities and institutions that are well established, and committed to the project. Most of these facilities are owned or managed by public entities, including the City of White Plains, Westchester County, the State of New York, and the federal government. The private facilities included in the study have all contributed to the project in various ways. These include the facilities associated with the White Plains Hospital.
2. ***Efficiently Organized Infrastructure***: The White Plains Community Microgrid is organized into a single "node" (not distributed into several geographically distinct nodes, as is commonly the case with community microgrids). This helps to control the overall cost of the project by minimizing the need to install new distribution infrastructure.
3. ***Leveraging underground infrastructure:*** In order for the resilience benefits of a community microgrid to be maximized, distribution infrastructure must be installed underground, to protect it from storm damage, sabotage, and other threats. However, underground installation can be quite expensive, and can quickly drive up the overall budget of a microgrid. The White Plains Community Microgrid will be built around existing underground infrastructure, ensuring a high degree of resilience while controlling costs.
4. ***Natural Gas Costs***: Natural gas is one of the largest cost drivers of this system. Increasing costs for natural gas will have a negative impact on the PPA rates for each of the facilities, but overall electricity cost savings should still increase year over year for microgrid customers compared to the cost of electricity from the grid.
5. ***Community Microgrid Financing Costs***: The cost of project financing is high for community microgrids. This is due to the fact that there are numerous stakeholders and potential

customers that have their own procurement requirements. The project team will need to seek out a financier that is knowledgeable about these projects, and can help keep transaction costs to a minimum.

6. ***Financial Prospects:*** The feasibility analysis indicates that the White Plains Community Microgrid project meets the financial requirements for third party financing and ownership.

Regulatory and Policy Recommendations

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

1. ***Franchises and Rights-of-Way***: Community microgrids almost always include critical facilities that are not co-located on the same parcel of land. To interconnect these facilities requires the crossing of one or more public right of ways. The installation of electrical distribution lines (above or below ground) or thermal distribution infrastructure across a public right of way will usually infringe on an existing franchise, or require a new one to be issued. In New York State, each municipality (town, village, city, etc.) has the statutory authority to grant franchise rights or similar permissions. In many cases, these franchise rights have already been granted to the distribution utility, and the installation of microgrid infrastructure by a third party may represent an infringement of that franchise.[3]

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

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

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

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

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

not help drive the broader market for microgrids as this limits the number of systems that will be implemented in the near term.

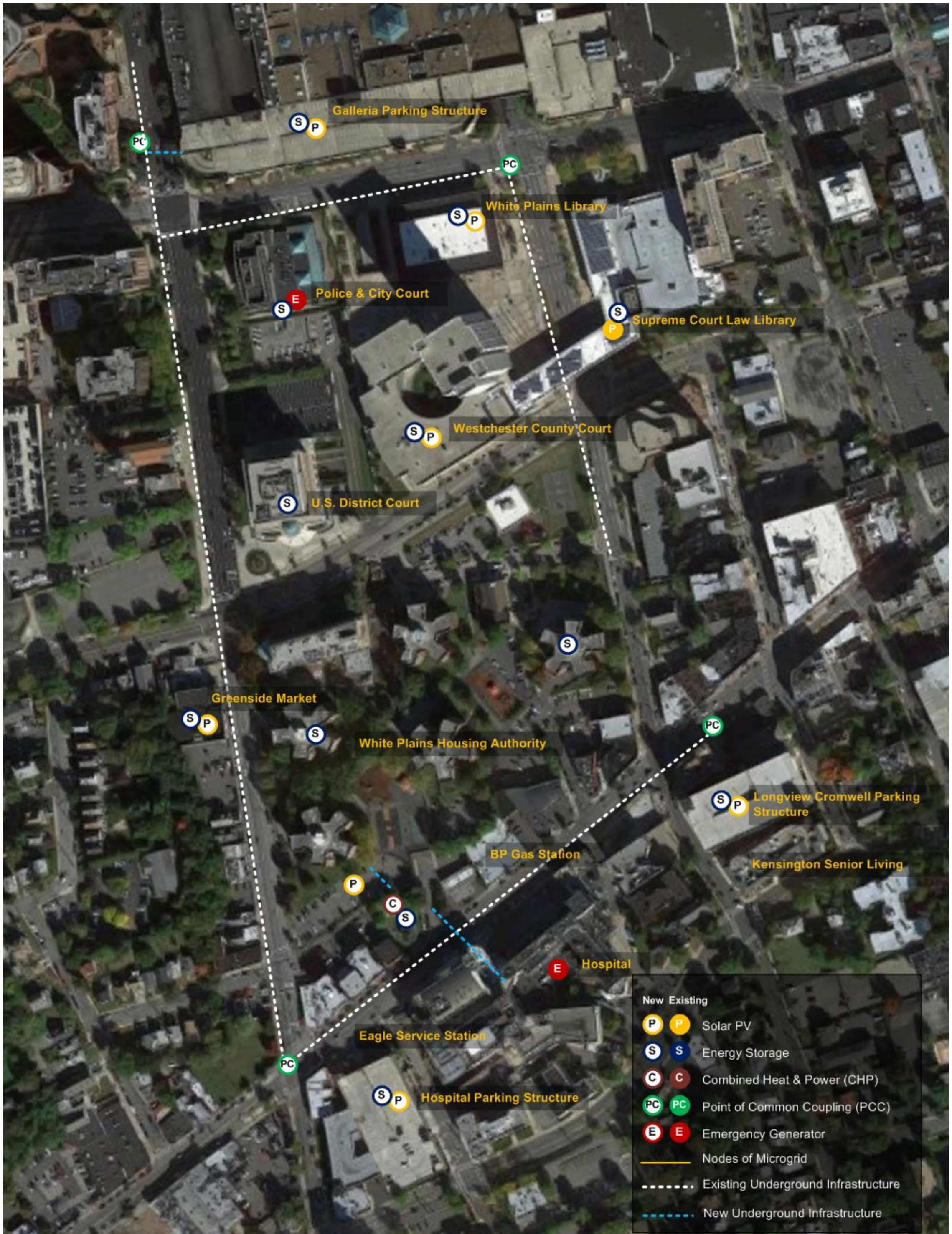
Greater clarity from the state on the circumstances under which utility ownership of microgrid assets would help communities interested in microgrid development assess utility ownership as an option, and evaluate the costs and benefits of this ownership model.

3. ***CHP Natural Gas Tariffs:*** The resilience of natural gas infrastructure to storm damage and other disruption makes it an attractive fuel source for powering microgrid energy resources (such as combined heat and power plants). The economic health of microgrids that use natural gas plants to meet base loads is subject to favorable natural gas tariffs. The application of natural gas generators create benefits in the form of a base natural gas load (including in the summer months when natural gas demand is lowest), and improved system efficiency (through generation located at the load, efficient operation on the power curve, and recovery of heat to offset other heating loads). Most utilities offer specific tariffs for the operation of distributed generation equipment. State support for attractive natural gas tariffs helps to assure viable business models for both CHP and microgrid development.
4. ***Multiple Customer Contracting:*** Multiple customers within the community microgrid create challenges of financing, procurement, and operations across the stakeholders in the community. Continued state support for the NY Green Bank mission of implementing structures that address gaps and overcome barriers in current and clean energy financing markets, particularly as related to community microgrids with multiple customers and customer types, may lead the industry toward sustainable solutions for addressing these issues.
5. ***Stage 2 and Stage 3 Funding Structure:*** Stage 2 funding should focus on advancing the project towards the construction phase, and less on reporting deliverables. Stage 3 funding sends a poor market signal, indicating that microgrids need subsidies in order to be cost effective, which is often not the case.
6. ***Municipal Lowest Rate Requirement:*** Regulations that require that municipal customers pay the lowest available rate for electricity and gas may prevent investment in microgrid infrastructure and resilience benefits through a PPA in certain cases. Projects that provide other societal benefits (support critical loads, serve the community at times of natural disaster, reduce emissions, etc.) should be eligible for consideration as projects that municipalities may execute.
7. ***Competitive Procurement Requirements*:** Given cost share requirements in Stage 2, development firms are going to hesitate to invest unless they are assured work in Stage 3. This could potentially be mitigated by state-issued guidance for special exemptions for the NY Prize program, or by encouraging a single procurement process for Stage 2 and 3.

The next steps that the White Plains Community will need to undertake are to finalize the ownership structure to be proposed, and identify a team of partners to engage in the detailed design phase of the project. Once these decisions are made, the project team will draft a proposal to NYSERDA to compete in Stage 2 of NY Prize. This Stage 2 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. 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.

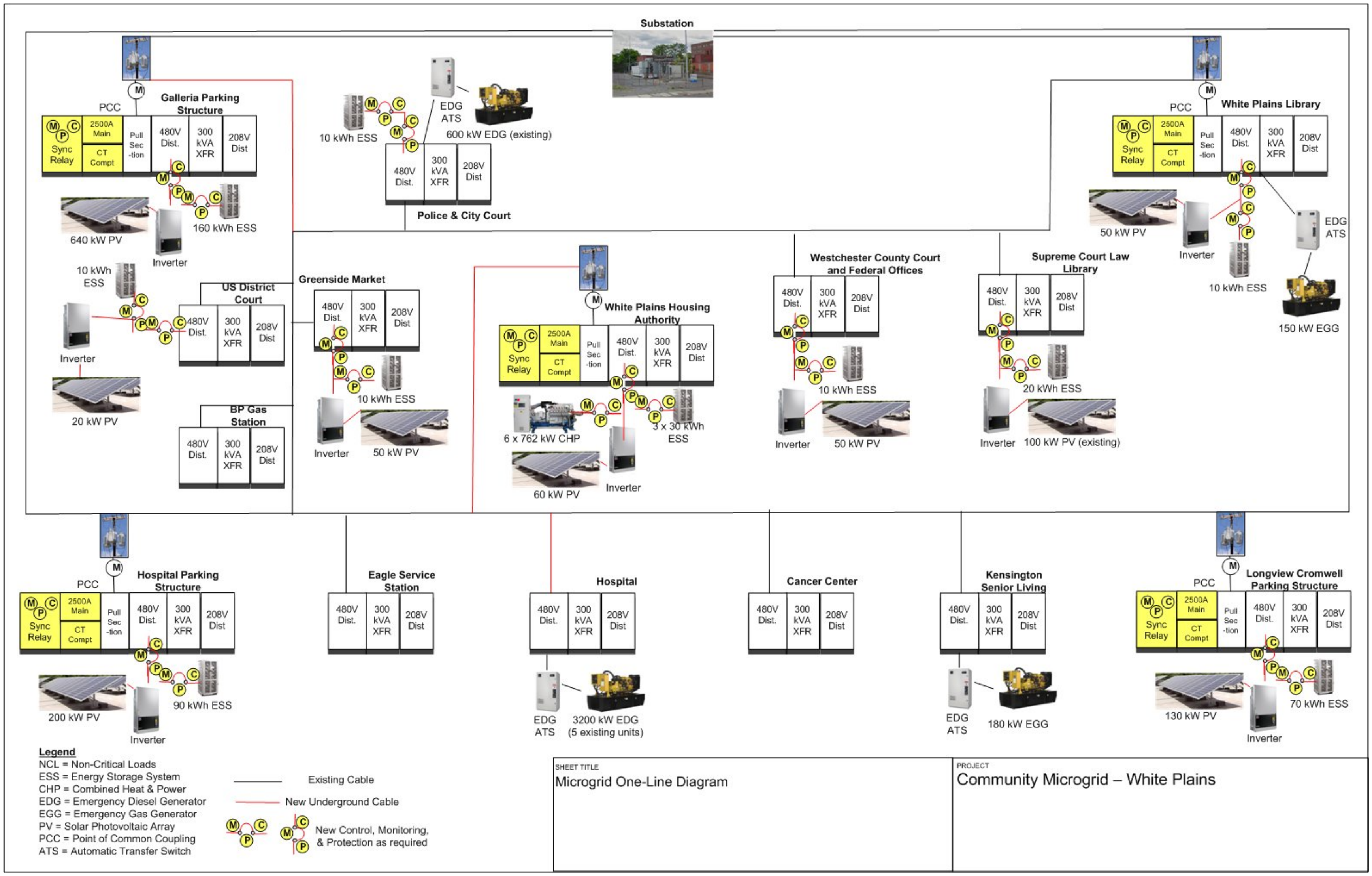
[End of Report]

APPENDIX A: WHITE PLAINS MICROGRID LAYOUT DIAGRAM



SHEET TITLE Microgrid Geospatial Diagram	PROJECT Community Microgrid – White Plains

APPENDIX B: WHITE PLAINS MICROGRID ONE-LINE DIAGRAM



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 White Plains 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, among other things, 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."[6]

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

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

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."[7] Storage integrated into a microgrid would not seem to qualify under this condition.

Speaking to the third scenario, the proposed project does target low/moderate income customers who may not otherwise be likely to receive microgrid service from the market, the Brookfield Commons residences. As these customers represent only a portion of the microgrid customers proposed, however, this factor should be discussed further with DPS Staff if Con Edison ownership is proposed under this scenario. A specific technical design, e.g., that proposed Con Edison ownership of assets sized and configured to serve the Brookfield Commons facility specifically may be more likely to gain approval than utility ownership of a much larger scale of generation assets serving the entire microgrid.

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).[8]

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

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[7] Id. at 69.

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

party ownership must be done in a manner that ensures safety, reliability and consumer protection."[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.[10]

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."[11] The Commission has not yet issued a formal deadline for the proposal of new demonstration projects at this time.

In the White Plains 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 White Plains 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

[9] Id. at 9.

[10] 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.

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

metering is available in New York to residential and nonresidential solar, wind, fuel cells, microhydroelectric, agricultural biogas, and residential micro-CHP.

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.[12]

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 White Plains 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.[13]

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.[14]

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 White Plains 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 Con Edison 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

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[12] NY PSL § 66-j.

[13] Available at http://www.Con Edison.com/documents/elecPSC10/GR24.pdf#nameddest=riderr.

[14] Available at http://www.Con Edison.com/documents/elecPSC10/SCs.pdf#nameddest=sc11.

control system provides signals to the units indicating when to run and when not to run. Burrstone's algorithm makes hourly operational decisions that are automatically implemented by the Energy Management System.

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[15] 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.[16] 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 Brookfield Commons Housing Development.

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 White Plains 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."[17]

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.[18]

3. Privately-Owned Microgrid Distribution

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

[16] 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

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

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

White Plains 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 White Plains 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[19] (investigating the manufacture, distribution, and transmission of electricity; ordering improvements; and performing audits), rates,[20] safe and adequate service,[21] all aspects of the billing process, financial, record-keeping, and accounting requirements,[22] corporate finance and structure,[23] and more. This expansive purview of regulation may prove too administratively onerous for a small project like the White Plains 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

White Plains' microgrid may be exempted from much of the PSL regulation applying to electric distribution companies if it is deemed a qualifying facility under the terms of PSL §2. A microgrid will be deemed a qualifying facility if it utilizes qualifying forms of generation,[24] is under 80 MW,[25]

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[19] PSL § 66.

[20] PSL § 65.

[21] PSL § 66.

[22] PSL § 66, 68(a).

[23] PSL § 69.

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

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

Type of generation facilities: In the White Plains 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 White Plains 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.[26] 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."[27] 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 White Plains microgrid, it would be wise, as the petitioners in *Burrstone* did, to petition the Commission for a declaratory ruling that the multiple users anticipated in this microgrid do not run counter to the Commission's interpretation of PSL §2.

Distribution facilities at or near generation: The physical distance that distribution facilities may extend from generation facilities has been questioned in several Commission decisions applying the qualifying facility standard.[28] 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.[29]

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resource recovery, refuse-derived fuel or wood burning facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts, which produces electricity, gas or useful thermal energy." NY PSL Ser § 2-b.

[25] Id.

[26] 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).

[27] Id.

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

[29] Id.

In the White Plains microgrid, the geographic footprint of private distribution facilities will likely 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 0.5 miles. Private distribution facilities would have to cross property lines, and several rights of way. Declaratory rulings addressing facilities in comparable environments have met or exceeded this distance, such as *Burrstone* (approximately half a mile),[30] *Nissoquogue Cogen Partners* (1.5 miles),[31] and *Nassau District Energy Corporation* (1.7 miles).[32] Of these, the closest precedent may be the Burrstone case, because the Commission in Burrstone considered whether crossing multiple property lines complicated the "at or near" analysis (while Nissoquogue and NDEC involved distribution passing almost entirely over a single property). If private distribution across the entire microgrid were proposed, it would likely mirror the length for which the Commission has provided positive precedent.

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

ii. Lightened Regulation

If the White Plains project does not otherwise qualify for regulatory exemption, it may petition the Commission for a lightened regulatory burden. The Commission may consider a "realistic appraisal" of the need to regulate the microgrid based on a three-prong analysis: 1) whether a particular section of the PSL is inapplicable on its face; 2) if a provision is facially applicable, whether it is possible for an entity to comply with its requirements; and 3) whether imposing the requirements on an entity is necessary to protect the public interest, or whether doing so would adversely affect the public interest.[33] 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.[34] 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 White Plains 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,"[35] 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

[30] 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).

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

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

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

[34] 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).

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

function or make specific proposals. Parties were invited to comment on this matter on May 1st, 2015. The White Plains 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.

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

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

Wholly utility-owned microgrids may have several advantages over privately-owned microgrids, including ease of the interconnection process, the utility's superior access to capital, and ease of customer solicitation, given the utility's existing relationship with its customers. Examples of microgrids where the utility owns at least some of the generation assets are the Consortium for Electric Reliability Technology Solutions (CERTS) demonstration project in Ohio, owned by American Electric Power,[36] and the Borrego Springs microgrid owned by San Diego Gas & Electric.[37] 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

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

[37] 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.

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.[38]

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, White Plains 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. Model contract templates for microgrid service have not yet been developed. 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,"[39] but left open for collaborative discussions how this agreement would be structured. Customers will want to be concerned with the following aspects of contracting for microgrid service:

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

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

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

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

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.[40]

In the White Plains 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.
- Rights of utility to access or control equipment and facilities to ensure operational safety (easements, fee for access, etc.)

3. <u>Contracting between Customer and Private Developer</u>

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.[41] 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

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[40] 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.”

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

- 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 White Plains project.

Regulatory Issues and Tariffs

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. Gen. City Law § 20(10), every city is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city.[42] "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.[43]

In the city of White Plains, the process for granting a franchise for electric distribution wires is not specified. Under N.Y. Gen. City Law, the City Council will have discretion in determining the application process to obtain a franchise or lesser consent. General provisions regarding the granting of franchises are specified under Article III of the City Code, which describes the powers of the Common Council. These provisions include:

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[42] N.Y. Gen. City Law § 20(10). (NYJUR Franchise s 4)

[43] 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)

- All franchises are nonexclusive, and are granted for a maximum period of twenty-five years.
- Every grant of a franchise must provide that the city may purchase (at a fair valuation price) and take over the property and plant of the grantee in whole or in part at its discretion.
- No franchise shall be granted without "fair compensation" paid to the city.
- The grantee will be required to annually pay to the city some percentage of the gross receipts arising from the use of the franchise, which percentage must be fixed in the grant of the franchise.[44]

The White Plains Code does specify application procedures and standards of review for the granting of telecom and cable franchises,[45] however, both of these provisions are expressly limited to their respective industries. These provisions may be persuasive in the electrical franchising process, but it is difficult to predict what portions of such conflicting codes may apply. Both the telecom and cable franchising provisions offer some substantial latitude to the Common Council in reviewing the franchise application. The telecom code does clarify that franchise applications should be made to the City's commissioner of public works and corporation counsel, to which project developers should appeal for a more precise interpretation of application procedure at the appropriate time.[46]

IV. Application of Other Local Codes

1. Zoning

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

- White Plains City Police Department and Courthouse, 77 South Lexington, White Plains NY 10601: CB-4 Core Business-4 District
- Westchester County Courthouse, 111 Dr. Martin Luther King Jr Blvd, White Plains NY 10601: CB-4 Core Business-4 District
- US District Courthouse, 300 Quarropas St, White Plains NY 10601: CB-4 Core Business-4 District
- Federal Office Building, 140 Grand St., White Plains NY 10601: CB-4 Core Business-4 District
- White Plains Hospital, 41 E Post Rd, White Plains NY 10601: O-R Office Residential District
- Kensington Assisted Living Residence, 100 Maple Ave, White Plains, NY 10601: O-R Office Residential District
- Hospital Road Pharmacy, 44 East Post Road, White Plains NY 10601: B-3 Intermediate Business District
- Brookfield Commons Housing, various addresses: RM 0.35 Residential Multifamily and B-3 Intermediate Business District
- Coachman Family Center (homeless shelter), 123 E Post Rd, White Plains NY 10601: CB-1 Core Business-1 District
- Open Arms Shelter and Social Services, 86 E Post Rd, White Plains NY 10601: B-3 Intermediate Business District

[44] White Plains City Code §3-33.
[45] See White Plains City Code §4-21 and §4-23.
[46] White Plains City Code §4-23-4.

- BP Gas Station, 34 E Post Rd, White Plains NY 10601: B-3 Intermediate Business District
- Eagle Service Station, 11 E Post Rd., White Plains NY 10601: B-3 Intermediate Business District

Generation as Permitted Use

Electric generation is not expressly listed as a permitted use in any district in White Plains, and the Code is clear that "any 'use' not specifically listed as being permitted shall be deemed to be prohibited."[47] Generation must be sited pursuant to some other permitted use, as an accessory use, a special permit use, or a variance. Solar generation may be exempt from these requirements, as detailed below. For these purposes, the relevant zoning implications will be identical across all zones.

Accessory Use: Unlike in many jurisdictions, permitted accessory uses are ostensibly listed exhaustively in the Zoning Code. The fact that some uses, like emergency generation, are listed elsewhere in the code without ever appearing as a permitted accessory use, however, strains this interpretation. If other accessory uses were allowed under White Plains' Code, they would have to meet the definition of being "incidental and subordinate to the principal 'use' on a 'lot,' and located on the same 'lot' therewith."[48]

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

Permitted Use of the City of White Plains: Every relevant zone includes "'Uses' of the City of White Plains" as a primary permitted use.[49] No definition or provision anywhere in the Zoning Code appears to limit or define what specific uses the City of White Plains may undertake pursuant to this permitted use. "Use" is defined in the Code as "The specific purpose for which land, water, a 'building' or a 'structure' is designed, arranged, intended or for which it is or may be occupied or maintained."[50] Without any further restriction apparent, there is a defensible interpretation of the Zoning Code that would permit the City of White Plains to site microgrid generation under this provision. Inquiries to Corporation Counsel and the Buildings Department related to this question have not been answered to date.

Special Permit Use for "Public Utility Buildings or Structures": Every relevant zone includes "Public Utility Buildings or Structures" as a special permit use.[51] "Public Utility" is defined as "any 'person' duly authorized to furnish to the public, under public regulation, electricity, gas, water, sewage treatment, steam, cable TV or telephone or telegraph service."[52] It is unlikely that this definition

[47] White Plains Zoning Code §5.0.
[48] White Plains Zoning Code §2.4.
[49] White Plains Zoning Code §5.1.
[50] White Plains Zoning Code §2.4.
[51] White Plains Zoning Code §5.1.
[52] White Plains Zoning Code §2.4.

would extend to a private microgrid operator, since microgrid services are not extended to the indefinite public in the same sense that Con Edison service is.

If, however, Con Edison were to own microgrid assets, this provision might permit the siting of these assets wherever the utility seeks a special permit. Special permits are granted following an application to the Buildings Department and a public hearing process.[53] The approving agency will have wide discretion in evaluating the application, subject to the following standards:

> 6.5.1 The location and size of the special permit "use," the nature and intensity of the operations involved in it or conducted in connection with it, the size of the site in relation to it, and the location of the site with respect to "streets" giving access to it are such that it will be in harmony with the appropriate and orderly development of the area in which it is located.
>
> 6.5.2 The location, nature and "height" of "buildings," walls and fences and the nature and extent of existing or proposed plantings on the site are such that the special permit "use" will not hinder or discourage the appropriate development and "use" of adjacent land and "buildings."
>
> 6.5.3 Operations in connection with any special permit "use" will not be more objectionable to nearby properties by reason of noise, traffic, fumes, vibration or other characteristics than would be the operations of permitted "uses" not requiring a special permit.[54]

Standards specific for the approval of a public utility structure variance include protective fencing, a surrounding screen of evergreens, landscaping, and a particular showing of necessity if the structure happens to be in a residential zone, which does not appear necessary in this project.[55]

<u>Variances</u>: The Zoning Board of Appeals is empowered to hear applications for variances from the use restrictions of the Zoning Code.

Code specifies that each variance applicant should meet four criteria:

(a) The applicant cannot realize a reasonable return, provided that lack of return is substantial as demonstrated by competent financial evidence;
(b) That the alleged hardship relating to the property in question is unique and does not apply to a substantial portion of the district or neighborhood;
(c) That the requested variance, if granted, will not alter the essential character of the neighborhood; and
(d) That the alleged hardship has not been self-created.[56]

These provisions are consistent with New York State precedent,[57] as well as State law incorporating that precedent. These requirements are unlikely to be satisfied for microgrid facilities, which may

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[53] White Plains Zoning Code §6.4.
[54] White Plains Zoning Code §6.5.
[55] White Plains Zoning Code §6.7.12.
[56] White Plains Zoning Code §10.3.5.1.

add value to the properties in question, but are not indispensable to the value of the properties in general.

Solar Energy Siting: Notwithstanding the absence of any mention among the permitted uses elsewhere, the Code states that "Solar energy systems, which are devices used to capture the sun's radiation and transform it into usable heat or electricity, are permitted as a part of, and may be attached to, any 'building.'"[58] Relevant dimensional and siting guidelines are included in §4.4.21.

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

2. Fire Code

Each of the individual building-related codes in White Plains incorporate their State corollaries.[59] The White Plains Fire Code, which acts as a supplement to the State Fire Code, does not contain any specific substantive provisions relating to electrical generation or transmission.

3. Building Code

The City of White Plains Building Code incorporates the New York State Building, Fire, Mechanical, Property Maintenance, Plumbing, Energy, Fuel Gas and Residential Codes.[60] It requires a permit from the Building Commissioner before the siting of any electrical generation,[61] as well as any underground structures required for utility service,[62] which allows the Commissioner to conduct

[57] *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.

[58] White Plains Zoning Code §4.4.21.1.

[59] See White Plains Building Construction Code, which reads, "The White Plains Supplemental Building Code promulgated pursuant to Section 238-t of the White Plains City Charter, as amended, when combined with the New York State Building, Fire, Mechanical, Property Maintenance, Plumbing, Energy, Fuel Gas and Residential Codes, shall be known and may be cited as the 'The White Plains Supplemental Building Code', and is hereinafter referred to as 'this Code' or 'the Code'. The White Plains Supplemental Building Code is comprised of a series of individual codes. These codes include The White Plains Building Code—Administration and Enforcement, The White Plains General Construction Code, The White Plains Mechanical Code, The White Plains Electrical Code, The White Plains Fire Code, The White Plains Smoke Control Code, The White Plains Plumbing Code, The White Plains Vertical Transportation Code and The White Plains Property Maintenance Code." Read together, each of these various City codes incorporate by cross-reference their State corollaries.

[60] White Plains Building Code, preamble.

[61] White Plains Building Code §l(1).

[62] White Plains Building Code §l(3)(ii).

general and periodic inspections at their discretion. It does not make any other substantive requirements impacting generation or electrical distribution.

4. Electric Code

Each of the individual building-related codes in White Plains incorporate their State corollaries.[63] The White Plains Electrical Code does not make any substantive additions impacting generation or electric distribution.

V. Applicable Tariffs

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

1. Standby Tariff

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[64] unless they are otherwise exempt.[65] 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 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.[66]

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

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[63] See fn. 54, above.

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

[65] 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).

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

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."[67] 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[68] 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 Facility with a name plate rating less than 50 MegaWatts and having an Annual Load Factor equal to or greater than 50 percent."[69] 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

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

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

[69] *See* Consolidated Edison's Rider H tariff, available at http://www.Con Edison.com/documents/gas_tariff/pdf/0003(06)-General_Information.pdf#page=37.

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.[70] 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.[71] Utilities can bear the cost of extensions and additional facilities beyond 100 feet if the utility deems the expansion to be cost justified.[72] 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.[73] 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.

[70] 16 NYCRR § 230.2(b).

[71] 16 NYCRR § 230.2 (c), (d), and (e).

[72] 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.

[73] 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: BENEFIT-COST ANALYSIS

Site 33 - City of White Plains

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the City of White Plains (the county seat of Westchester County) has proposed development of a microgrid that would enhance the resiliency of electric service for the following facilities:

- White Plains Hospital & Parking Pavilion;
- Kensington Center assisted living facility;
- White Plains Police and Court;
- Supreme Court Law Library;
- U.S. District Court;
- Westchester County Court and Federal Offices;
- Westchester County Court Parking Garage;
- White Plains Housing Authority affordable housing;
- White Plains Library;
- Cancer Center; and,
- Several commercial facilities, including BP Gas Station, Eagle Service Station, the Galleria Mall at White Plains Parking Structure, Greenside Market, and Longview Cromwell Municipal Garage.

The microgrid would incorporate combined heat and power (CHP) and solar capabilities to provide base load power. Three 1.5 MW natural gas-fired CHP units would be located at the White Plains Housing Authority affordable housing facility. Existing solar capability would supplement the microgrid, with photovoltaic (PV) equipment distributed among the facilities providing 1.2 MW of nameplate capacity. In addition, a battery storage system and energy efficiency measures would be incorporated into the microgrid.[74] The operating scenario submitted by the project's consultants indicates that these new resources together would produce approximately 37,800 MWh of electricity per year, roughly 85 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

[74] In addition to these resources, the microgrid would incorporate the emergency generators that currently serve the facilities listed above. These units, however, would only be relied upon in extreme circumstances and would not operate on a regular basis. An existing PV array at the Supreme Court Law Library with 0.1 MW of capacity would also be integrated into the microgrid; the operating profile of this unit is not expected to change with development of the microgrid.

electricity use at the facilities served by the microgrid.[75] They also indicate that the system would be capable of providing ancillary services to the grid.

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

METHODOLOGY AND ASSUMPTIONS

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

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

This analysis relies on an Excel-based spreadsheet model developed for NYSERDA to analyze the costs and benefits of developing microgrids in New York State. The model evaluates the economic viability of a microgrid based on the user's specification of project costs, the project's design and operating characteristics, and the facilities and services the project is designed to support. The model analyzes a discrete operating scenario specified by the user; it does not identify an optimal project design or operating strategy.

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.[76] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of

[75] As noted previously, the capacity of the new resources appears sufficient to supply 85 percent of average daily electricity use at facilities within the microgrid's island; the remainder would come from the existing PV and emergency generators the system would incorporate.

[76] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO_2 emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO_2, NO_x, and $PM_{2.5}$, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

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

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[77]

RESULTS

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

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.7 DAYS/YEAR
Net Benefits - Present Value	-$11,500,000	$165,000
Benefit-Cost Ratio	0.8	1.0
Internal Rate of Return	-10.2%	6.1%

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

Scenario 1

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

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

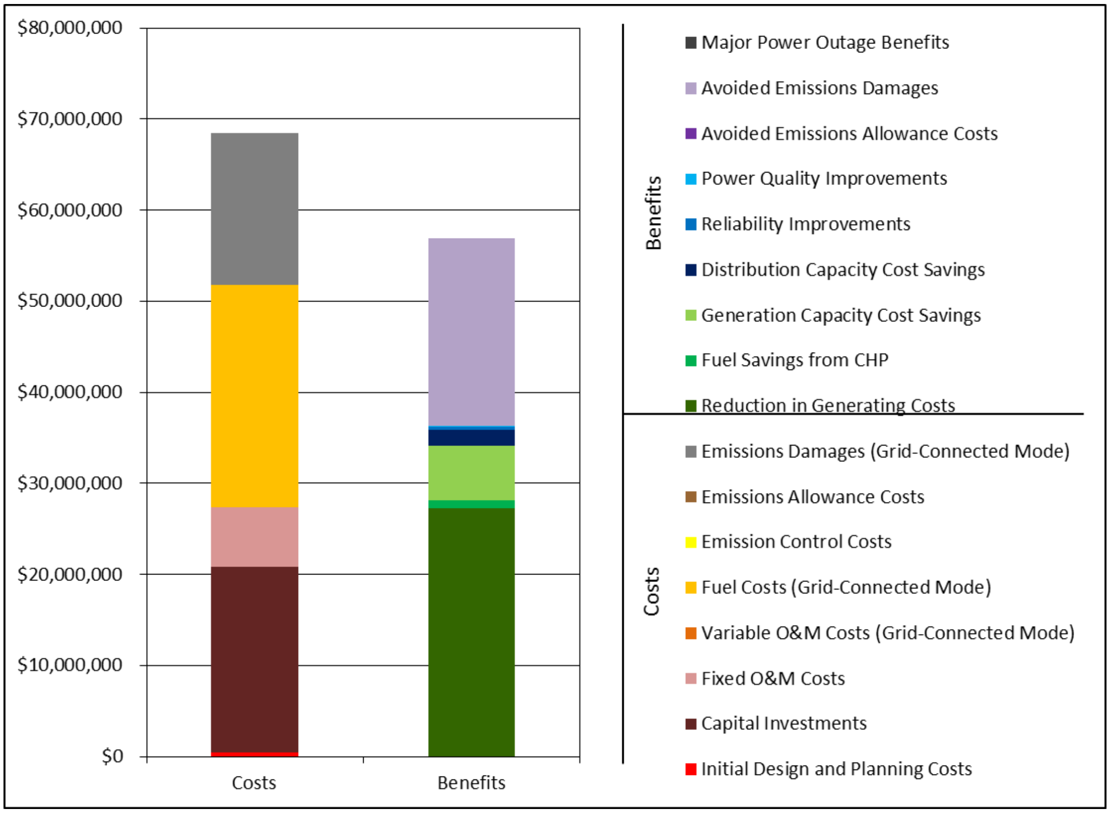

Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$20,400,000	$1,610,000
Fixed O&M	$6,520,000	$576,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$24,400,000	$2,150,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$16,600,000	$1,090,000
Total Costs	**$68,500,000**	
Benefits		
Reduction in Generating Costs	$27,200,000	$2,400,000
Fuel Savings from CHP	$879,000	$77,600
Generation Capacity Cost Savings	$6,000,000	$529,000
Distribution Capacity Cost Savings	$1,790,000	$158,000
Reliability Improvements	$278,000	$24,600
Power Quality Improvements	$130,000	$11,500
Avoided Emissions Allowance Costs	$13,400	$1,180
Avoided Emissions Damages	$20,600,000	$1,350,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$56,900,000**	
Net Benefits	**-$11,500,000**	
Benefit/Cost Ratio	**0.8**	
Internal Rate of Return	**-10.2%**	

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.[78] The present value of the project's capital costs is estimated at approximately $20.4 million, including costs associated with installing the new CHP units, PV arrays, battery storage, and associated microgrid infrastructure (controls, communication systems, information technology, etc.). The present

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

value of the microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at $6.52 million, based on an annual cost of $576,000.

Variable Costs

A significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's three CHP units. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.[79] Based on these figures, the present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $24.4 million.

In addition, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's CHP units are estimated at approximately $1.09 million annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $16.6 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $27.2 million; this estimate takes into account both the electricity that the microgrid's CHP units and PV arrays would produce and an anticipated reduction in annual electricity use at the facilities the microgrid would serve.[80] In addition, the new CHP systems would cut consumption of natural gas for heating purposes; the present value of these savings over the 20-year period analyzed is approximately $879,000. 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 $13,400 and avoided emissions damages with a present value of approximately $20.6 million.[81]

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

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

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

[81] 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.

capacity.[82] Based on application of standard capacity factors for the CHP units, as well as the capacity of the battery storage systems, the analysis estimates the present value of the project's generating capacity benefits to be approximately $6.0 million over a 20-year operating period. Similarly, the project team estimates that the microgrid project would reduce the need for local distribution capacity by approximately 4.32 MW/year, yielding annual benefits of approximately $158,000. Over a 20-year period, the present value of these benefits is approximately $1.79 million.

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

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $24,600 per year, with a present value of $278,000 over a 20-year operating period. This estimate was developed using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[83]

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.[84]

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.[85] 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.

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[82] 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.

[83] www.icecalculator.com.

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

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

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. The White Plains 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 $130,000 over a 20-year operating period.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.8; i.e., the estimate of project benefits is approximately 80 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

The estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[86,87]

As noted above, the City of White Plains' proposed microgrid project would serve 16 facilities during an extended outage. In the BCA model, several factors influence the costs that facilities would incur during an outage, including the following:

- Whether or not backup generation currently exists at the facility;
- Whether the facility would rent a backup generator to supply power during an outage;
- The ability of the facility to operate when using backup power;
- The ability of the facility to operate during a complete loss of power;
- The cost of operating existing or rental generators;

[86] 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.

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

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

Table 3 summarizes these parameters for the facilities included in the microgrid. 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. Summary of Major Power Outage Parameters, Scenario 2

FACILITY (OR FACILITIES)	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
	VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY
White Plains Hospital	FEMA methodologies		40%	100%	$0	$4,694	$0	$0
Police and City Court	FEMA methodologies		50%	60%	$0	$606	$0	$0
White Plains Housing Authority (affordable housing facility)	FEMA methodologies		50%	100%	$1,000	$500	$0	$0
Kensington Center (assisted living facility)	$13,098	Genworth	40%	100%	$0	$215	$75,000	$0
White Plains Public Library	$144,537	ICE	50%	100%	$0	$360	$0	$0
11 large commercial facilities (BP Gas Station, Eagle Service Station, Cancer Center, Galleria Mall at White Plains Parking Structure, Greenside Market, Longview Cromwell Municipal Garage, Supreme Court Law Library, U.S. District Court, Westchester County Court and Federal Offices, Westchester County Court Parking Garage, and White Plains Hospital Parking Pavilion)	$1,339,145	ICE	50%	100%	$11,000	$5,500	$0	$0

As shown in Table 3, facilities are grouped as follows for purposes of analyzing the effects of a major power outage:

- **The White Plains Hospital.** The hospital has backup generators and would maintain 60 percent of its service capabilities in the event of an outage. The analysis calculates the impact of an outage on the hospital using standard FEMA methodologies.[88]

- **Police & Court Complex**. This complex has a backup generator and would maintain 50 percent of its service capabilities in the event of an outage. The analysis calculates the impact of an outage on this facility using standard FEMA methodologies.

- **White Plains Housing Authority affordable housing facility**. The housing authority facility does not have a backup generator, but would rent one in the event of a major outage. The facility houses approximately 1,800 residents. The analysis assumes these residents would not be relocated during an outage. It calculates the impact of an outage using standard FEMA methodologies.

- **Kensington Center**. This assisted living center has a backup generator and would maintain 60 percent of its service capabilities in the event of an outage. The value of service is estimated based on Genworth's values for assisted living costs for New York State (Rest of State). Additional costs that would occur as a result of a complete loss of power include a one-time cost of $75,000 for evacuating and moving patients to other facilities.

- **The White Plains Library**. The library has a backup generator and can maintain half of its service capabilities while on backup power. The value of service for the library is estimated using the ICE Calculator.

- **11 large commercial facilities**. This subset of commercial facilities has no existing backup capabilities. The analysis assumes that these facilities would rent backup generators to maintain 50 percent of their operations during a power outage. The collective value of service, as estimated by the ICE Calculator, is high (about $1.4 million per day), reflecting extensive power use.

Summary

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

[88] For purposes of the analysis, the population served by the hospital is calculated based on the number of emergency room visits provided by the project team; White Plains Hospital handles around 55,000 emergency room visits per year.

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

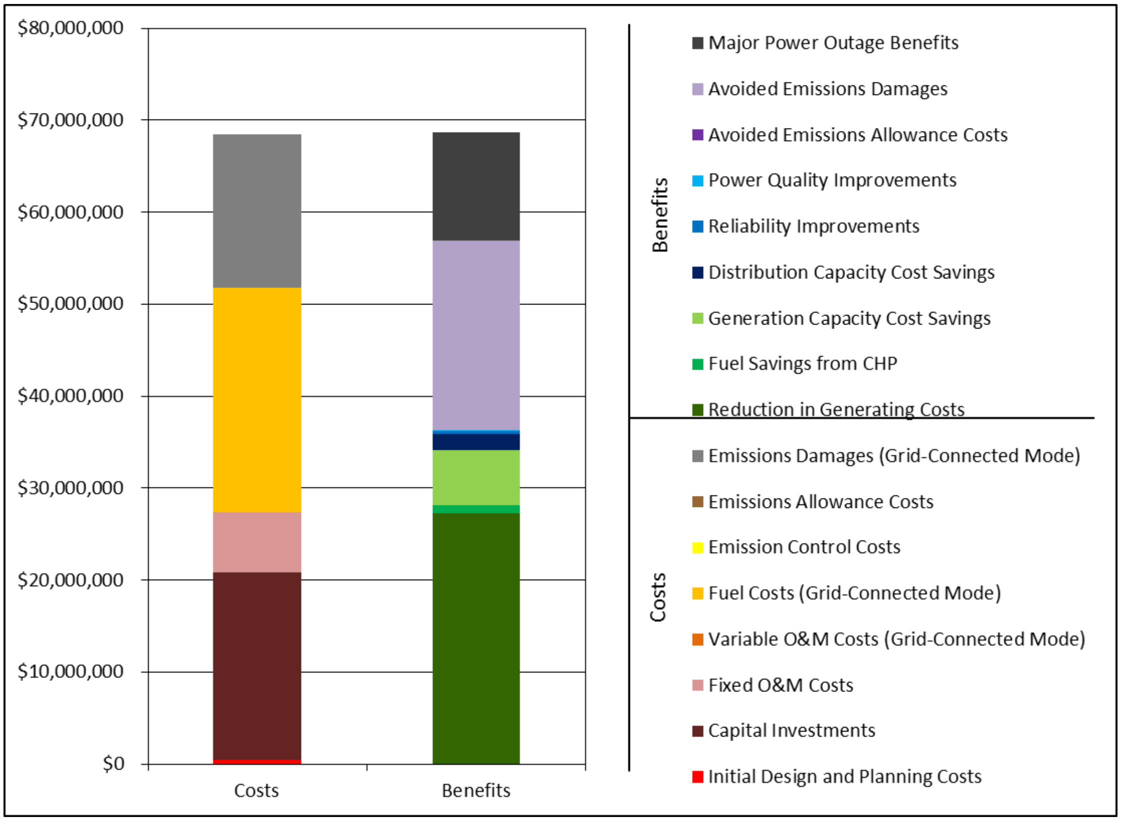

Table 4. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.7 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$20,400,000	$1,610,000
Fixed O&M	$6,520,000	$576,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$24,400,000	$2,150,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$16,600,000	$1,090,000
Total Costs	**$68,500,000**	
Benefits		
Reduction in Generating Costs	$27,200,000	$2,400,000
Fuel Savings from CHP	$879,000	$77,600
Generation Capacity Cost Savings	$6,000,000	$529,000
Distribution Capacity Cost Savings	$1,790,000	$158,000
Reliability Improvements	$278,000	$24,600
Power Quality Improvements	$130,000	$11,500
Avoided Emissions Allowance Costs	$13,400	$1,180
Avoided Emissions Damages	$20,600,000	$1,350,000
Major Power Outage Benefits	$11,700,000	$1,030,000
Total Benefits	**$68,600,000**	
Net Benefits	**$165,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.1%**	

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
- SCADA – supervisory control and data acquisition
- SGIP- Smart Grid Interoperability Panel
- SOC- state of charge
- SPE- special purpose entity