

## **28 - Village of Irvington**

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# **Irvington Community Microgrid**

## **Final Report – NY Prize Stage 1: Feasibility Assessment**

**Submitted to:**

**NYSERDA**

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**TABLE OF CONTENTS**

Project Team .....	I
Irvington Community Microgrid - Key Overview Metrics .....	II
EXECUTIVE SUMMARY .....	III
TECHNICAL DESIGN .....	1
Key Features of the Microgrid .....	6
Community Microgrid Controller.....	6
Telecommunications Infrastructure .....	10
Communications – Microgrid and Utility.....	11
Distributed Energy Resources Characterization .....	12
Geospatial Diagrams and One-Line Subsections .....	16
Modeling Methodology .....	22
Load Description .....	22
Combined Heat and Power .....	25
Solar Photovoltaics.....	29
Energy Storage Systems .....	33
Island Mode Modeling Results.....	37
Microgrid DERs Resiliency.....	38
Reliability of Fuel Sources .....	40
FINANCIAL FEASIBILITY .....	40
Installed Cost.....	40
Third Party Ownership .....	41
Benefit-Cost Analysis .....	43
Development, Construction, and Operating Approach .....	48
SWOT Analysis.....	51
PROJECT TEAM.....	52
LEGAL VIABILITY .....	53
CONCLUSIONS AND NEXT STEPS.....	55
Appendix A: Irvington Microgrid Layout Diagram .....	59
Appendix B: Irvington Microgrid One-Line Diagram.....	60
Appendix C: Legal and Regulatory Review.....	61
Appendix D: IEc Benefit-Cost Analysis .....	80

Appendix E: Consolidated Edison Comments and Responses .....	92
Appendix F: Acronym Glossary .....	94

## **PROJECT TEAM**

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### **Pace University**

- Thomas Bourgeois
- Daniel Leonhardt
- Jordan Gerow

### **GI Energy**

- Peter Falcier

### **Green Energy Corps.**

- Paul Gregory

## **PROJECT STAKEHOLDERS**

- The Village of Irvington
- Irvington Union Free School District
- Immaculate Conception Church
- Irvington Public Library
- Irvington Public Works Department
- Irvington Senior Citizens Center
- Various Private Businesses

## IRVINGTON COMMUNITY MICROGRID - KEY OVERVIEW METRICS

### Team

Lead (Awardee):	Village of Irvington
Technical Partners:	Hitachi Microgrids, Pace University, Sustainable Westchester, Green Energy Corp, GI Energy

### Utilities

Electric:	Con Edison
Gas:	Con Edison

### Supporting Organizations

Consolidated Edison	Monte Nido River Towns
Irvington Ambulance Corps	Irvington Union School District
Irvington Recreation and Parks	

### Microgrid Financials

Total Installed Cost:	\$ 4,491,000
Net Installed Cost:	\$ 4,162,000
Annual Resiliency Savings:	\$ 216,000
Annual GHG Offset:	\$ 53,000
Avg. Cost of Electricity:	\$0.141/kWh

### Microgrid System Design

Size:	739	kW
Load Served:	6,039,951	kWh/yr
DER	Quantity	Capacity
Combined Heat & Power:	6	571 kW
Photovoltaic:	8	168 kW
Existing Photovoltaic:	1	7 kW
Energy Storage Systems:	7	190 kWh
Existing Emergency Gen:	4	168 kW

### Customer Types

Gov't Administrative:	4
Emergency Services:	3
Municipal Services:	0
Education	3
Health Care:	1
Large Commercial:	3
Small Commercial:	25
Multi-Unit Residential:	0
<b>Total:</b>	<b>39</b>

### Electric Demand & Consumption with Microgrid

	Max kW	Avg kW	kWh / yr
Node 1	1,900	597	5,229,593
Node 2	63	12	105,362
Node 3	209	16	138,657
Node 4	260	51	448,907
Node 5	55	13	117,432
<b>Total</b>	<b>2,487</b>	<b>689</b>	<b>6,039,951</b>

### Benefit Cost Analysis Outputs

	Scenario 1	Scenario 2
Days of Major Outage	0 days/yr	1.7 days/yr
Total Benefits**	\$ 6,790,000	\$ 11,200,000
Total Costs**	\$ 11,000,000	\$ 11,000,000
Net Benefits**	\$ -4,260,000	\$ 200,000
Benefit/Cost Ratio	0.6	1.0

\*Estimates based on financial modeling

\*\*Net present values

## **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, and
- Promote cleaner sources of energy

This report describes the results of Stage 1 of the NY Prize Feasibility Assessment for the Irvington Community Microgrid. Hitachi microgrids lead the development of the microgrid design based on NYSERDA's requirements and the specific needs and priorities of community stakeholders. The design was developed using an iterative process that supports optimization of the design based on cost, emissions and resilience goals. The Village of Irvington led the feasibility assessment in collaboration with the Irvington government. Various community organizations and partners, including the future customers of the Irvington Community Microgrid, lent additional support.

### **Community Overview**

The Village of Irvington is a bedroom community of about 6,500 residents. Located 15 miles north of New York City along the Hudson River, the village is home to one of the main stops on the Metro North Railway. The village's small commercial center is organized along Main St., a half-mile stretch of road leading from Rt. 9 all the way to the water. The Main Street area has been designated as a historic district by New York State and is currently under consideration for inclusion in the National Register of Historic Places. This location initially provided easy access to shipping and trade. However, it also creates vulnerabilities to flooding during major storm events.

The Irvington Community Microgrid is designed to take advantage of the geographic proximity of critical facilities along the Main Street corridor by including them all in one microgrid node. These facilities include the Village Hall, police station, fire station and EMS station, four schools, and many small businesses located on or around Main Street. The Irvington Community Microgrid is designed as a "distributed microgrid" with several distinct nodes. Additional nodes were included to protect other critical facilities and services, such as the department of public works, a senior center, a residential healthcare facility, and another school.

### **Community Requirements and Microgrid Capabilities**

The Irvington Community Microgrid is designed to meet specific needs within the community. These include the need to harden infrastructure against storm damage, and the need to ensure continuity of emergency operations and critical village services.

First, the microgrid is designed to protect the safety and welfare of Irvington residents. The five schools included in the Irvington Community Microgrid have a total enrollment of nearly 1,900 students. The microgrid will protect students by ensuring that these buildings stay fully powered and open during an outage. This will also allow the parents/guardians of these students to attend work as usual during outage events. The microgrid includes satellite nodes that cover the Irvington



Senior Citizens Center and the Monte Nido Healthcare facility. The microgrid will ensure that these facilities are able to continue to serve the vulnerable populations that depend on them without curtailing care or services.

Due to its downstate location on the bank of the Hudson River, Irvington is vulnerable to coastal storm activity and flooding. Irvington was hit hard by Hurricane Irene in 2011, Hurricane Sandy in 2012, and several recent severe snow and wind events. To address this vulnerability, the microgrid will ensure that government services, including emergency response, will be supported by a constant supply of power in emergency situations. Facilities included in the microgrid that offer critical emergency services include the Village Hall and Police Dept., the EMS station, and the Firehouse. Several other facilities will become critical in extended outages, including the Sunnyside Bank, the Lambros gas station, and the Natural Fit Pharmacy. Finally, the public library, senior citizens center, and other facilities could serve as emergency shelters if there should be a need.

The microgrid is also designed to benefit 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 into the service territory, the microgrid will facilitate participation in Con Edison's demand response programs, which will help the utility to cost effectively meet peak demands.

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

### **Technical Design**

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

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

storage, PV, and building management systems to manage load and reduce the afternoon peak load when needed.

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

**Executive Summary Table 1 - Microgrid Resources Comparison**

Node	Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW
1	Business as Usual	1900	1	7	-	-	-	-	2	120
	Microgrid	580	4	87	3	30/60	2	496	2	120
2	Business as Usual	63	-	-	-	-	-	-	-	-
	Microgrid	38	1	7	1	5/10	1	15	-	-
3	Business as Usual	209	-	-	-	-	-	-	-	-
	Microgrid	90	1	12	1	35/70	1	15	-	-
4	Business as Usual	260	-	-	-	-	-	-	-	-
	Microgrid	250	1	35	1	20/40	1	35	-	-
5	Business as Usual	55	-	-	-	-	-	-	1	48
	Microgrid	18	1	27	1	5/10	1	10	1	48

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

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

Node	Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
	Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
1	1,900	597	5,229,593	435,799	23,835,317	1,986,276	10,529,569	877,464
2	63	12	105,362	8,780	1,322,592	110,216	271,669	22,639
3	209	16	138,657	11,555	463,281	38,607	185,004	15,417
4	260	51	448,907	37,409	5,840,825	486,735	560,477	46,706
5	55	13	117,432	9,786	874,260	72,855	125,523	10,460
<b>Total</b>	<b>2,487</b>	<b>689</b>	<b>6,039,951</b>	<b>503,329</b>	<b>32,336,275</b>	<b>2,694,690</b>	<b>11,672,242</b>	<b>972,687</b>

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

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

### **Financial Feasibility**

The project team developed a general budget for the Irvington 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 \$4,491,000 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 \$4,162,000. This cost does not include other incentives that may be applicable to the project that will be applied during the detailed analysis in Stage 2.

The outputs of the technical modeling process described above were used to evaluate the financial viability of the proposed microgrid from two perspectives. First, the project team analyzed the financial strength of the project when deployed using the proposed third-party ownership business model. Under this model, the project is funded through outside investment and debt which is recouped through a power purchase agreements (PPAs) with each facility. In addition, NYSERDA contracted with Industrial Economics, Incorporated (IEc) to perform a benefit-cost analysis. The focus of this analysis is to evaluate the societal benefit of the microgrid, including benefits from emissions reductions, cost reductions, and resilience improvements.

**Business Model Financial Results:** Under the proposed business model, a third party would fund all development and construction of the microgrid, own and operate the assets, and sell the energy generated from the microgrid to community customers through PPAs. The community would incur no costs to build the project and would receive all of the benefits of energy resilience during a grid outage, and improved sustainability. Community stakeholders have indicated that 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 \$0.141/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 will match or be slightly above this current weighted electrical rate, depending on the award of further grants from the NY Prize Program and the potential to share costs for installing distribution lines underground.

**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 Irvington Community Microgrid, the breakeven outage case is 1.7 days of major power outage per year. The cost benefit results are presented in Executive Summary Table 3.

**Executive Summary Table 3 – Cost Benefit Analysis Results**

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 1.7 DAYS/YEAR
Net Benefits - Present Value	-\$4,260,000	\$184,000
Total Costs – Present Value	\$11,000,000	\$11,000,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-19.7%	6.9%

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 Irvington's financial feasibility analysis are based on the Con Edison's distributed generation rate. This resulted in year 1 gas rates of \$6.34 and \$5.80, 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 \$160,000.
- 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 \$329,000.
- Capital replacement costs used in the benefit-cost analysis BCA were calculated as a full replacement costs, whereas the project team assumed a 'rebuild' cost that is not equal to the full cost of replacement. The rebuild cost for the Irvington Community Microgrid is \$314,000 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.

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

### **Conclusions and Next Steps**

The NY Prize feasibility assessment indicates that the Irvington Community Microgrid is technically viable, and may be economically viable if future grants are awarded from NYSERDA in the NY Prize Stage 2 and 3. The microgrid will protect the operation of the critical facilities along the Main Street corridor, ensuring that business and government can continue uninterrupted, while the schools can be used as emergency shelters for the community. Additional microgrid nodes will protect other important facilities and functions including the village's public works and a large residential healthcare facility.

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

The next steps that the Irvington 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.

# **Irvington Community Microgrid**

## **Final Report – NY Prize Stage 1: Feasibility Assessment**

### **TECHNICAL DESIGN**

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

A screening process was developed and implemented to select the best sites for the microgrid based upon a set of criteria. The proposed microgrid will includes several schools, a public library, a church, several retail facilities including a bank and a grocery store, the village hall and police station, a firehouse with adjacent ambulance facility, the public works department, a senior citizens community center, and a healthcare facility. Collectively, there is a total of five “nodes” that make up the Irvington Community Microgrid.

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

**Table 1 – Overview of Microgrid Nodes**

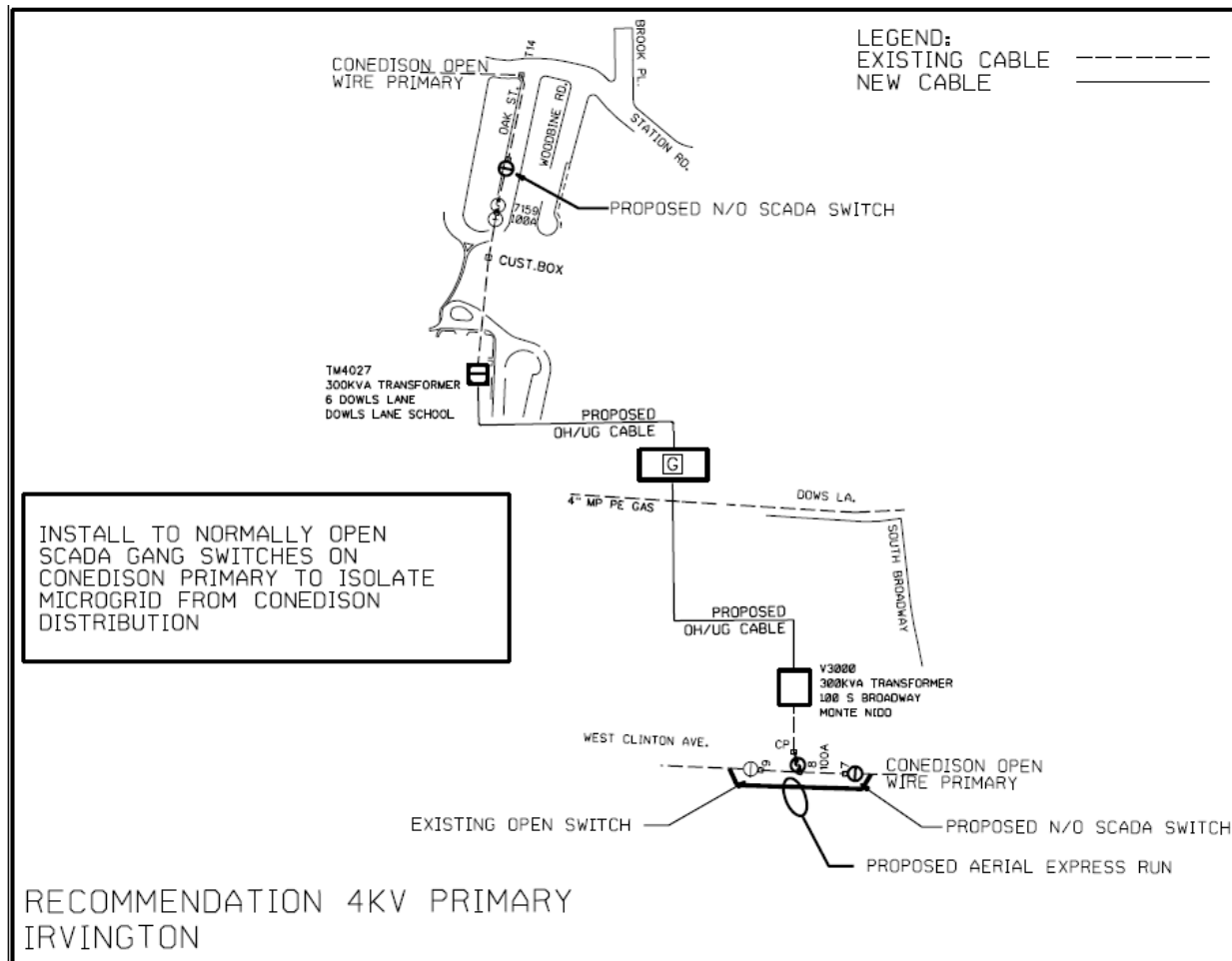
Microgrid Node #	Facilities	Functions
1	<ul style="list-style-type: none"><li>• High School</li><li>• Middle School</li><li>• Public Library</li><li>• Immaculate Conception Church</li><li>• John Cardinal O'Connor School</li><li>• Village Hall &amp; Police Station</li><li>• Main St. School</li><li>• Geordane's Food Market</li><li>• Sunnyside Bank</li><li>• EMS Ambulance Corp.</li><li>• Firehouse</li><li>• Natural Fit Pharmacy</li><li>• Lambros Service Center</li><li>• Additional Commercial Non-Critical Loads along Main St</li></ul>	<ul style="list-style-type: none"><li>• Municipal offices and services</li><li>• Fire and emergency services</li><li>• Emergency Shelters</li><li>• Medicine</li><li>• Education</li><li>• Community services including food, religious services, banking, and pumping station/auto repair</li></ul>
2	<ul style="list-style-type: none"><li>• Public Works Department</li></ul>	<ul style="list-style-type: none"><li>• Municipal improvement projects and emergency response</li></ul>
3	<ul style="list-style-type: none"><li>• Senior Citizens/Community Center</li></ul>	<ul style="list-style-type: none"><li>• Senior and community services</li></ul>
4	<ul style="list-style-type: none"><li>• Dows Lane School</li></ul>	<ul style="list-style-type: none"><li>• Education</li><li>• Emergency Shelter</li></ul>
5	<ul style="list-style-type: none"><li>• Monte Nido Healthcare</li></ul>	<ul style="list-style-type: none"><li>• Medical Services</li></ul>

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

The design team met with a Con Edison distribution engineering team to review utility infrastructure that impacts the microgrid design. Figure 1 below includes a visual modification to Nodes 4 and 5 that was presented by Con Edison and agreed upon by the design team. This includes a proposed normally open SCADA switch, some new underground cabling, and a new hardened aerial express run.



**Figure 1 - Con Edison Proposed Infrastructure Upgrades to Support Nodes 4 and 5**



The proposed Irvington Community Microgrid will benefit all of the village's 6,550 residents by protecting the services and institutions on which they rely. Key institutions covered by the microgrid are listed below, along with the populations they serve:

**Table 2 – Community Stakeholders to Benefit from the Microgrid**

<b>Business</b>	<b>Current Condition in Grid-Loss Scenario</b>	<b>Future Condition with Microgrid in Grid-Loss Scenario</b>
High School and Middle School	The High School and Middle School are not currently served by any backup generation, and are shut down during a grid outage.	Irvington High School has an enrollment of 650 students, and Irvington Middle has 425 students. The microgrid will allow the schools to draw on the entire portfolio of microgrid resources to remain completely powered and open during an outage. This will ensure that students can attend school and allow parents of students to attend work as usual. This facility may also serve as a temporary shelter for community members in an emergency.
Public Library	The public library is not currently served by any backup generation, and is typically not operational during a grid outage.	The microgrid will allow the library to remain powered and open through power outages. As a community center, the library could serve as a public shelter.
Immaculate Conception Church	This community church is currently not served by backup generation, and must close during a power outage.	Like the library, the 143 year old Immaculate Conception Church serves as a community center in Irvington. The microgrid would allow the church to remain open and operational. The church is an active collection point for food aid, and in an emergency, could offer public shelter.
John Cardinal O'Connor School	The school is not currently served by backup generation, and must close during a power outage.	The John Cardinal O'Connor School serves 50 students in grades 2-8 with special needs, and employs seven full-time teachers. The microgrid would allow the school to stay open through power outages, which would allow the parents of students to attend work as usual. The school could also serve as a public shelter in an emergency.
Village Hall & Police Station	The Village Hall and Police Station is served by a 60 kW EDG. Even with this backup generation, the Irvington Police report that they lose 30% of service effectiveness during a power outage, and the Village Hall reported a 40% loss in service.	The Village Hall will serve as a command center during an emergency in Irvington. The microgrid will allow the village's government to continue to operate at 100%. The police force that is housed in this facility serves all of the village's 6,420 residents. The microgrid will allow the police station to operate at 100%.
Main Street School	The school is not currently served by backup generation, and must close during a power outage.	The Main St. school serves 270 students in grades 4 and 5. The microgrid would allow the school to stay open through power outages, which would allow the parents of students to attend work as usual. The school could also serve as a public shelter in an emergency.

Business	Current Condition in Grid-Loss Scenario	Future Condition with Microgrid in Grid-Loss Scenario
Geordane's Food Market	Geordane's is not currently served by backup generation, and must close during an outage. 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 to stay open and powered. 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.
Sunnyside Bank	The bank is not currently served by backup generation, and must close during a power outage.	The microgrid will allow the bank to stay open during a power outage, and ensure community members will have access to cash during a prolonged emergency situation.
EMS Ambulance Corps	The EMS and Ambulance Corps facility is not served by backup generation. Staff at this facility report a 90% loss in service when the power is out.	The emergency services housed in this facility serve 7000 residents in the Irvington area, and provide frequent mutual aid to surrounding communities. The microgrid would allow this facility to remain 100% operational during a power outage, protecting the safety of all area residents.
Firehouse	The firehouse is not served by backup generation. Staff at this facility report a 30% increase in response time during a power outage.	Like the EMS facility, the firehouse serves 7000 residents, and provides mutual aid to surrounding communities. The microgrid will allow the firehouse to stay powered and operational through power outages. This will support the operation of the truck bay doors, communication and dispatch, and firefighters support functions of the firehouse.
Natural Fit Pharmacy	The pharmacy is not served by any backup generation, and will be forced to close in a power outage.	The microgrid will allow the pharmacy to stay open. Refrigeration will continue to preserve medications, and the pharmacy can continue to serve local health needs.
Lambros Service Center	This gas station is not served by any backup generation, and will be forced to close in a power outage.	The microgrid will allow gas pumps to remain powered, and continue to support both transportation and the operation of home generators.
Public Works Department	The Public Works building is not currently served by any backup generation, and is typically not operational during a grid outage.	The microgrid will allow this facility to draw on all of the resources in the microgrid portfolio. This will extend the life of the EDG, and ensure that the facility will remain powered even if the EDG fails or runs out of fuel. This will protect the ability of the Public Works Department to respond to emergencies and assure vital services to residents.
Irvington Senior Citizens Center	The Irvington Senior Citizens Center is not served by backup generation, and must close during an emergency.	The senior center provides a variety of services to the village's elderly, including escort services for medical appointments. The microgrid will allow the center to continue all activities and services. The center may also serve as a public shelter in an emergency.

Business	Current Condition in Grid-Loss Scenario	Future Condition with Microgrid in Grid-Loss Scenario
Dows Lane Elementary School	The Dows Lane school is not served by any backup generation, and must close during a power outage.	The Dows Lane school has an enrollment of 500 students in grades K-3. The microgrid would allow the school to stay open through power outages, which would allow the parents of students to attend work as usual. The school could also serve as a public shelter in an emergency.
Monte Nido Clinic	This facility is served by a 43 kW emergency natural gas generator (EGG). When using backup power, facility officials report a 40% loss in service.	The microgrid would allow this facility to continue to operate at 100% during power outages, protecting the safety and security of its residential patients.

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

**Table 3 – Community Stakeholders to Benefit from the Microgrid**

Organization	Benefits from Irvington Community Microgrid
Consolidated Edison of New York (Con Edison)	By serving the local load and providing resilient energy, the system will allow the utility to delay potential investments in the existing substation equipment. Con Edison is implementing other resiliency upgrades to their system and the microgrid complements these other efforts.
Irvington, NY, Independent Business Owners	The microgrid will protect mission continuity for several essential services in Irvington, including fire and public works, which serve all businesses in the village. Even those businesses that are not included in the microgrid will benefit from the improved public service the microgrid supports.

## Key Features of the Microgrid

### Community Microgrid Controller

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

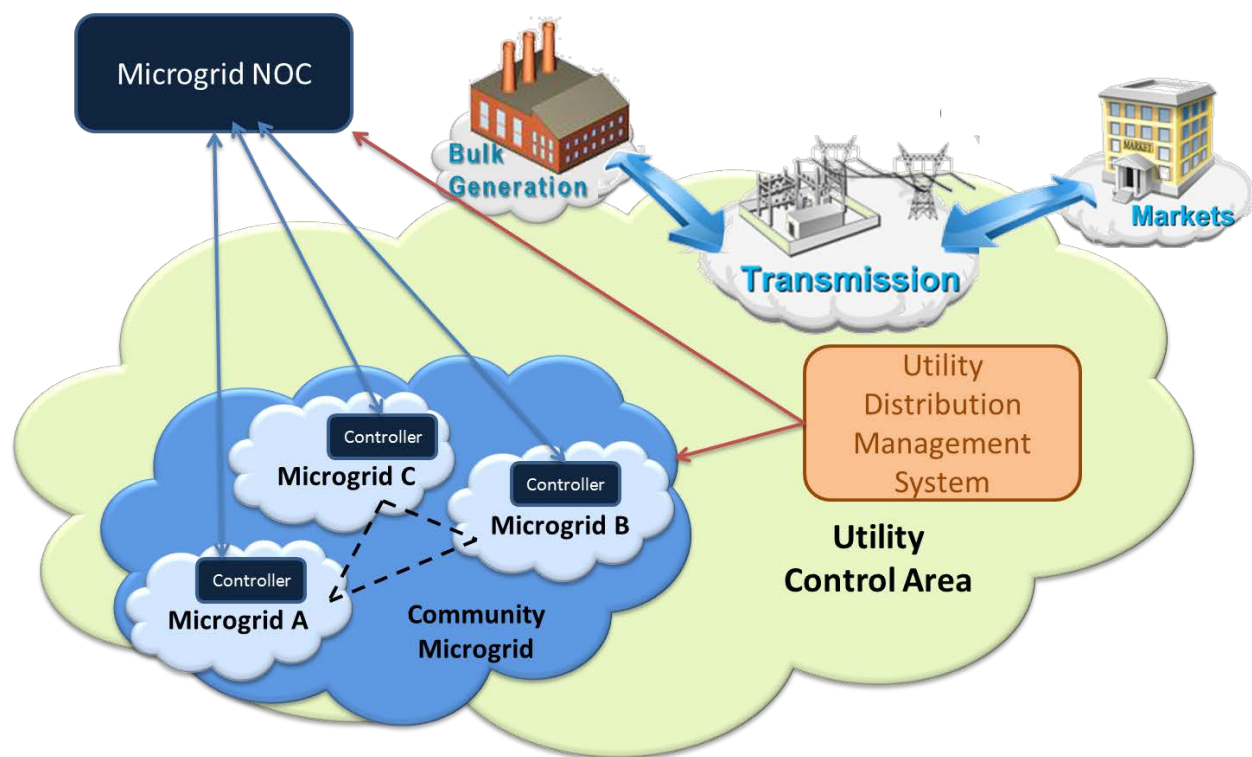
Our team has developed a project concept for the community microgrid that allows for simultaneous control of multiple microgrids in the community as well as coordination with the local utility. Specifically, the solution includes local controllers in each microgrid part as well as a

hosted controller in the Microgrid network operating center (NOC) that can operate each microgrid part separately or collectively.

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

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

**Figure 2: Project Concept for Community Microgrid**



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

1. **Frequency control:** In normal operations, the microgrid may not have enough resources to affect frequency on the grid. It could participate in the ancillary services markets by increasing output to support the frequency in the local grid, but total impact would be small. Nevertheless, the system will monitor frequency along several thresholds, providing a discrete high-low range; the system will detect if frequency is out of range and respond by taking resources off-

line or dispatch other resources to manage frequency. Also, the system will analyze data to detect subtler trends that do not exceed thresholds but provide evidence of a possible problem.

2. **Voltage control:** In both grid-connected and islanded modes, the voltage control application will be used to provide stability to the microgrid and connected circuits. Voltage control leverages line sensing and metering to provide control actions when necessary. This application will take into account traditional volt/VAr instruments such as tap changers and cap banks along with inverter-based resources, which should provide a greater degree of optimization.
3. **Intentional islanding:** For each microgrid node, the islanding process will be semi-automatic so that a utility operator or local energy manager will be able to move through each step before opening the PCC. The utility operator will provide the appropriate permissives for opening the PCC. The local microgrid controller for each microgrid node will be responsible for setting the voltage source and load following resource.
4. **Unintentional islanding:** The designed PCC structure, coupled with additional analysis compliant with IEEE 1547.4, enables the utility-controlled breaker or switch to immediately open (frequency = 59.3 Hz) on loss of the grid. The microgrid managed synchronizing breaker will remain closed for a few more milliseconds until microgrid frequency reaches 57.0 Hz. Since the inverters and generator controls are keying off the synchronizing breaker, these few additional milliseconds enable the energy storage and power electronics to better manage the transient as the microgrid resources pick up the portion of the load served by the utility grid just before the grid was lost. When, or if, the frequency dips to 57.0 Hz and the synchronizing breaker opens, the microgrid will move into island mode. The microgrid controller will adjust all microgrid resources 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.

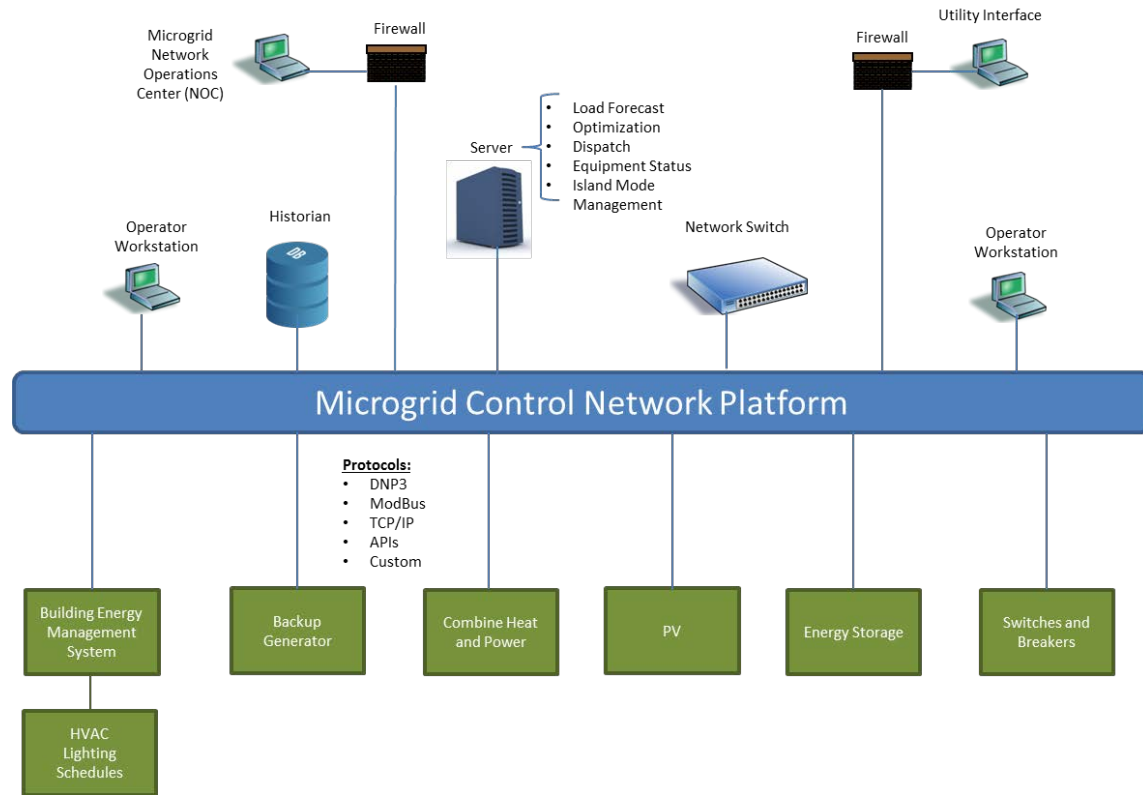
In addition, the microgrid controller will:

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

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

A microgrid controller design needs to be reliable and have redundancy comparable to the other microgrid resources. A standard controller approach such as central controller or 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 3.

**Figure 3 – Conceptual Microgrid Controller Topology**



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

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

### Telecommunications Infrastructure

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



The architecture will conform to requirements established by and generally accepted communications protocols, such as ModBus (TCP/IP), DNP3 (TCP/IP), and IEC61850, as well as field networks for buildings such as LonWorks and BACnet. ModBus will be used throughout the microgrid nodes for communications, as it is currently the most prominent communications protocol within the DER and inverter community. Communications with the utility distribution management systems will use DNP3, as that is the prominent protocol used by the utility industry.

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

### **Communications – Microgrid and Utility**

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

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

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

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

## Distributed Energy Resources Characterization

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

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

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

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

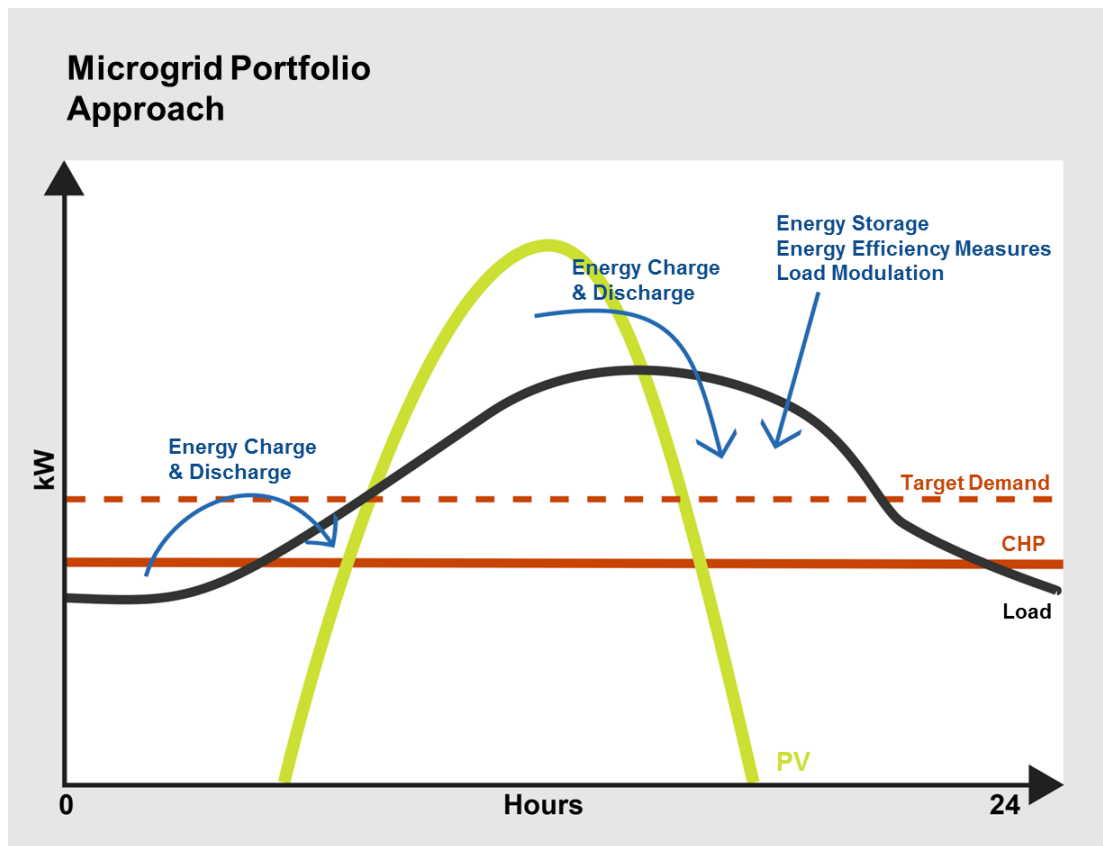
To support steady-state frequency requirements, as well as the ANSI 84.1-2006 standard voltage requirements and to support the customer power quality requirements at PCC, the microgrid controller will actively manage the dispatch of generation resources; actively manage the charge and discharge of energy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

## Normal and Emergency Operations

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

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 “always-on” 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. This concept is presented in Figure 4.

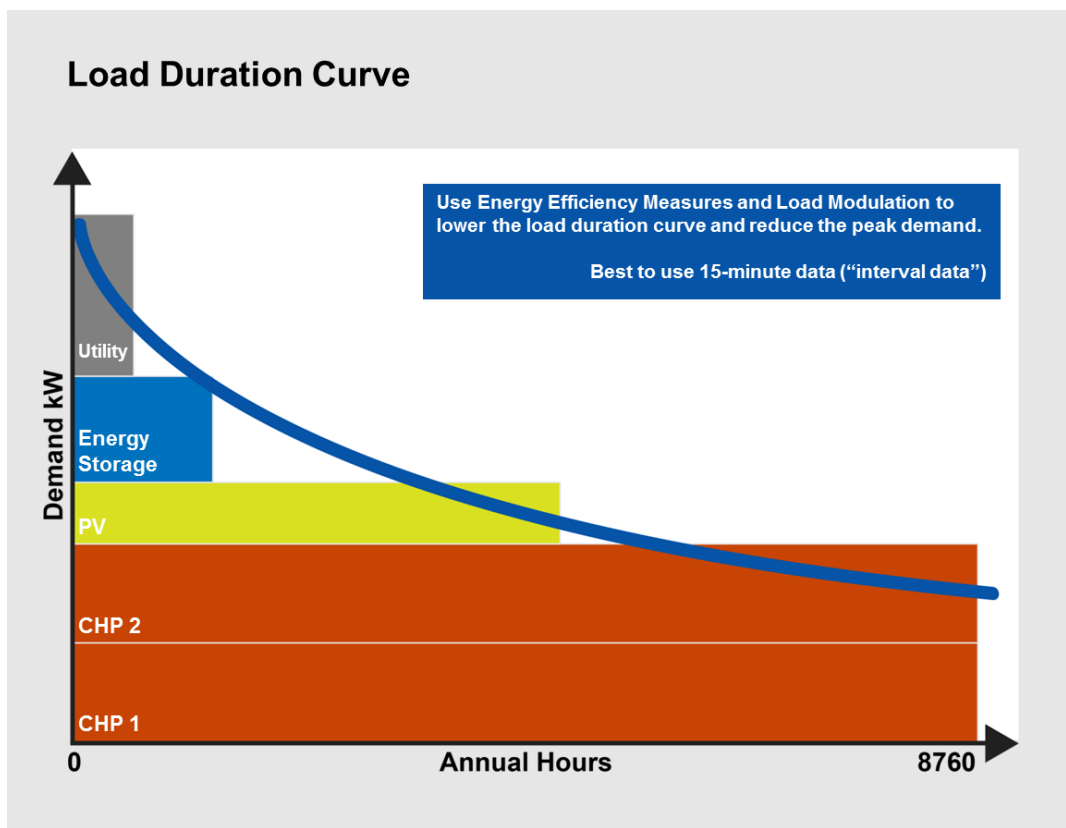
**Figure 4 – Microgrid Portfolio Approach**



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 5 illustrates another element of the resource selection and sizing strategy for the Irvington 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 5 – Load Duration Curve**



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

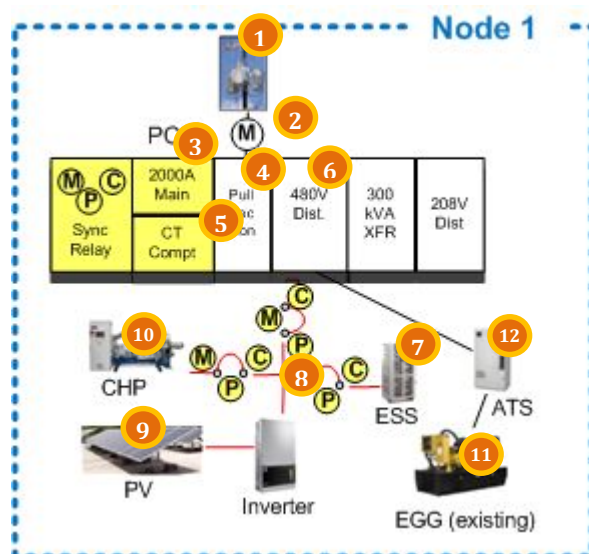
- **Planned Transition:** In a planned transition, outside information is used to ramp up resources so there is zero grid import to the microgrid. A seamless transition occurs into island operations at the appropriate time. Outside information includes weather forecasts, grid frequency deviations, local voltage sags, or other information provided by the utility.
- **Unplanned Transition:** In an unplanned transition, an unanticipated outage takes place such as the loss of a transformer or a car hitting a distribution power pole. Depending on the microgrid resources operating at the time, an outage may take place that requires the microgrid to establish itself through a black start sequence of operation.

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

In addition, a microgrid one-line diagram is presented in Appendix B. The diagram includes the substation, major electrical equipment, and the rated capacity for each microgrid distributed energy resource. The PCC 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 6 – One-Line Diagram Explanation**



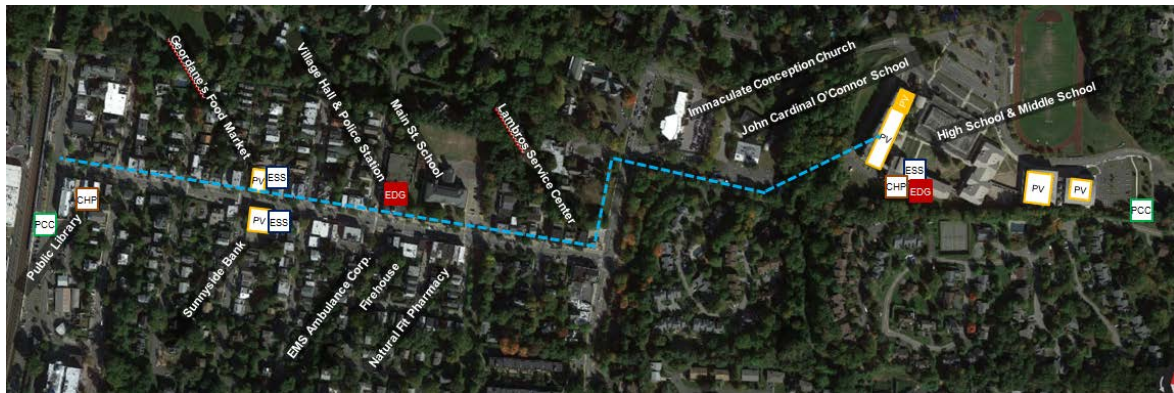
1. Transformer to the critical facility
2. Utility meter
3. Synchronizing relay controls / main breaker with monitoring (M), protection relays (P), and controls (C)
4. Main disconnect (pull section)
5. Instrument current transformer compartment
6. Main 480 Volt 3-phase distribution panel; step-down transformer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

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

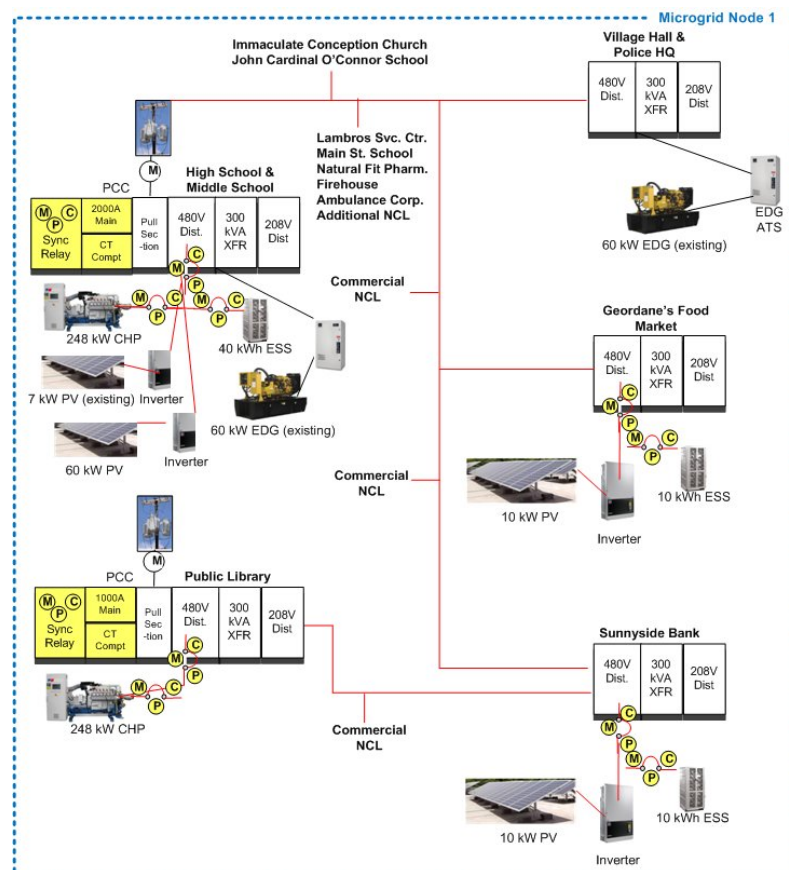
## Geospatial Diagrams and One-Line Subsections

### Node 1 System Configuration

#### Geospatial Diagram



#### One-Line Diagram



## Description

Node 1 includes multiple facilities as listed below. Two PCCs will be located at each end of the node - one to the east and one to the west. The node includes an existing PV system (7 kW) on the roof of the High School and two existing emergency diesel generators at the Village Hall (60 kW), and the High School & Middle School (60 kW).

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

- **PV (60 kW):** A PV system will be placed on the west roof of the High School to add to the current capacity.
- **PV (10 kW):** A PV system will be placed on the roof of Geordane's Food Market.
- **PV (10 kW):** A PV system will be placed on the roof of Sunnyside Bank.
- **CHP (248 kW):** A CHP system will be placed outside the High School near the south side of the building.
- **CHP (248 kW):** A CHP system will be placed outside the Library.
- **ESS (40 kWh):** An ESS unit will be placed inside the High School electric room.
- **ESS (10 kWh):** An ESS unit will be placed inside Geordane's Food Market.
- **ESS (10 kWh):** An ESS unit will be placed inside Sunnyside Bank.

## Facilities

- High School
- Middle School
- Public Library
- Immaculate Conception Church
- John Cardinal O'Connor School
- Village Hall & Police Station
- Main St. School
- Geordane's Food Market
- Sunnyside Bank
- EMS Ambulance Corp.
- Firehouse
- Natural Fit Pharmacy
- Lambros Service Center
- Additional Commercial Non-Critical Loads along Main St.

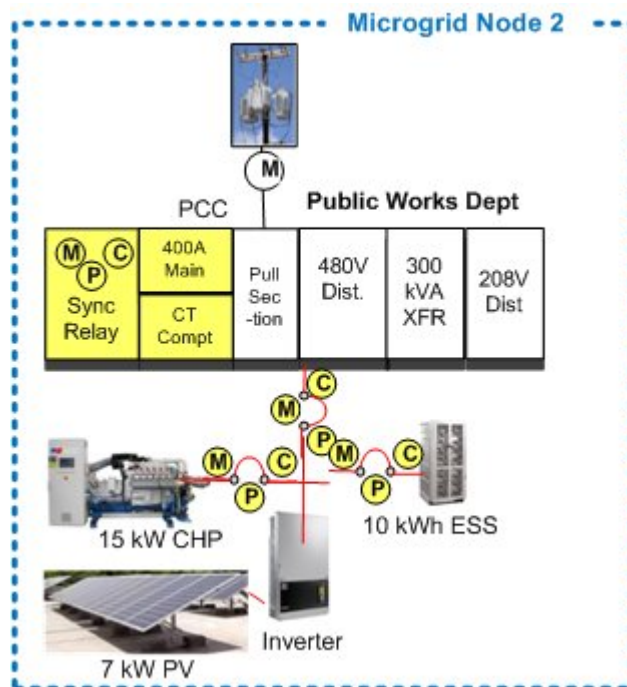


## Node 2 System Configuration

### Geospatial Diagram



### One-Line Diagram



### Facility

- Public Works Department

### Description

Node 2 is a single facility node. The PCC will be located behind the building near S. Astor St.

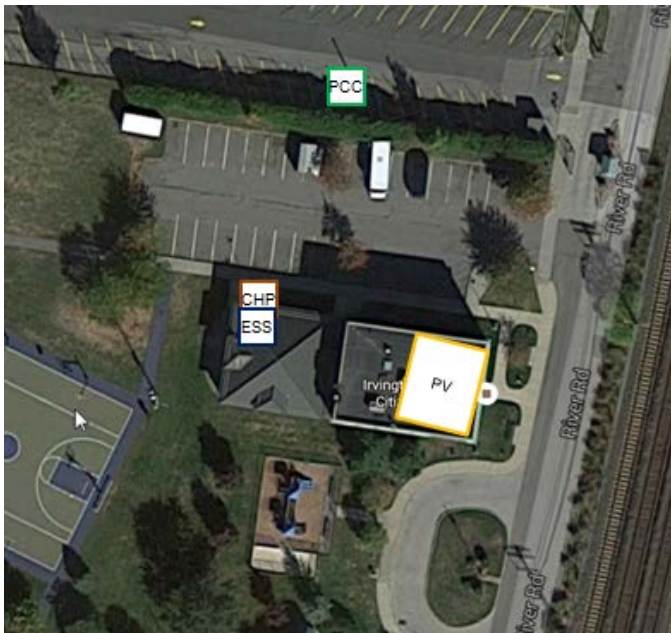
As part of the microgrid, the following will be installed:

- **PV (7 kW):** A PV system will span one side of the roof.
- **CHP (15 kW):** A small CHP unit will be placed behind the building.
- **ESS (10 kWh):** An ESS unit will be placed inside the building.

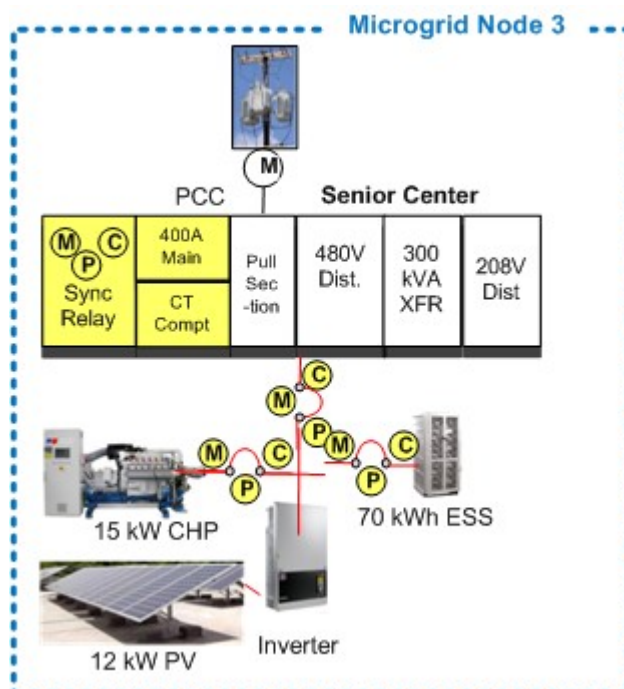


## Node 3 System Configuration

### Geospatial Diagram



### One-Line Diagram



### Facility

- Senior Citizen / Community Center

### Description

Node 3 is a single facility node. The PCC will be located at the edge of the parking lot.

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

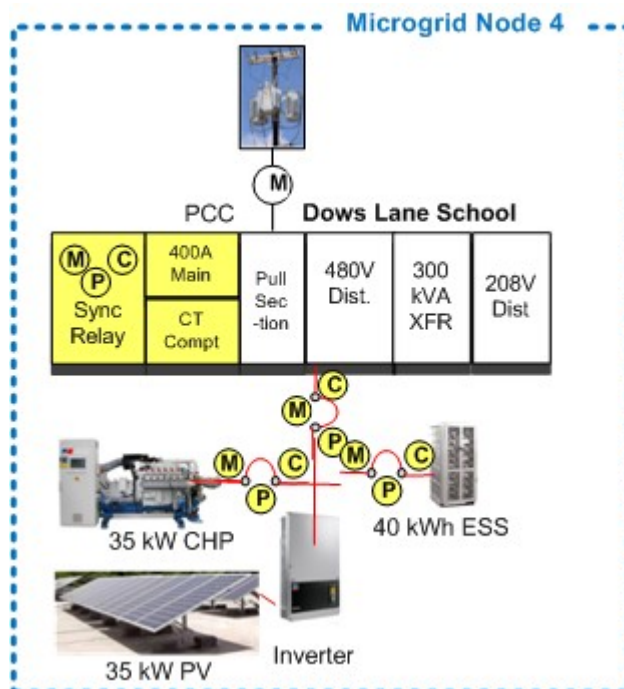
- **PV (12 kW):** A PV system will cover the part of the flat roof space.
- **CHP (15 kW):** A CHP system will be placed outside to the side of the building.
- **ESS (70 kWh):** An ESS unit will be placed inside the building.

## Node 4 System Configuration

### Geospatial Diagram



### One-Line Diagram



### Facility

- Dows Lane School

### Description

Node 4 is a single facility node. The PCC will be located near the southeast corner of the school near Dows Lane.

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

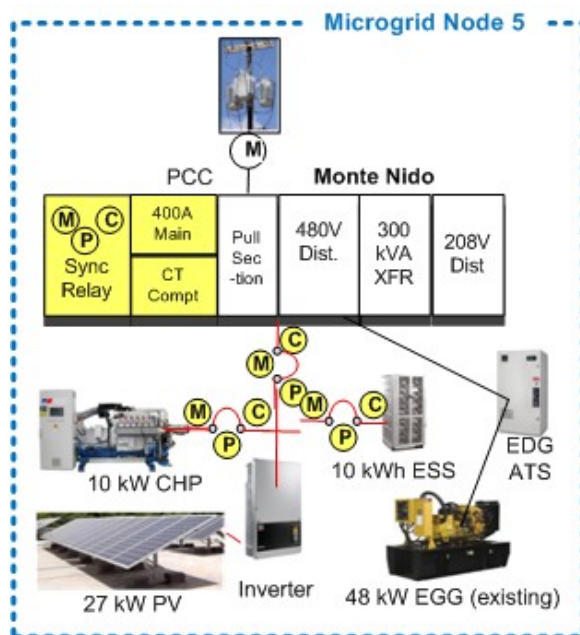
- **PV (35 kW):** A rooftop PV system will cover most of the roof.
- **CHP (35 kW):** A small CHP unit will be placed in the north corner behind the building.
- **ESS (40 kWh):** An ESS unit will be placed inside the building.

## Node 5 System Configuration

### Geospatial Diagram



### One-Line Diagram



### Facilities

- Monte Nido Healthcare

### Description

Node 5 is a single node facility. It includes an existing emergency propane generator (48 kW). The PCC will be located in the field near W. Clinton Ave.

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

- **PV (27 kW):** A ground-mounted PV system will be placed behind the building near the pool.
- **CHP (10 kW):** A CHP unit will be placed outside at the north side of the building.
- **ESS (10 kWh):** An ESS unit will be placed inside the building.

## Modeling Methodology

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

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

## Load Description

The microgrid design team modeled and optimized each of the eight nodes separately. Table 4 presents an overview of the annual energy operations of the microgrid by node. The microgrid will have a maximum demand of 2,487 kW and an average demand of 689 kW. The microgrid will deliver approximately 6,000,000 kWh per year. The thermal loads in the microgrid will be approximately 32,300,000 kBTU per year, of which approximately 11,700,000 kBTU will be recovered from the CHP systems and reused to support on-site thermal loads.

**Table 4 –Microgrid Energy Overview: Grid Connected Operation**

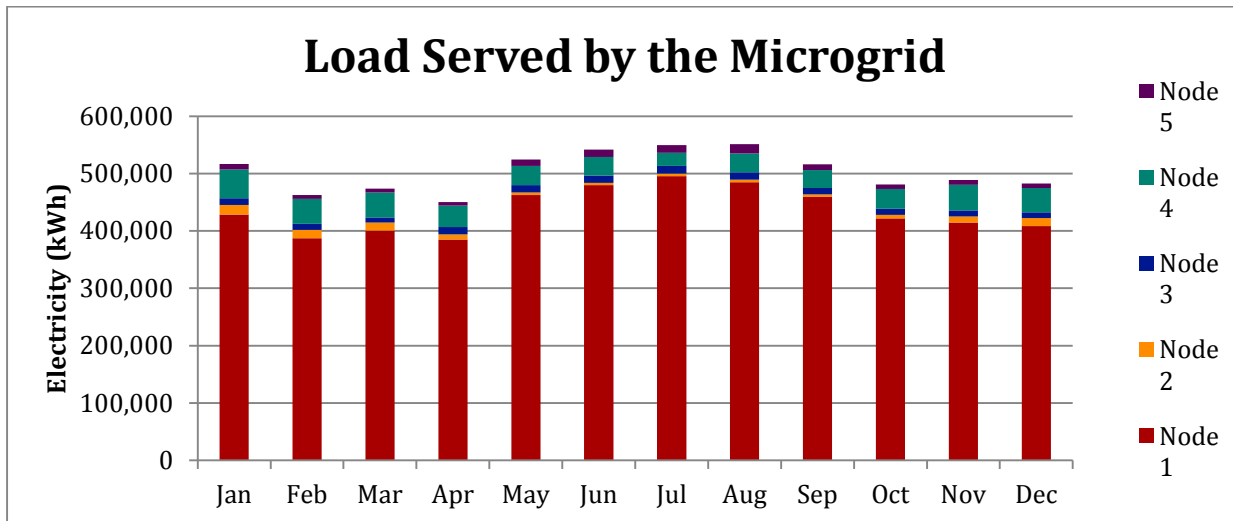
Node	Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
	Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
1	1,900	597	5,229,593	435,799	23,835,317	1,986,276	10,529,569	877,464
2	63	12	105,362	8,780	1,322,592	110,216	271,669	22,639
3	209	16	138,657	11,555	463,281	38,607	185,004	15,417
4	260	51	448,907	37,409	5,840,825	486,735	560,477	46,706
5	55	13	117,432	9,786	874,260	72,855	125,523	10,460
<b>Total</b>	<b>2,487</b>	<b>689</b>	<b>6,039,951</b>	<b>503,329</b>	<b>32,336,275</b>	<b>2,694,690</b>	<b>11,672,242</b>	<b>972,687</b>

The monthly energy delivery by microgrid node is presented in Table 5 and presented graphically in Figure 7.

**Table 5 –Monthly Grid Connected Operation by Node**

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Total
	(kWh)					
Jan	428,623	16,470	12,161	49,809	9,580	516,642
Feb	387,166	14,606	10,416	44,018	6,684	462,890
Mar	400,956	13,748	9,107	43,188	7,033	474,032
Apr	384,803	9,452	12,589	37,196	6,126	450,165
May	462,737	4,270	12,873	33,534	11,104	524,517
Jun	479,651	4,107	13,074	32,401	12,883	542,116
Jul	495,717	4,039	13,421	22,919	13,604	549,700
Aug	485,137	4,344	12,486	33,074	16,042	551,083
Sep	459,510	4,123	11,045	31,441	10,338	516,456
Oct	421,806	6,254	10,758	34,222	7,830	480,869
Nov	414,796	10,267	10,666	44,750	8,392	488,871
Dec	408,692	13,684	10,062	42,356	7,816	482,610
<b>Total</b>	<b>5,229,593</b>	<b>105,362</b>	<b>138,657</b>	<b>448,907</b>	<b>117,432</b>	<b>6,039,951</b>

**Figure 7 - Monthly Grid Connected Operation by Node**



The Irvington Community 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 reliability history of the grid into reliability optimization.

The reliability of the Irvington 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 Irvington Community Microgrid design so that equipment loss is mitigated or accommodated in the specific microgrid nodes for this community, under grid-connected and islanded modes of operation. Table 6 summarizes the microgrid resources in each node in terms of number of devices and the total installed capacity by technology.

**Table 6 - Microgrid Node Resources Comparison**

Node	Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW
1	Business as Usual	1900	1	7	-	-	-	-	2	120
	Microgrid	580	4	87	3	30/60	2	496	2	120
2	Business as Usual	63	-	-	-	-	-	-	-	-
	Microgrid	38	1	7	1	5/10	1	15	-	-
3	Business as Usual	209	-	-	-	-	-	-	-	-
	Microgrid	90	1	12	1	35/70	1	15	-	-
4	Business as Usual	260	-	-	-	-	-	-	-	-
	Microgrid	250	1	35	1	20/40	1	35	-	-
5	Business as Usual	55	-	-	-	-	-	-	1	48
	Microgrid	18	1	27	1	5/10	1	10	1	48

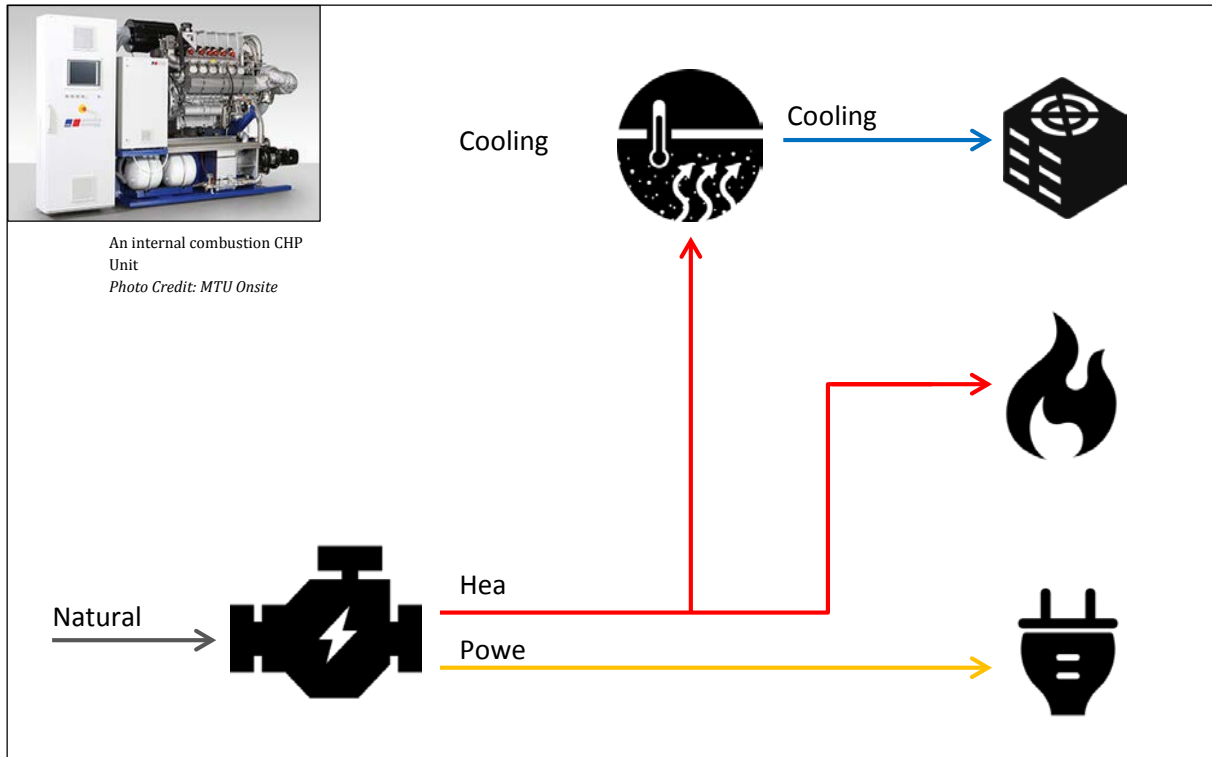
An overview of each technology, installation, operating strategy, and modeled operation are presented in this section.

### **Combined Heat and Power**

CHP generators provide electrical and thermal energy from a single source. The use of fuel to generate both heat and power makes CHP systems more cost effective than traditional power generation. Most power generation produces heat as a byproduct, but because power is generated far from the end user, the heat is lost. CHP units take advantage of the fact that they are collocated with the end user and make use of thermal energy for heating and sometimes even cooling nearby buildings. For this microgrid application, internal combustion engine based CHP systems have been modeled. Internal combustion engines, also called reciprocating engines, use a reciprocating motion to move pistons inside cylinders that turn a shaft and produce power. Internal combustion engines typically range between 5 kW-7 MW and are best suited for load-following applications. An image of an internal combustion engine generator is presented in Figure 8.



**Figure 8 – CHP System Overview**



### 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 may be available through NYSERDA, and investment tax credits available for eligible customers

### CHP Approach

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



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

### CHP in the Microgrid

The size and location of the planned CHP units is presented in the layout diagram and single-line diagram presented in the Appendix. Table 7 summarizes the CHP components by node of the microgrid.

**Table 7 - Microgrid CHP Resources by Node**

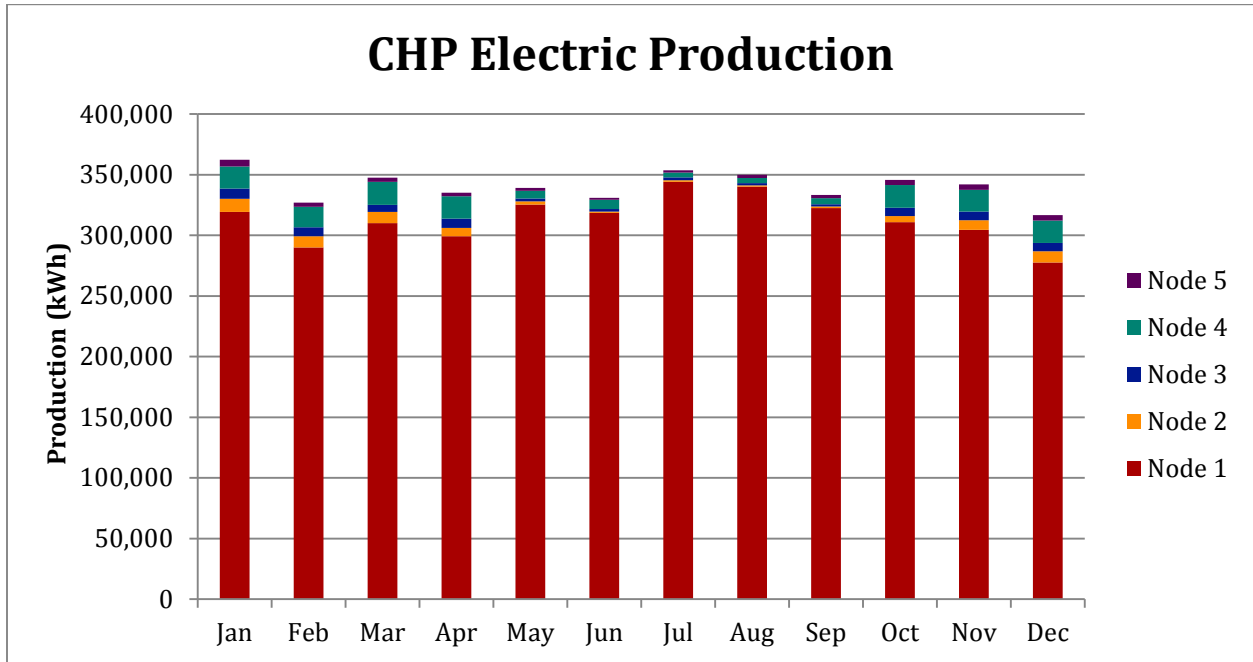
Node	Natural Gas Engine or CHP	
	Qty	Total kW
<b>1</b>	2	496
<b>2</b>	1	15
<b>3</b>	1	15
<b>4</b>	1	35
<b>5</b>	1	10
<b>Total</b>	<b>6</b>	<b>571</b>

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

**Table 8 - Microgrid CHP Electric Production by Node**

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Total
	Electric Production (kWh)					
Jan	319,384	10,756	8,313	18,279	5,557	362,290
Feb	289,908	9,284	7,515	16,784	3,465	326,958
Mar	310,056	9,220	5,869	18,811	3,613	347,569
Apr	299,337	6,704	7,753	18,288	3,143	335,225
May	325,279	2,601	2,385	6,438	2,345	339,048
Jun	318,455	1,114	2,148	7,575	1,670	330,962
Jul	344,186	1,200	2,278	4,011	1,897	353,573
Aug	339,997	1,243	1,836	4,279	2,619	349,974
Sep	322,546	1,119	1,844	5,173	2,462	333,143
Oct	310,736	5,023	6,995	18,725	4,192	345,671
Nov	304,520	7,810	7,113	17,971	4,467	341,881
Dec	277,571	9,140	6,958	18,594	4,255	316,518
<b>Total</b>	<b>3,761,975</b>	<b>65,214</b>	<b>61,007</b>	<b>154,929</b>	<b>39,686</b>	<b>4,082,811</b>

**Figure 9 – Microgrid CHP Electric Production**



**Table 9 - Microgrid CHP Heat Recovery by Node**

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Total
Heat Recovery (kBtu)						
Jan	1,752,027	47,611	30,973	66,884	19,769	1,917,265
Feb	1,572,838	41,120	28,272	61,419	12,327	1,715,977
Mar	1,590,493	40,837	20,717	68,724	12,853	1,733,624
Apr	1,069,449	29,690	27,516	66,803	11,179	1,204,637
May	141,632	10,539	2,513	22,716	7,933	185,333
Jun	94,236	1,151	0	26,881	3,500	125,768
Jul	68,188	1,127	0	13,382	1,374	84,072
Aug	80,526	1,226	0	13,898	2,638	98,289
Sep	101,334	1,053	0	17,724	8,011	128,122
Oct	1,138,892	22,241	24,093	68,360	14,912	1,268,497
Nov	1,496,490	34,591	24,608	65,707	15,889	1,637,284
Dec	1,423,464	40,482	26,312	67,980	15,137	1,573,375
<b>Total</b>	<b>10,529,569</b>	<b>271,669</b>	<b>185,004</b>	<b>560,477</b>	<b>125,523</b>	<b>11,672,242</b>

**Figure 10 – Microgrid CHP Heat Recovery**

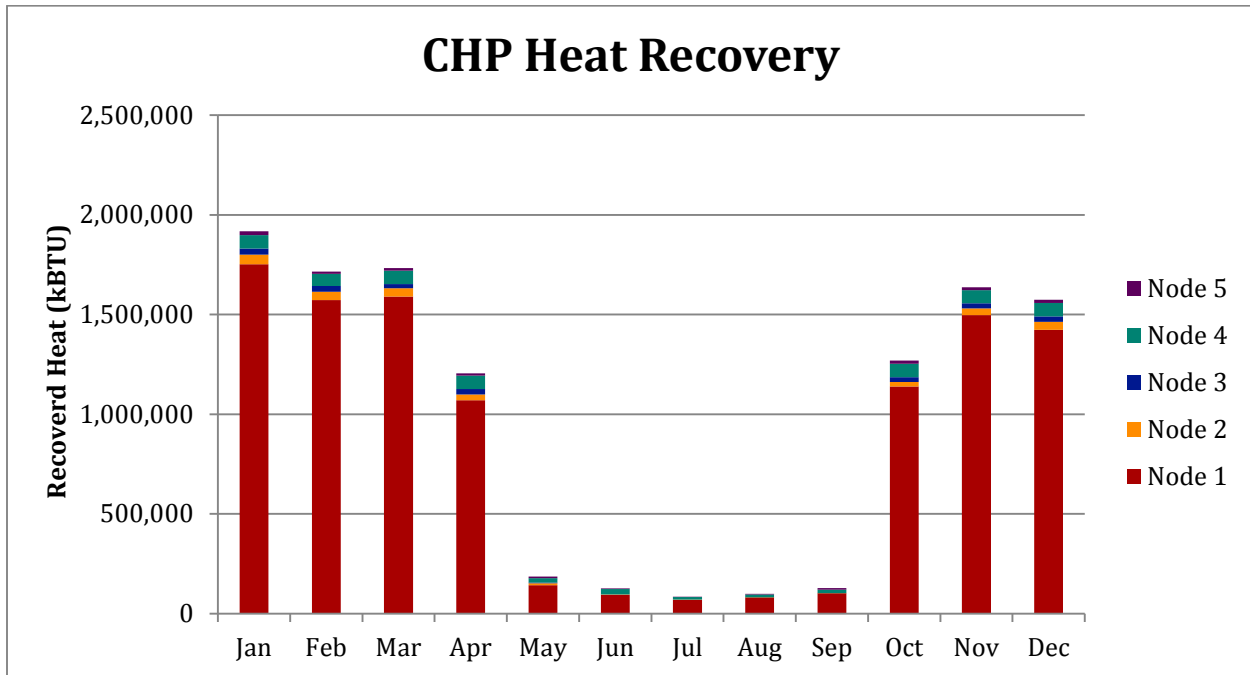
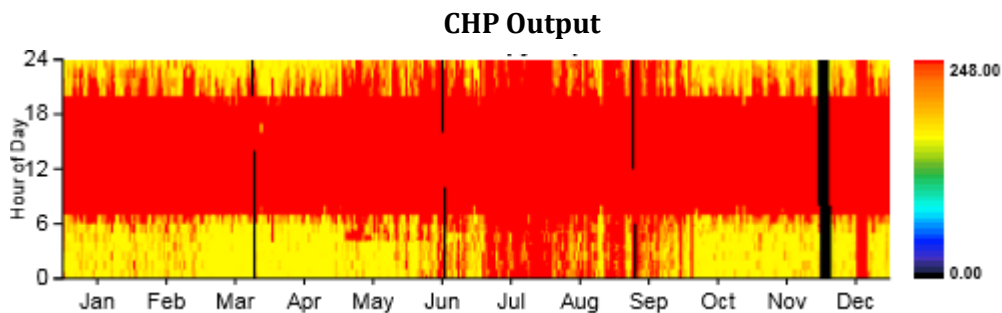


Figure 11 presents the hourly operation of the CHP in an example node in the form of a heat map. This representation demonstrates that the CHP unit is operating near full capacity for a majority of hours (red), then does some electric load following during the other hours (orange) but is loaded at an overall high level of output during the course of the year.

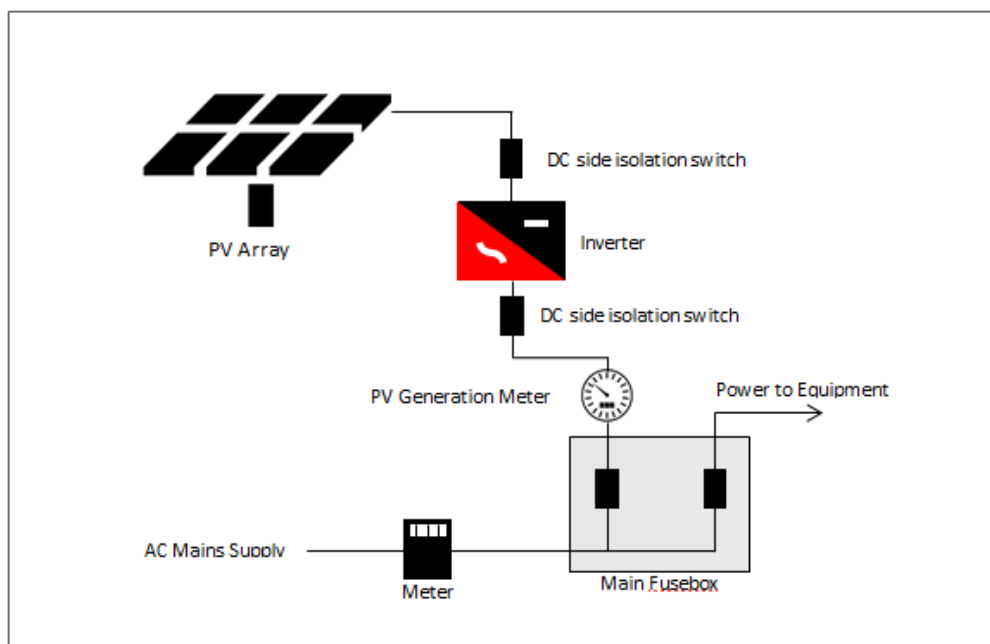
**Figure 11 – Example Node CHP Operational Summary**



### Solar Photovoltaics

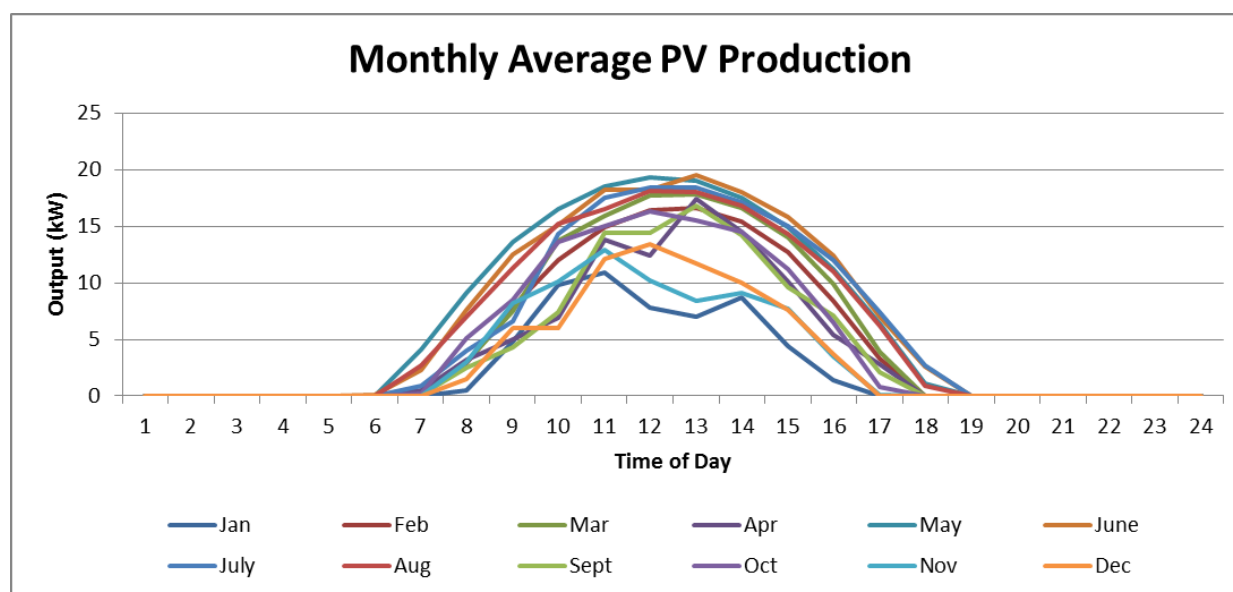
The PV will be rooftop, parking lot, or ground mounted using hail-rated solar panels. PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by photons and can be 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 12.

**Figure 12 – PV Installation Diagram (Customer Side of Meter)**



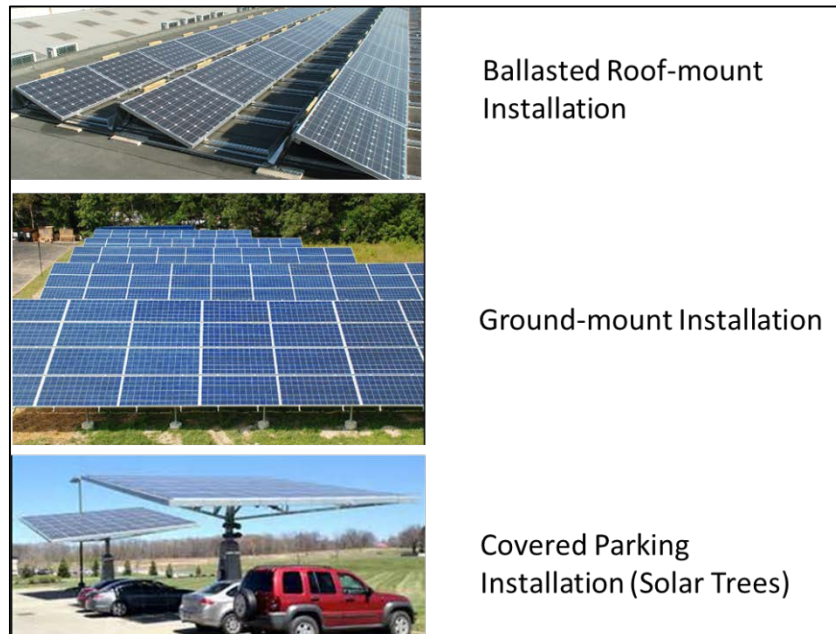
Since the PV systems are driven by sunlight, the electric production profile varies with the position of the sun and is impacted by the level of cloud cover. Figure 13 presents the typical average daily PV generation profiles by month and demonstrates the seasonal variation of PV as a generation resource. The HOMER model takes this variability into account when simulating and optimizing the sizing of PV as a microgrid resource.

**Figure 13 – Typical PV Daily Generation Profiles**



PV systems are planned for rooftops, parking spaces, and ground-mount configurations. Figure 14 presents examples of each these types of installations

**Figure 14 – 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 by node of the microgrid.

**Table 10 - Microgrid PV Resources by Node**

Node	PV	
	# of Inverters	Total kW
1	4	87
2	1	7
3	1	12
4	1	35
5	1	27
<b>Total</b>	<b>8</b>	<b>168</b>

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

**Table 11 – Microgrid PV Fleet Electric Production**

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Total
Electric Production (kWh)						
Jan	7,126	642	1,101	3,212	2,478	14,560
Feb	7,949	701	1,201	3,503	2,702	16,055
Mar	10,807	957	1,641	4,786	3,692	21,884
Apr	9,851	867	1,486	4,335	3,344	19,884
May	10,361	911	1,562	4,556	3,515	20,905
Jun	9,921	873	1,496	4,363	3,366	20,018
Jul	9,670	850	1,457	4,250	3,279	19,507
Aug	9,634	848	1,454	4,242	3,272	19,452
Sep	9,591	845	1,449	4,226	3,260	19,372
Oct	8,824	776	1,331	3,881	2,994	17,807
Nov	6,774	602	1,033	3,012	2,324	13,744
Dec	6,602	582	997	2,908	2,243	13,331
<b>Total</b>	<b>107,110</b>	<b>9,455</b>	<b>16,209</b>	<b>47,275</b>	<b>36,470</b>	<b>216,519</b>

**Figure 15 – Microgrid PV Fleet Electric Production**

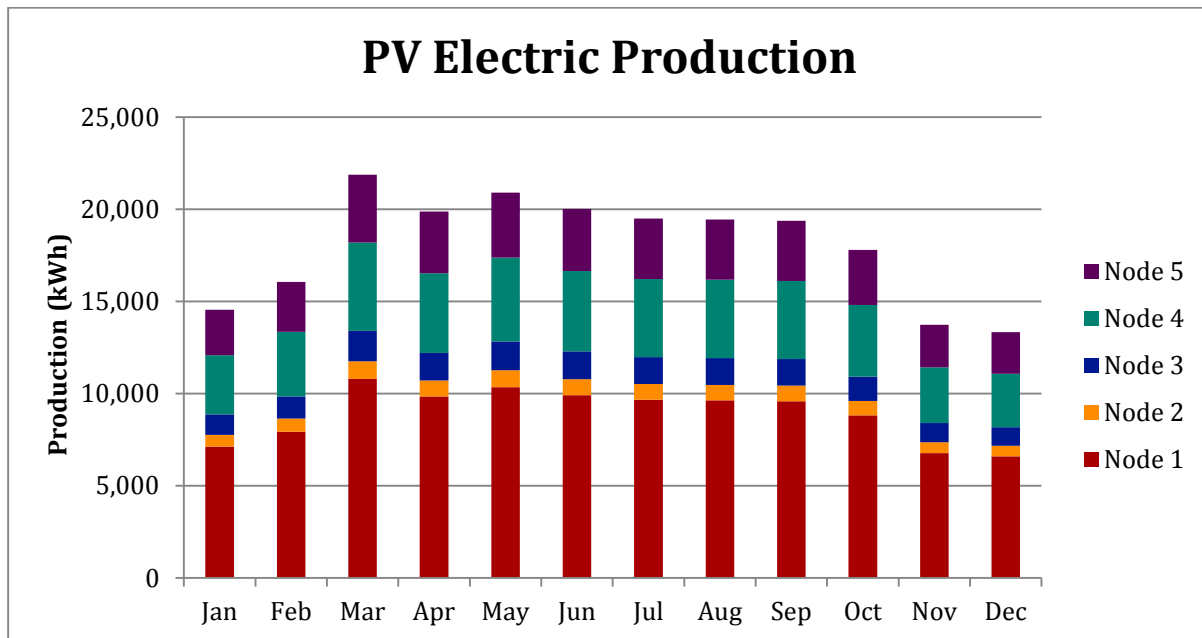
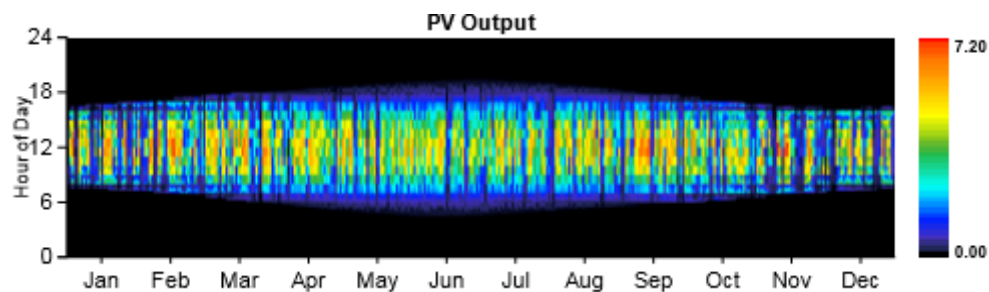


Figure 16 presents the hourly operation of the PV in an example node in the form of a heat map. This representation demonstrates how the PV units operate during hours of sunshine with maximum production in the middle of the day, ramping up in the mornings and ramping down in the afternoon hours. This also illustrates the trend of narrower daily bands of production in the winter and then expansion to maximum production in the summer.

**Figure 16 – Example Node PV Operational Summary**



## Energy Storage Systems

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

footprint, and a relatively high round trip efficiency. Li-ion batteries have some unique operational characteristics:

- The usable energy capacity is between a 15% and 95% state of charge (SOC)
- The life of the batteries are impacted by temperature and charge rate
- Most systems are capable of approximately 3,000 deep discharge cycles (+/- 80% SOC cycles)
- Most systems are capable of more than 100,000 shallow discharge cycles (+/- 15% SOC cycles)
- The batteries are at a high risk of failure if the system is discharged to a zero percent state 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 17 presents examples of energy storage installations for the technologies addressed for this microgrid design.



**Figure 17 – Example ESS Installations**



### **Energy Storage Approach**

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

### **ESS in the Microgrid**

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

**Table 12 - Microgrid ESS Resources by Node**

Node	Battery Energy Storage		
	Qty	kW	kWh
1	3	30	60
2	1	5	10
3	1	35	70
4	1	20	40
5	1	5	10
<b>Total</b>	<b>7</b>	<b>95</b>	<b>190</b>

Unlike the other microgrid resources, the ESS both consumes and produces energy. When properly used, the net energy consumed is very small. The annual operation of the ESS in Node 2 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 - Example Node**

Month	Charge	Discharge	Net
	(kWh)		
Jan	750	495	256
Feb	154	142	12
Mar	105	97	8
Apr	165	151	13
May	1,415	1,302	113
Jun	4,479	4,120	358
Jul	2,285	2,188	97
Aug	4,368	4,082	285
Sep	2,082	1,766	316
Oct	1,597	1,469	128
Nov	380	545	-165
Dec	994	719	275
<b>Total</b>	<b>18,774</b>	<b>17,076</b>	<b>1,698</b>

**Figure 18 – Microgrid ESS Operation**

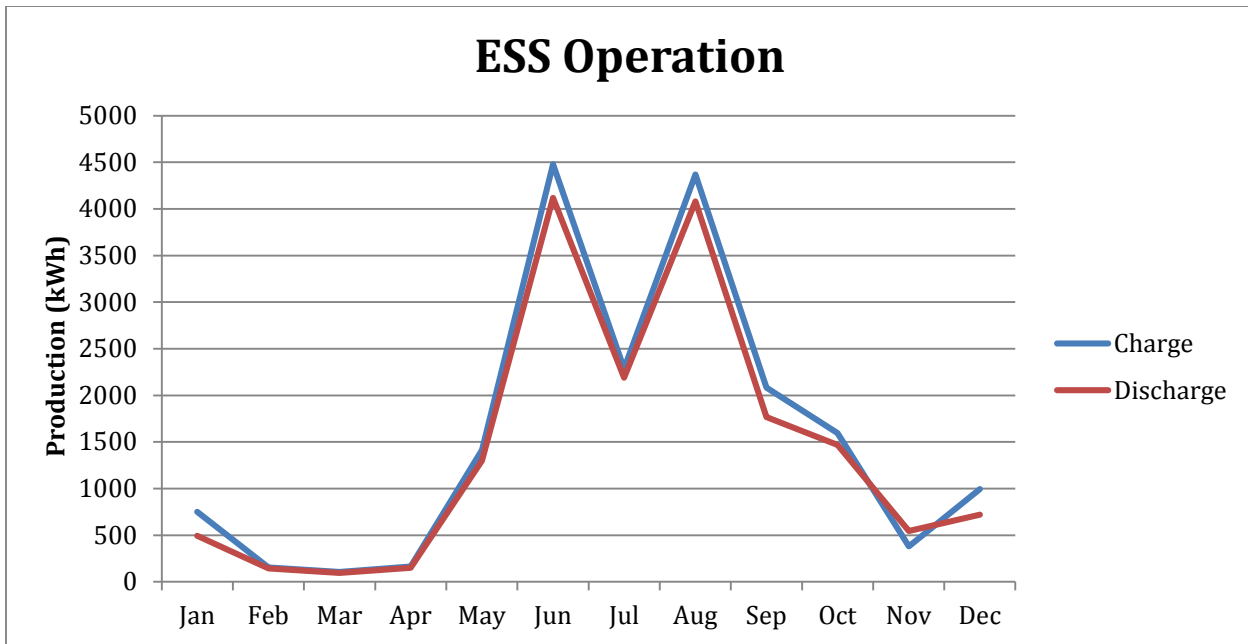
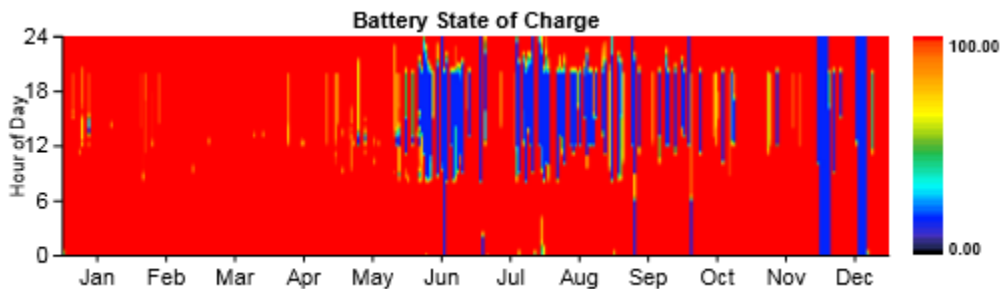


Figure 19 presents the hourly operation of the ESS in an example node in the form of a heat map. This representation demonstrates how the ESS units operate. Typically, the units are charged to a high SOC in the middle of the day. The operations represent PV intermittency support, PV load shifting, peak shaving (to manage utility imports), and supporting CHP loading.

**Figure 19 – Example Node ESS Operational Summary**



## Island Mode Modeling Results

The resources included in the Irvington 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 Irvington Community Microgrid is to supply the critical load at a level that enables the critical services that keep the community functioning at a sufficient level throughout the entire event duration. This provides full functionality for police, fire, and emergency services while also providing some level of heat and power to other facilities and residents. Each node was modeled for operation during an extended outage (one week) to evaluate and optimize microgrid resources operating in island mode. Two outage events were modeled to represent an outage during the winter and an outage during the summer. Energy flows during the outages are presented as weekly averages in Table 14.

**Table 14 –Microgrid Energy Overview: Island Mode Operation**

Node	Season	Electric Demand		Electric Consumption	Thermal Load	Thermal Recovery
		Max (kW)	Avg (kW)	kWh/week	kBTU/week	kBTU/week
1	Winter	824	559	93,968	1,574,828	454,184
	Summer	670	559	93,915	17,202	17,202
2	Winter	36	18	3,075	71,653	4,216
	Summer	24	6	977	281	281
3	Winter	38	19	3,206	19,554	9,855
	Summer	157	18	3,043	0	0
4	Winter	139	36	6,001	311,916	18,443
	Summer	80	31	5,278	3,640	3,540
5	Winter	31	14	2,301	50,484	5,624
	Summer	37	16	2,681	349	349
<b>Total</b>	<b>Winter</b>	<b>1,069</b>	<b>646</b>	<b>108,551</b>	<b>2,028,435</b>	<b>492,322</b>
	<b>Summer</b>	<b>968</b>	<b>630</b>	<b>105,894</b>	<b>21,473</b>	<b>21,372</b>

### Microgrid DERs Resiliency

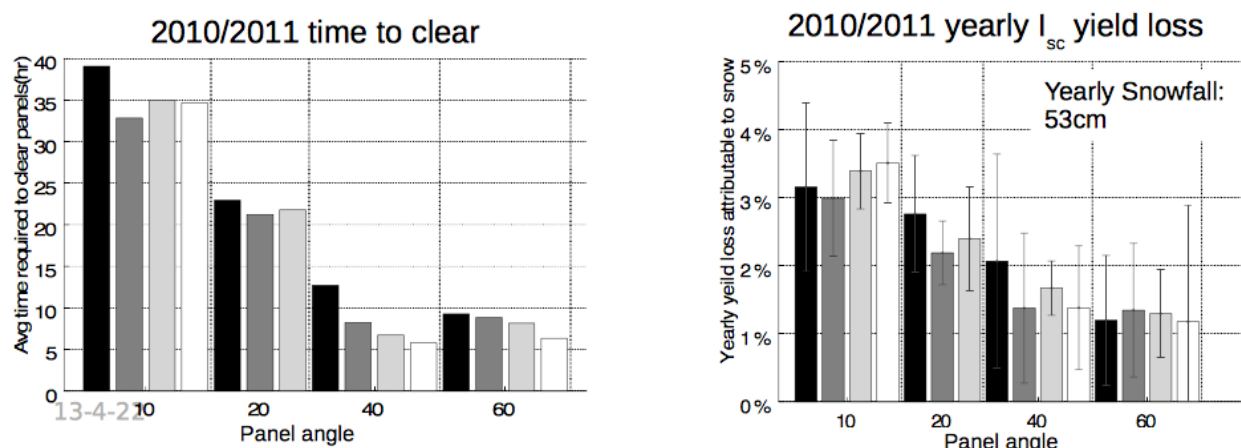
Under Task#1, the team assessed the resiliency risk profile for various forces of nature to inform the microgrid design. This profile was evaluated in the following areas, with the associated design emphasis results:

1. Wind / Tornado – the design of the DER structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical and thermal distribution equipment will withstand Category F2 wind speeds for this area. Installation of energy storage systems will be inside interior building electrical or mechanical rooms wherever possible.

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

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

**Figure 20 – PV Impedance from Snowfall**



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

### **Reliability of Fuel Sources**

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

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

- (1) there are multiple network sources of natural gas
- (2) the actual natural gas network load decreases in a major storm because the non-critical loads are not operating
- (3) there is no history of loss of service in past major storms

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

## **FINANCIAL FEASIBILITY**

The outputs of the technical modeling process described above were used to evaluate the financial viability of the proposed microgrid from two perspectives. First, the project team analyzed the financial strength of the project when deployed using the proposed third-party ownership business model. Under this model, the project is funded through outside investment and debt which is recouped through a power purchase agreement (PPA) with each facility. In addition, NYSERDA contracted with Industrial Economics, Incorporated (IEC) to perform a benefit-cost analysis. The focus of this analysis is to evaluate the societal benefit of the microgrid, including benefits from emissions reductions, cost reductions, and resilience improvements.

### **Installed Cost**

At this feasibility stage of the project, a high-level project budget for the Irvington Community Microgrid project was developed and incorporated into the technical model to ensure that the design meets both the technical and economic requirements of the project. This budget includes costs for engineering, permitting, capital equipment, site preparation, 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 \$4,491,000 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 \$4,162,000. This cost does not include other incentives that may be applicable to the project that will be applied during the detailed analysis in Stage 2.

The project team evaluated several available financial incentives when performing the financial analysis for the Irvington Community Microgrid. The following programs<sup>[1]</sup> 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 Irvington 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 Irvington project is ready to take advantage of them, which is why no specifics are included here.
- **NY SUN initiative:** This program provides rebates and performance incentives for new residential and commercial solar PV installations.
- **New York Power Authority – Energy Services Program for Public Utilities:** This program provides various rebates on energy efficient equipment.
- **Federal Energy-Efficient Commercial Buildings Tax Deduction:** This deduction provides \$0.30-\$1.80 per square foot, depending on technology and amount of energy reduction for buildings that become certified as meeting specific energy reduction targets as a result of improvements in interior lighting; building envelope; or heating, cooling, ventilation, or hot water systems.
- **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.

### Third Party Ownership

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

The SPE will engage the design team to finalize the construction drawings and utility interconnection agreements. The SPE will engage an engineering, procurement, and construction firm to build the microgrid, and will be financially responsible for all engineering, procurement, and

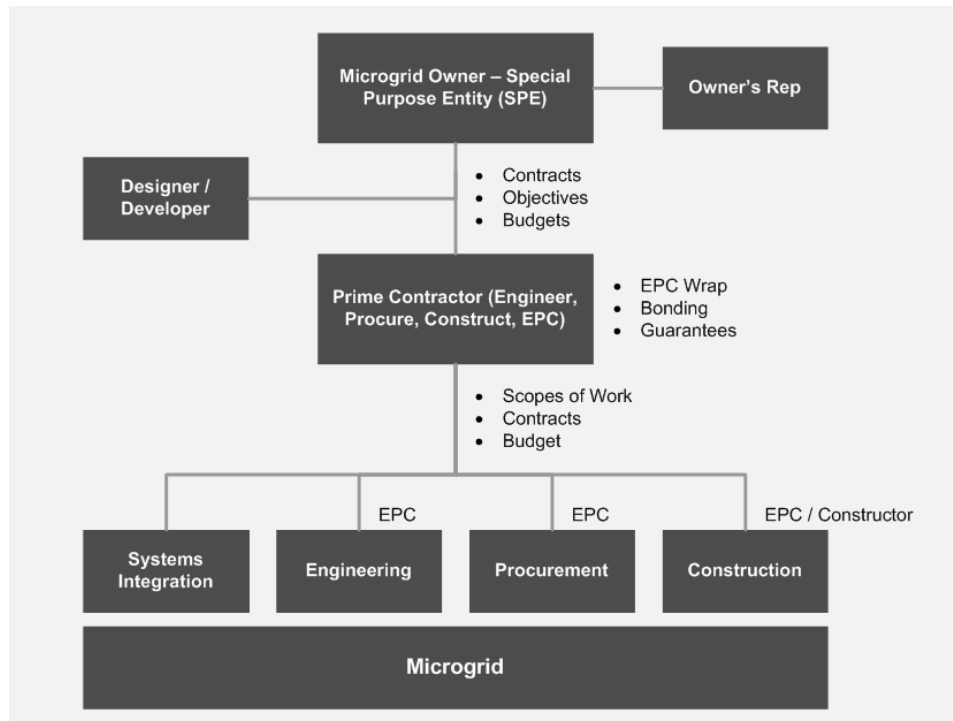
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<sup>[1]</sup> Identified from the DSIRE database as of December 2015.

<http://programs.dsireusa.org/system/program?state=NY>

construction for the system. The SPE will also be financially responsible for integrating the controls and communications systems. This process is presented in Figure 21 below.

**Figure 21: 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 per-kWh price and discuss those options with potential system participants.

The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately \$0.141/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 will match or be slightly above this current weighted electrical rate, depending on the award of further grants from the NY Prize Program and the potential to share costs for installing distribution lines underground.



## 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 Irvington Community Microgrid, the breakeven outage case is 1.7 days of major power outage per year. The cost benefit results are presented in Table 15. 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 1.7 days per year (Scenario 2).

**Table 15 – Cost Benefit Analysis Results**

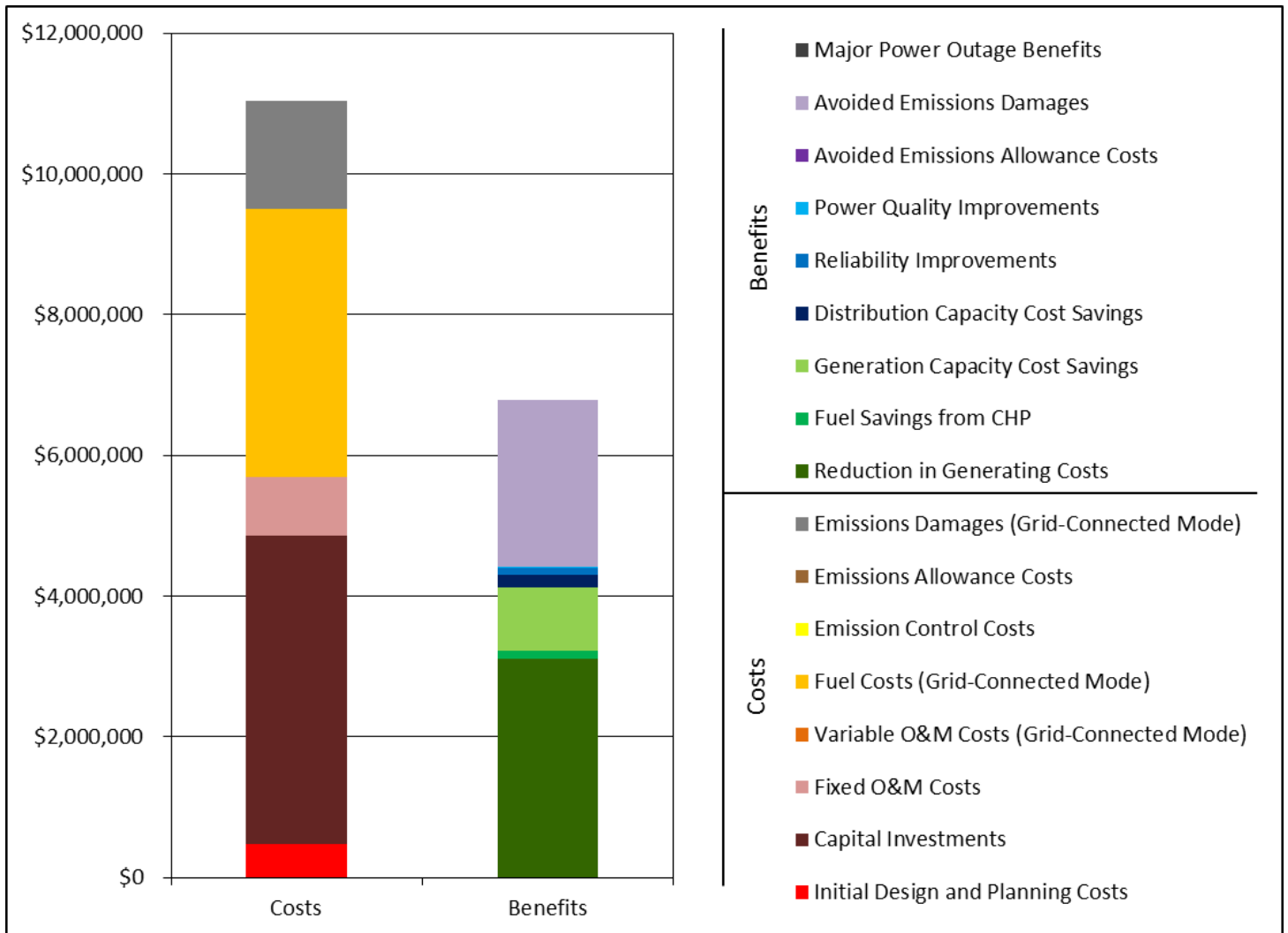
Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 1.7 DAYS/YEAR
Net Benefits - Present Value	-\$4,260,000	\$184,000
Total Costs – Present Value	\$11,000,000	\$11,000,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-19.7%	6.9%

The cost benefit analysis results for scenario 1 are presented in Table 16.

**Table 16 – Cost Benefit Analysis Scenario 1  
(No Major Power Outages; 7 Percent Discount Rate)**

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
<b>Costs</b>		
Initial Design and Planning	\$475,000	\$41,900
Capital Investments	\$4,390,000	\$349,000
Fixed O&M	\$823,000	\$72,600
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$3,810,000	\$336,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$1,550,000	\$101,000
<b>Total Costs</b>	<b>\$11,000,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$3,110,000	\$274,000
Fuel Savings from CHP	\$107,000	\$9,480
Generation Capacity Cost Savings	\$898,000	\$79,200
Distribution Capacity Cost Savings	\$183,000	\$16,100
Reliability Improvements	\$102,000	\$9,020
Power Quality Improvements	\$19,400	\$1,710
Avoided Emissions Allowance Costs	\$1,530	\$135
Avoided Emissions Damages	\$2,360,000	\$154,000
Major Power Outage Benefits	\$0	\$0
<b>Total Benefits</b>	<b>\$6,790,000</b>	
<b>Net Benefits</b>	<b>-\$4,260,000</b>	
<b>Benefit/Cost Ratio</b>	<b>0.6</b>	
<b>Internal Rate of Return</b>	<b>-19.7%</b>	

**Figure 22 – Cost Benefit Analysis Scenario 1  
(No Major Power Outages; 7 Percent Discount Rate)**

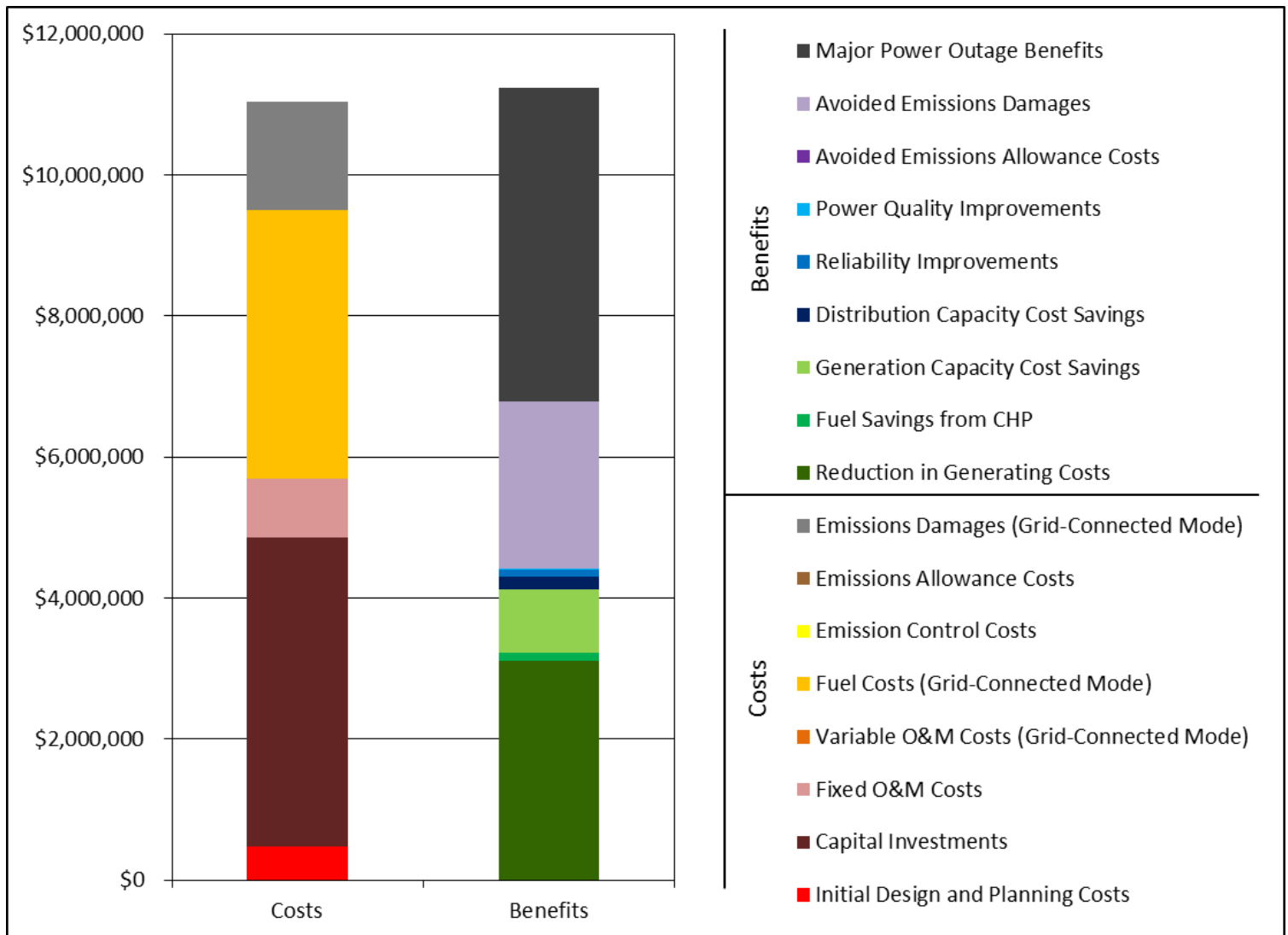


The major drivers of costs are the capital investments and fuel, where the major benefits are reduction in generation costs and avoided emissions damages.

**Table 17 – Cost Benefit Analysis Scenario 2**  
**(Major Power Outages Averaging 1.7 Days/Year; 7 Percent Discount Rate)**

<b>COST OR BENEFIT CATEGORY</b>	<b>PRESENT VALUE OVER 20 YEARS (2014\$)</b>	<b>ANNUALIZED VALUE (2014\$)</b>
<b>Costs</b>		
Initial Design and Planning	\$475,000	\$41,900
Capital Investments	\$4,390,000	\$349,000
Fixed O&M	\$823,000	\$72,600
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$3,810,000	\$336,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$1,550,000	\$101,000
<b>Total Costs</b>	<b>\$11,000,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$3,110,000	\$274,000
Fuel Savings from CHP	\$107,000	\$9,480
Generation Capacity Cost Savings	\$898,000	\$79,200
Distribution Capacity Cost Savings	\$183,000	\$16,100
Reliability Improvements	\$102,000	\$9,020
Power Quality Improvements	\$19,400	\$1,710
Avoided Emissions Allowance Costs	\$1,530	\$135
Avoided Emissions Damages	\$2,360,000	\$154,000
Major Power Outage Benefits	\$4,440,000	\$392,000
<b>Total Benefits</b>	<b>\$11,200,000</b>	
<b>Net Benefits</b>	<b>\$184,000</b>	
<b>Benefit/Cost Ratio</b>	<b>1.0</b>	
<b>Internal Rate of Return</b>	<b>6.9%</b>	

**Figure 23 – Cost Benefit Analysis Scenario 2  
(Major Power Outages Averaging 1.7 Days/Year; 7 Percent Discount Rate)**



The benefits from the 1.7 days of outages result in \$4,440,000 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 Irvington's financial feasibility analysis are based on the Con Edison's distributed generation rate. This resulted in year

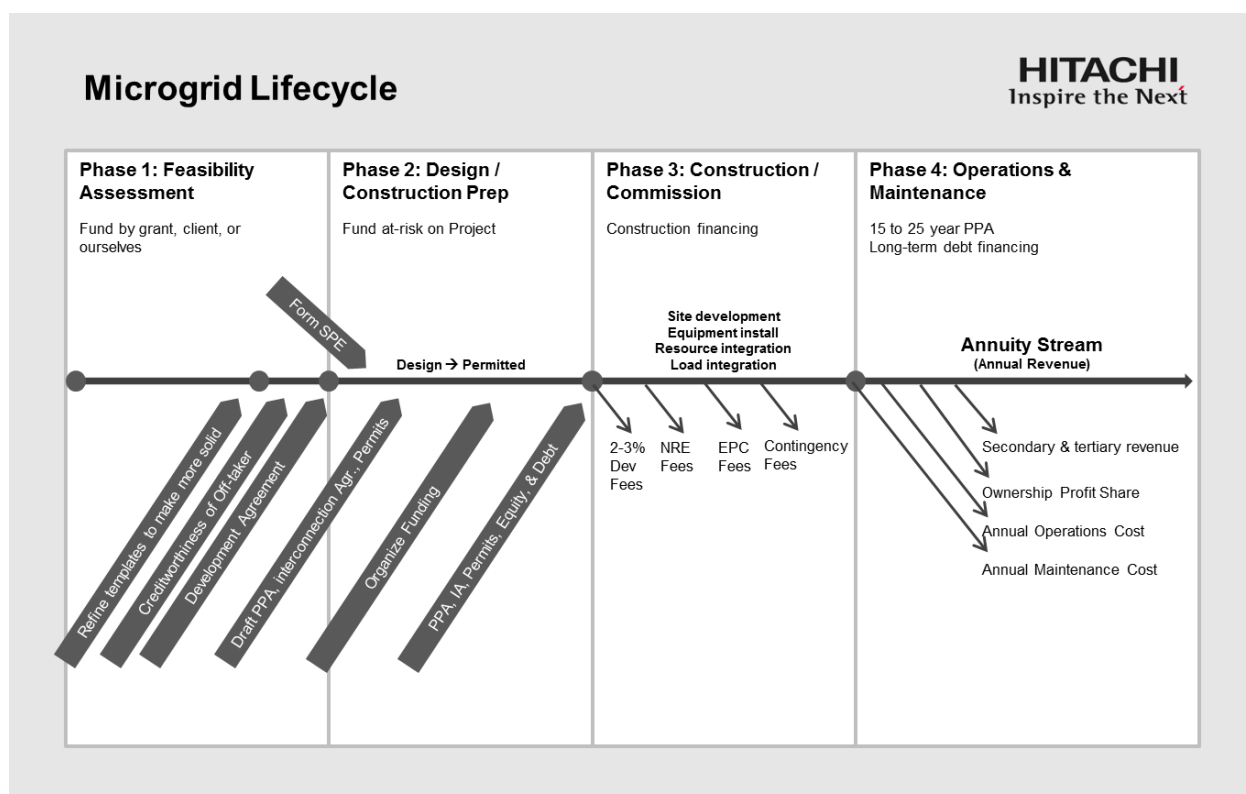
1 gas rates of \$6.34 and \$5.80, for the benefit-cost analysis and the financial feasibility analysis, respectively. If Con Edison's distributed generation rate were applied to the benefit-cost analysis, net benefits would be increased by \$160,000.

- The benefit-cost analysis derives a price for electricity based on average wholesale energy costs, whereas the financial feasibility assessment evaluates the savings to the community based on actual costs paid by community participants.
- The financial feasibility assessment incorporates the tax benefits of the Federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit reduces the capital cost of the project by \$329,000.
- 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 Irvington Community Microgrid is \$314,000 less than the full cost of replacement.
- The period of analysis in the benefit cost analysis is 20 years and the third party ownership model is based on a period of analysis of 25 years.

### **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 24:

**Figure 24: Hitachi Microgrid Lifecycle**



In addition to the elements included in NY Prize Stage 1, the Hitachi Microgrid Lifecycle includes an evaluation of the customer creditworthiness.

In addition to the elements included in NY Prize Stage 2, the Hitachi Microgrid Lifecycle includes establishing a SPE early in the process to formulate the business model negotiation.

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

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

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

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

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

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

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

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

Operation of the microgrid will include several key components:

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

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

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



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

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

## **SWOT Analysis**

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

### **Strengths**

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

### **Weaknesses**

- At the end of the PPA term, the PPA must be renegotiated. Alternatively, the assets can be transferred to the facility owner(s). This can also occur before the end of the PPA termination period, subject to “fair market value” terms defined in the agreement.
- If the buyers' demand for energy significantly decreases, the PPA requires the buyer to continue to purchase the guaranteed amount of kilowatt-hours energy at the price agreed upon in the PPA.

- Savings from new, more cost-effective solutions that are integrated into the microgrid over the life of the PPA are captured by the SPE rather than the community.
- Additional coordination is required for maintenance and replacement of facility infrastructure (e.g., roofs) for facilities housing microgrid components (e.g., PV panels).

### **Opportunities**

- The community will have capital and operating expense resources available to pursue other village resilience projects or other priorities.
- Irvington 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.
- Irvington has a set of resources at specific critical facilities to include in a comprehensive emergency preparedness plan.

### **Threats**

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

## **PROJECT TEAM**

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

Other stakeholders have been kept informed throughout the process and have assisted the study by supporting site audits, providing facility information, and participation in regular status calls. As this project enters the next phase, the project team should hold face-to-face meetings with

participants to review the results of the feasibility study and touch base on their interest in participating in the microgrid once it becomes live.

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

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

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

## **LEGAL VIABILITY**

The project team has developed a model for the legal organization of the Irvington 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,

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 PPAs are now a well-established financing opportunity, only ten years ago, they were little understood by financiers. Today, microgrids are not as well understood in the financial sector. The financial industry has not yet created standardized financing products for microgrids, and each new project has required a custom deal. This tends to drive up the cost of capital.

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 Irvington 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 positive levels of support and cooperation with the feasibility study phase. Should this trend continue, Irvington can expect this risk to be manageable in the next phase. 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, Irvington can expect this risk to be fairly small in the next phase.

### **Regulatory Issues**

The ownership model of the Irvington 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,<sup>1</sup> is under 80 MW,<sup>2</sup> serves a qualifying number of users, and its related facilities (including any private distribution infrastructure) are located “at or near” its generating facilities. This saves the system from a raft of burdensome regulatory requirements.

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

### **Privacy**

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

## **CONCLUSIONS AND NEXT STEPS**

### **Conclusions and Next Steps**

The NY Prize feasibility assessment indicates that the Irvington Community Microgrid is technically viable, and may be economically viable if future grants are awarded from NYSEERDA in the NY Prize Stage 2 and 3. The microgrid will protect the operation of the critical facilities along the Main Street corridor, ensuring that business and government can continue uninterrupted, while the schools can be used as emergency shelters for the community. Additional microgrid nodes will protect other

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<sup>1</sup> 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 <sup>1</sup>

<sup>2</sup>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.

<sup>2</sup> Id.

important facilities and functions including the village's public works and a large residential healthcare facility.

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

1. **Engaged Stakeholders:** The larger loads in the Irvington Community Microgrid are all at facilities and institutions that are well established, and committed to the project, including many that are directly managed by village government.
2. **Many Small Distributed Systems:** The fact that the microgrid includes several nodes, and that several of them are quite small, contributes to a higher total installed cost.
3. **Natural Gas Costs:** One of the other cost drivers for the project is natural gas. Increasing costs for natural gas will have a negative impact on the PPA rates for each of the facilities. However, the PPA rate is likely to grow at a slower rate over time than the total cost of electricity from the grid.
4. **Community Microgrid Financing Costs:** The cost of project financing is high for community microgrids. This is due to the fact that there are numerous stakeholders and potential customers, and that each stakeholder has its own procurement requirements. The project team will need to seek out a financier that is knowledgeable about these projects, and can help keep transaction costs to a minimum.
5. **Financial Prospects:** As it stands, the Irvington Community Microgrid project is not likely to meet the financial requirements for third party financing and ownership. In order to meet these requirements, one or more of the following conditions would need to be met:
  - a. The award of Stage 2 and Stage 3 NY Prize grants from NYSERDA
  - b. The inclusion of additional commercial customers with higher electric costs
  - c. Removal of smaller facilities and nodes
  - d. The use of PPA rates above the current average cost of energy for prospective microgrid customers.

## Regulatory and Policy Recommendations

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

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

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

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

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."<sup>4</sup> In February, 2015, the PSC published the "Order Adopting Regulatory Policy Framework and Implementation Plan"<sup>5</sup> which described several circumstances when utility ownership of DER would be allowed. One of these circumstances is for a project that is "sponsored for demonstration purposes." This may be applicable to some NY Prize projects, but it is unclear what the criteria would be for an acceptable demonstration project. Also, this does not help drive the broader market for microgrids as this limits the number of systems that will be implemented in the near term.

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

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

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<sup>3</sup> See *Texas Ohio Power v. Connecticut Light and Power*, 243 Conn. 635, 651 (1998).

<sup>4</sup> New York Public Service Commission. 1998. "Vertical Market Power Policy (VMPP) Statement

<sup>5</sup> New York Public Service Commission. 2015. "Order Adopting Regulatory Policy Framework and Implementation Plan."

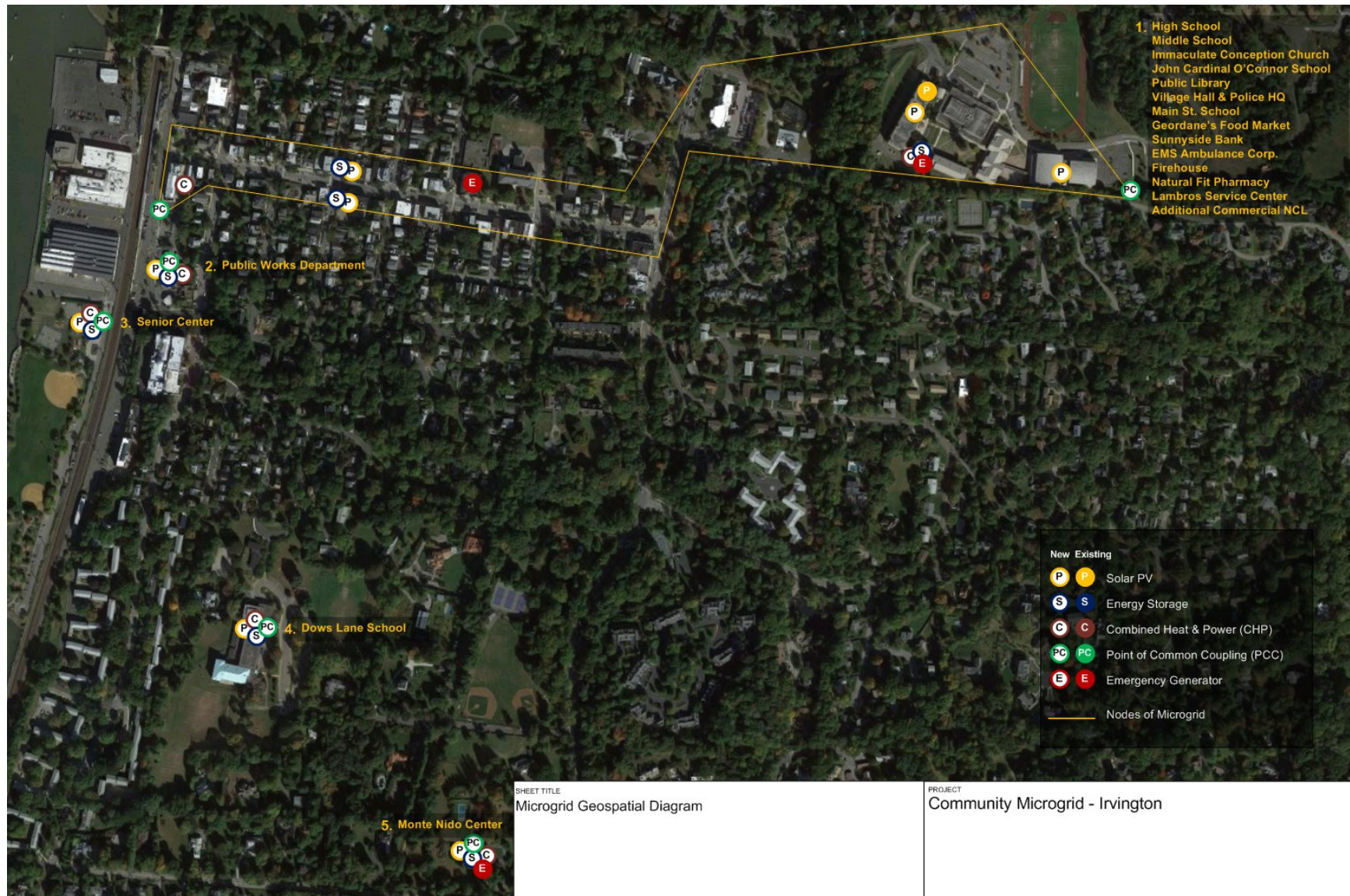
4. **Multiple Customer Contracting:** Multiple customers within the community microgrid create challenges of financing, procurement, and operations across the stakeholders in the community. Continued state support for the NY Green Bank mission of implementing structures that address gaps and overcome 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 Irvington 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.

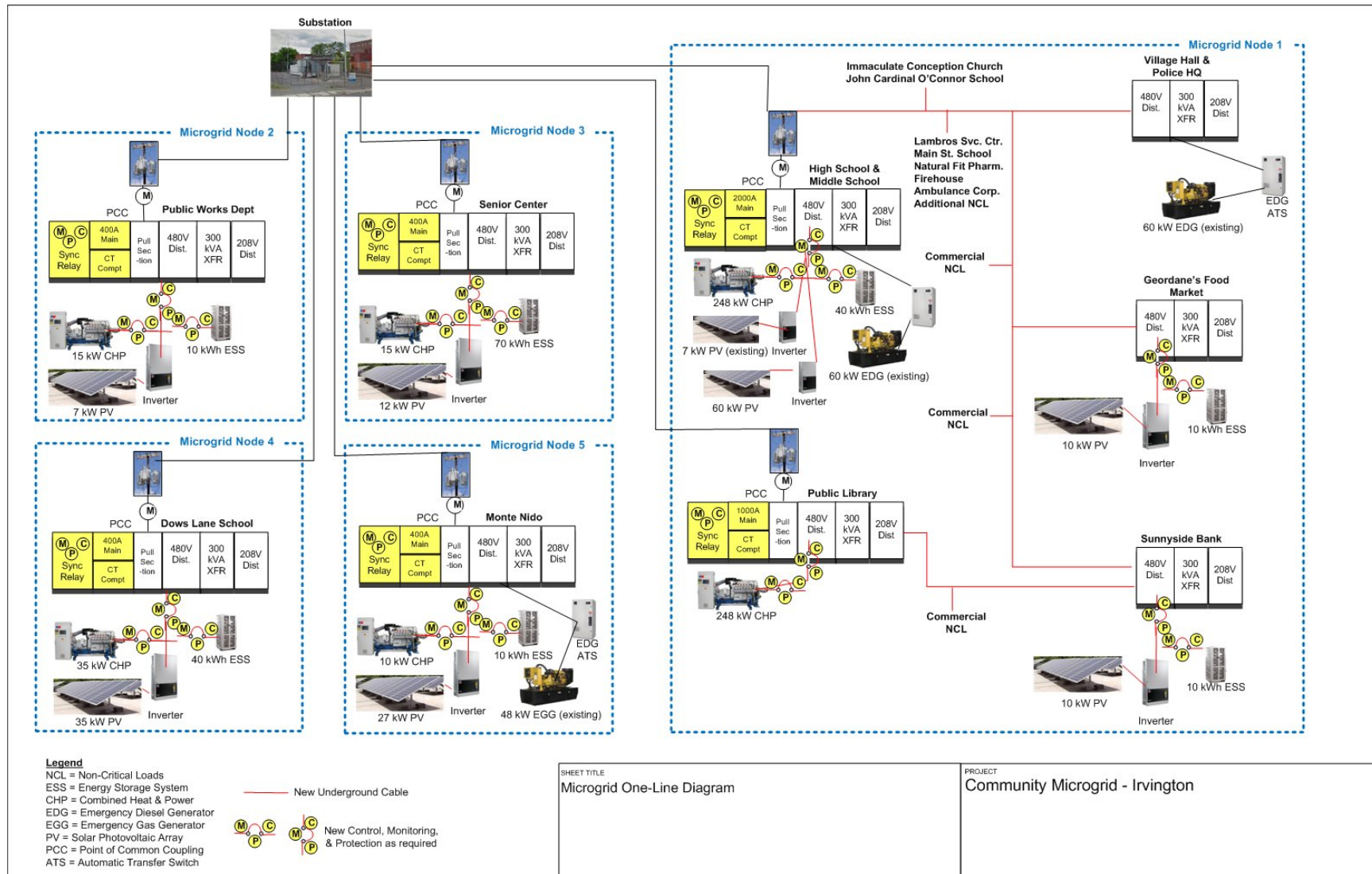
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## APPENDIX A: IRVINGTON MICROGRID LAYOUT DIAGRAM



## APPENDIX B: IRVINGTON MICROGRID ONE-LINE DIAGRAM





## APPENDIX C: LEGAL AND REGULATORY REVIEW

### I. Ownership and Public Service Law Regulatory Treatment

The ownership model that the Irvington 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 of project status.

The Public Service Commission (Commission) has considered utility ownership of distributed energy resources (DERs), which would include *inter alia* microgrid generation and storage assets. The Commission's stated policy from its February 26<sup>th</sup> "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."<sup>6</sup>

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.

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

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<sup>6</sup> Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan, Feb. 26, 2015, at 67-70.

Commission intends for projects qualifying under this condition to be primarily geared towards expanding the utility's understanding of how storage assets can provide benefits to the distribution grid, and specifically noted that "[w]ith respect to resources at the customer location, utility ownership should not be necessary."<sup>7</sup> Storage integrated into a microgrid would not seem to qualify under this condition.

Speaking to the third scenario, the proposed project does not target low/moderate income customers who would otherwise not be likely to receive microgrid service from the market. As such it may not target utility ownership as a potential DER ownership structure under this condition.

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).<sup>8</sup>

The fourth principle for demonstration projects articulated by the Commission leaves some uncertainty regarding what conditions of utility ownership will be permitted under the context of a demonstration project. The Commission elsewhere notes that "proponents of demonstration projects should strive for third party ownership of DER, keeping in mind that any regime of third party ownership must be done in a manner that ensures safety, reliability and consumer protection."<sup>9</sup>

In practice, the Commission has approved demonstration projects that involve utility ownership of DERs. Con Ed's Virtual Power Plant demonstration project, for example, allows Con Ed to own

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<sup>7</sup> Id. at 69.

<sup>8</sup> Case 14-M-0101, "Memorandum and Resolution on Demonstration Projects," Dec. 12, 2014, at Appendix A.

<sup>9</sup> Id. at 9.

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.<sup>10</sup>

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.”<sup>11</sup> The Commission has not yet issued a formal deadline for the proposal of new demonstration projects at this time.

In the Irvington microgrid, it is plausible that Con Ed 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. Utility Ownership of Non-Generation Microgrid Assets Only**

Even if Con Ed does not own any of the DER assets within the Irvington 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 Ed ownership of only distribution microgrid assets is proposed, it will be necessary to address the method under which the microgrid will export to the utility grid. There are several potential regimes under which individual customers within the microgrid may export power onto the utility grid.

### **A) Net metering**

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

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,

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<sup>10</sup> 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.

<sup>11</sup> Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan, Feb. 26, 2015, at 117.

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.<sup>12</sup>

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 Irvington microgrid project, proposed PV generation assets may be eligible to receive net metering credit. Con Ed's net metering tariff may be found at Rider R: Tariff for Net-Metered Customers.<sup>13</sup>

## 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 Ed's buyback tariff can be found at Service Classification SC-11.<sup>14</sup>

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

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

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<sup>12</sup> NY PSL § 66-j.

<sup>13</sup> Available at <http://www.coned.com/documents/elecPSC10/GR24.pdf#nameddest=riderr>.

<sup>14</sup> Available at <http://www.coned.com/documents/elecPSC10/SCs.pdf#nameddest=sc11>.

### C) Application of the Offset Tariff

Con Ed's offset tariff can supplant the traditional standby tariff to allow customers connecting an efficient CHP system<sup>15</sup> 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.<sup>16</sup> 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 Village Hall, Main St. School, Fire Station and Ambulance.

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 Irvington 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."<sup>17</sup>

This criteria may open the door for Con Ed 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.<sup>18</sup>

## 3. Privately-Owned Microgrid Distribution

Irvington 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

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<sup>15</sup> As designated pursuant to the order of the Public Service Commission, dated January 23, 2004, in Case 02-E-0781.

<sup>16</sup> 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

<sup>17</sup> Case 14-M-0101, "Memorandum and Resolution on Demonstration Projects," Dec. 12, 2014, at Appendix A.

<sup>18</sup> See, e.g., Case 14-E-0318, "Testimony of the Reforming the Energy Vision Panel," July 15, 2014, at 14.

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

Irvington's microgrid may be exempted from much of the PSL regulation applying to electric distribution companies if it is deemed a qualifying facility under the terms of PSL §2. A microgrid will be deemed a qualifying facility if it utilizes qualifying forms of generation,<sup>24</sup> is under 80 MW,<sup>25</sup>

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<sup>19</sup> PSL § 66.

<sup>20</sup> PSL § 65.

<sup>21</sup> PSL § 66.

<sup>22</sup> PSL § 66, 68(a).

<sup>23</sup> PSL § 69.

<sup>24</sup> 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.

<sup>25</sup> Id.



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 Irvington 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 Irvington 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.<sup>26</sup> 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.”<sup>27</sup> 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 Irvington 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.<sup>28</sup> 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.<sup>29</sup>

In the Irvington microgrid, the geographic footprint of private distribution facilities may or may not satisfy the “at or near” test developed by the Commission, depending on where distribution facilities are required. The maximum distance between properties proposed to be incorporated in

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<sup>26</sup> 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).

<sup>27</sup> *Id.*

<sup>28</sup> See NYSEDA, “Microgrids for Critical Infrastructure Resiliency in New York,” (Dec. 2014), at 31.

<sup>29</sup> *Id.*

the microgrid appears to be approximately 1.5 miles. Private distribution facilities would have to cross property lines and several rights of way. Declaratory rulings addressing facilities in comparable environments have been close to this distance, such as *Burrstone* (approximately half a mile),<sup>30</sup> *Nissoquogue Cogen Partners* (1.5 miles),<sup>31</sup> and *Nassau District Energy Corporation* (1.7 miles).<sup>32</sup> 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 approach or exceed the length for which the Commission has provided positive precedent. If a smaller circuit of private distribution were proposed, it may better compare to precedent.

In light of the above factors, the Irvington microgrid project may or may not satisfy the “at or near” requirement to achieve qualifying facility status, depending on the specific distribution infrastructure proposed. 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 Irvington 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.<sup>33</sup> 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.<sup>34</sup> 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 Irvington project.

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

In its February 26<sup>th</sup> “Order Adopting Regulatory Framework and Implementation Plan,”<sup>35</sup> the Commission considered that a third model for regulating “community microgrids” with respect to the PSL might be appropriate. The Commission did not fully articulate how this model would function or make specific proposals. Parties were invited to comment on this matter on May 1<sup>st</sup>,

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<sup>30</sup> 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).

<sup>31</sup> Case 93-M-0564, *In re Nissoquogue Cogen Partners*, Declaratory Ruling (1993)

<sup>32</sup> Case 89-E-148, *Nassau District Energy Association*, Petition for a Declaratory Ruling (Sept. 27, 1989).

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

<sup>34</sup> 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).

<sup>35</sup> Case 14-M-0101, *Order Adopting Regulatory Framework and Implementation Plan*, Feb. 26, 2015, at 110.

2015. The Irvington 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.

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

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

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

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

<sup>37</sup> 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.

microgrid proposal and the other three options involved more traditional measures that included rebuilding miles of electric distribution lines. Due to its rugged and remote terrain, additional transmission and distribution investments were not comparably cost effective, as well as being an environmentally inferior option.<sup>38</sup>

In other settings, utilities have proposed microgrid ownership as part of pilot projects. Con Ed, 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 Ed 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, Irvington does not appear to suffer from service adequacy issues that would invoke the need to build a utility-owned microgrid purely for reliability purposes. It is likely that, if this project were to proceed as a utility-owned microgrid, it would need to seek a PSC approval as a demonstration project or pilot.

From a contracting perspective, utilities may have broad latitude to develop unique contracting arrangements directly with customers in a pilot or demonstration project. There do not exist model contract templates for microgrid service. In Central Hudson's microgrid proposal, for example, it proposed developing "a service agreement for a specified term under which the cost for [microgrid] facilities would be recovered,"<sup>39</sup> 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

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

<sup>39</sup> Case 114-E-0318, Testimony of Reforming the Energy Vision Panel (July 25, 2014) at 14.

- Transferring service obligation to future property owners / encumbering property
- Potential joint-financing schemes (i.e., a municipal customer with a higher credit rating than utility may take lead on securing financing for some portion of project)

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

There does not presently exist a model tariff for utilities to provide islanding service to a group of customers served by privately-owned DERs. However, different microgrids have proposed to move forward under existing or novel tariffs with the incumbent utility to use utility distribution and rely on the utility to integrate with private microgrid controllers to support islanding functionality.<sup>40</sup>

In the Irvington 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. Contracting between Customer and Private Developer**

Privately-owned microgrids are permissible in New York, subject to the regulatory concerns around PSL regulation discussed in the previous section. See the Burrstone Energy Center case study in NYSED’s 2010 microgrid report.<sup>41</sup> 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

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<sup>40</sup> See, e.g., discussion of the Parkville microgrid in NYSED’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.”

<sup>41</sup> NYSED, “Microgrids: An Assessment of the Value, Opportunities, and Barriers to Deployment in New York State,” (Sept. 2010) at A-45.

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

It is premature at this time to make a recommendation on ownership structure for the Irvington 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. Vil. Law § 4-412, every Village Board of Trustees is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city.<sup>42</sup> "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.<sup>43</sup>

In the village of Irvington, the process for granting a franchise for electric distribution wires is not specified in any local code. Under N.Y. Vil. Law, the Board of Trustees will have discretion in

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<sup>42</sup> N.Y. Vil. Law § 4-412.

<sup>43</sup> 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)

determining the application process to obtain a franchise or lesser consent. Comparable jurisdictions have adopted specific franchise requirements that Irvington may look to.<sup>44</sup> The Study Team has approached Village Counsel for guidance on this question, but it has not been considered fully yet.

#### **IV. Application of Other Local Codes**

##### **1. Zoning**

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

- Village Hall and Police Headquarters, 85 Main St., Irvington NY 10533: B Business District
- Irvington Fire Chief, 90 Main St., Irvington NY 10533: B Business District
- Dept. of Public Works Garage, South Astor St., Irvington NY 10533: B Business District
- Irvington Senior Center, 29 Bridge St. Irvington NY 10533: I Industrial District (alternately referred to as WF District in conflicting copies of local code)
- South Astor St. Sewer Pump Station, South Astor St., Irvington NY 10533: B Business District
- Main St. School, 101 Main St., Irvington NY 10533: 2F Two-Family Residence District
- Irvington Middle and High Schools, 40 N. Broadway, Irvington NY 10533: 1F-20 One-Family Residence District
- John Cardinal O'Connor School, 16 US 9, Irvington NY 10533: 1F-20 One-Family Residence District
- Natural Fit Pharmacy, 104 Main St., Irvington NY 10533: B Business District
- Geordane's Food World Inc., 57 Main St., Irvington NY 10533: B Business District
- Lambros Service Center, 1 North Broadway, Irvington NY 10533: B Business District
- Sunnyside Federal Bank, 56 Main St., Irvington NY 10533: B Business District
- Chase Bank, 45 Main St., Irvington NY 10533: B Business District
- Irvington Public Library, 12 S. Aster St., Irvington NY 10533: B Business District
- Irvington Sewer Department, 120 Station Rd., Irvington NY 10533: 1F-40 One Family Residence District
- Water Booster Station at Harriman Rd. and Fieldpoint Dr., Irvington NY 10533: 1F-40 One Family Residence District
- Two Water Booster Stations on Riverview Rd., Irvington NY 10533: 1F-20 One Family Residence District
- Dows Lane School, 3 Dows Lane, Irvington NY 10533: 1F-40 One Family Residence District
- Monte Nido, 100 S. Broadway, Irvington NY 10533: 1F-40 One Family Residence District

##### **Generation as Permitted Use in Irvington Residential Districts (1F-40, 1F-20, 2F)**

Many proposed microgrid customers are located in residential districts, including 1F-40, 1F-20, and 2F districts. Electric generation is not an enumerated permitted use in residential districts. Typically, in that case, developers would look to cast electric generation as an accessory use, a special permit use, or seek a zoning variance.

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<sup>44</sup> See, e.g., Chapter 292 of New Rochelle Code, available at <http://ecode360.com/6737770>.

It does not appear that generation will be permitted as an accessory use in residential districts in Irvington. Generally, Irvington defines accessory uses as those “customarily incidental and subordinate to the main use of a lot, whether such ‘accessory use’ is conducted in a principal or accessory building.”<sup>45</sup> However, in residential districts specifically, Irvington lists an exclusive list of permissible accessory uses,<sup>46</sup> restricting developers from proposing unlisted uses that might otherwise comply with the general definition of “accessory use.”

No special use permit provision in residential zones would apply to microgrid generation.

Variances across all zones in Irvington are covered below.

#### Generation as Permitted Use in Irvington Business Districts (B)

Electric generation is potentially an enumerated permitted use in Irvington Business Districts, at least if owned by Con Ed. The Irvington Zoning Code allows for “Public utility installations needed to serve the Village or the neighborhood, subject to a determination by the Board of Appeals that no other reasonable location in a less restricted district can be used for the purpose contemplated and subject, further, to such conditions as said Board may deem to be appropriate for the protection of adjoining uses and of the character of the district.”<sup>47</sup> This provision is not associated with any special permit process, so it is unclear what application process would be required to petition the Zoning Board of Appeals. “Public utility installations” are not defined in the Code, so the scope of facilities permitted under this provision is subject to interpretation.

If the microgrid does not feature utility-owned generation, or if this provision does not apply for any reason, generation would have to be sited as an accessory use, a special permit use, or a variance.

As opposed to Irvington’s strict accessory use policy in residential districts, Irvington allows all “Accessory buildings and accessory uses customarily incidental to a permitted use” in Business Districts.<sup>48</sup> This pathway is uncertain to permit the scale of generation required for a microgrid, however. 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.

No special use permit provision in Business Districts would apply to microgrid generation.

Variances across all zones in Irvington are covered below.

#### Generation as Permitted Use in Irvington Waterfront/Industrial District

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<sup>45</sup> Irvington Code §224-3.

<sup>46</sup> Irvington Code §224(8)(B).

<sup>47</sup> Irvington Code §224-36.

<sup>48</sup> Irvington Code §224-36.



One microgrid customer, the Irvington Senior Center, is located in a Waterfront/Industrial District.<sup>49</sup> If generation is sited in this District, it will face the least hurdle. In the Waterfront/Industrial District, “any land or building may be used for any use not otherwise prohibited by law,” allowing for specific enumerate exceptions which do not likely apply here.<sup>50</sup> The only relevant exception applies to “any use which, in the opinion of the Board of Appeals, is noxious or offensive by reason of waste, smoke, gas, fumes, noise, odor, dust, vibration, or radiation or that presents a hazard to public health, safety or welfare.”<sup>51</sup>

### Variances in Irvington

If microgrid generation is not deemed permitted or accessory to the permitted uses of the district, the project would have to seek a variance. Irvington’s 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.<sup>52</sup>

These provisions are consistent with New York State precedent,<sup>53</sup> as well as State law incorporating that precedent. These requirements are unlikely to be satisfied for microgrid facilities, which may add value to the properties in question, but are not indispensable to the value of the properties in general.

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

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<sup>49</sup> The Irvington Zoning Map and the Code appear in conflict at first, with the relevant parcel marked as an “Industrial” District on the map, while no section of the actual code refers to a District by this name. The “Waterfront District” article, however, bears a note explaining the name change from “Industrial” in 2014, which seems not to have been updated in the map.

<sup>50</sup> Irvington Code §224-39.

<sup>51</sup> *Id.*

<sup>52</sup> Irvington Code §224-97(B).

<sup>53</sup> 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.

## **2. Fire Code**

The Irvington Fire Protection Code makes reference to inspectors' authority to issue orders to remedy dangerous or hazardous conditions or materials or any other violation of the New York State Uniform Fire Prevention and Building Code and the Energy Conservation Construction Code of New York State. The Irvington Fire Protection Code makes no relevant substantive additions.<sup>54</sup>

## **3. Building Code**

The Irvington Building Construction Code incorporates the New York State Uniform Fire Prevention and Building Code and the State Energy Conservation Construction Code, as well as the Zoning Code of the Village of Irvington, without any substantive addition that would affect distributed generation or local distribution facilities.<sup>55</sup>

## **4. Electric Code**

Irvington's Electrical Standards adopt the New York State Building Construction Code, the National Electrical Code (NFPA 70) or the most current edition of the National Electrical Code adopted by New York State as part of the New York State Residential and/or Building Codes.<sup>56</sup>

# **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 Ed's standby tariff<sup>57</sup> unless they are otherwise exempt.<sup>58</sup> Under current standby rate design, Con Ed 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,

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<sup>54</sup> Irvington Code §118.

<sup>55</sup> Irvington Code §86-6.

<sup>56</sup> Irvington Code §110-2.

<sup>57</sup> Located at <http://www.coned.com/documents/elecPSC10/GR1-23.pdf#nameddest=gr20>.

<sup>58</sup> 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).

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 Ed and Staff came to a rate case settlement that will establish a performance incentive, lowering the contract demand charge, for customers running generation reliably. Con Ed 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.<sup>59</sup>

The actual level at which the contract demand charge is set can be established by the customer or Con Ed. If the customer opts to set their own contract demand charge, penalties can be levied if the charge is exceeded, while a charge set by the utility is not subject to penalties. Exceedance penalties will result in a surcharge equal to between 12 to 24 times (depending on the level of exceedance) the sum of the monthly demand charges for the demand in excess of the contract demand.

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

Standby rates are under reexamination as part of the REV proceeding. Staff has noted that "the methodology for allocating costs that determine the contract demand and as-used demand components of standby rates should be reviewed in this new [REV] context."<sup>60</sup> 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<sup>61</sup> 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.

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<sup>59</sup> Case 15-E-0050, "Order Adopting Terms of Joint Proposal to Extend Electric Rate Plan," (June 19, 2015).

<sup>60</sup> Case 14-M-0101, "Staff Whitepaper on Ratemaking and Utility Business Models," (July 28, 2015).

<sup>61</sup> Case 15-E-0082, "Order Establishing a Community Distributed Generation Program and Making Other Findings," (July 17, 2015).

### **3. Residential/Non-Residential DG Gas Rate**

A distributed generation rate is established in Con Ed'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."<sup>62</sup> This rate may be economically advantageous for CHP components of the microgrid, although customers should compare costs against a Transportation Rate or the price offered by a third-party gas marketer, as these may also propose a cost-effective solution.

#### **3.1 Cost of Gas Service Upgrades**

Microgrids that incorporate new natural gas-fired generators or CHP systems may require the delivery of substantially more natural gas to the site than was previously provided by the utility. If the additional natural gas demand exceeds the current infrastructure's capacity, the relevant natural gas mains, service piping and related facilities will need to be upgraded for the project to succeed. The requirements of utilities and gas upgrade applicants regarding gas service upgrades are governed by 16 NYCRR §230. Prior to any upgrades, the applicant must sign an agreement to assure the Con Edison that he/she will be a reasonably permanent customer, pay the utility for any installation and materials costs beyond the costs the utility is required to bear, and pay a rate for future gas delivery charged to similarly situated customers.<sup>63</sup> 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.<sup>64</sup> Utilities can bear the cost of extensions and additional facilities beyond 100 feet if the utility deems the expansion to be cost justified.<sup>65</sup> 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.<sup>66</sup> 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

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<sup>62</sup> See Consolidated Edison's Rider H tariff, available at [http://www.coned.com/documents/gas\\_tariff/pdf/0003\(06\)-General\\_Information.pdf#page=37](http://www.coned.com/documents/gas_tariff/pdf/0003(06)-General_Information.pdf#page=37).

<sup>63</sup> 16 NYCRR § 230.2(b).

<sup>64</sup> 16 NYCRR § 230.2 (c), (d), and (e).

<sup>65</sup> 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.

<sup>66</sup> 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.

to the transmission line, which would be built and paid for under the same set of rules the govern gas service upgrades, described above.

## APPENDIX D: IEC BENEFIT-COST ANALYSIS

# Benefit-Cost Analysis Summary Report

## Site 28 – Village of Irvington

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### PROJECT OVERVIEW

As part of NYSEERDA's NY Prize community microgrid competition, the Village of Irvington has proposed development of a microgrid that would serve a wide array of public and private commercial facilities in the community. With a population of approximately 6,500, Irvington is suburban village located within the Town of Greenburgh, on the Hudson River in Westchester County. The proposed microgrid would seek to address flood-related power outages of the type Irvington faced following Superstorm Sandy.

The proposed microgrid would support the following facilities:

- The Irvington Public Library;
- A variety of businesses along Main Street, including Geordane's Food Market, Sunnyside Federal Bank, and Natural Fit Pharmacy;
- Lambros Service Center, an auto repair shop;
- Several schools, including Main Street School (public elementary), Dows Lane School (public elementary), Irvington High School and Middle School, and John Cardinal O'Connor School and Immaculate Conception Church;
- The Irvington Public Works Department;
- The Irvington Senior Citizens Center (a community and recreational facility);
- Several emergency response facilities, including the Village Hall and Police headquarters, the village firehouse, and the Ambulance Corps; and
- Monte Nido, an eating disorder treatment facility.

The microgrid would combine CHP and solar capabilities to provide base load power. Eight CHP units would be distributed among the participating facilities, and would range in capacity from 0.01 to 0.248 MW; of these, seven would burn natural gas and one would burn diesel. Solar capability would supplement the microgrid, with PV equipment distributed among the facilities. The solar installations would add 0.168 MW of capacity to the microgrid. A battery storage system and energy efficiency measures would be incorporated in each segment of the microgrid. Finally, a pair of generators, one fueled by natural gas, one by diesel, would be available to supplement the microgrid's capacity during major power outages, ensuring that 100 percent of the facilities' average electricity needs would be met.

## METHODOLOGY AND ASSUMPTIONS

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

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

This analysis relies on an Excel-based spreadsheet model developed for NYSERDA to analyze the costs and benefits of developing microgrids in New York State. The model evaluates the economic viability of a microgrid based on the user's specification of project costs, the project's design and operating characteristics, and the facilities and services the project is designed to support. Of note, 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.<sup>67</sup> It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

With respect to public expenditures, the model's purpose is to ensure that decisions to invest resources in a particular project are cost-effective; i.e., that the benefits of the investment to society will exceed its costs. Accordingly, the model examines impacts from the perspective of society as a whole and does not identify the distribution of costs and benefits among individual stakeholders (e.g., customers, utilities).

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<sup>67</sup> 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<sub>2</sub> 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<sub>2</sub>, NO<sub>x</sub>, and PM<sub>2.5</sub>, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.<sup>68</sup>

## RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results suggest that if no major power outages occur over the microgrid’s assumed 20-year operating life, 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 exceed approximately 1.7 days per year (Scenario 2). The discussion that follows provides additional detail on the findings for these two scenarios.

**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: 1.7 DAYS/YEAR
Net Benefits - Present Value	-\$4,260,000	\$184,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-19.7%	6.9%

### Scenario 1

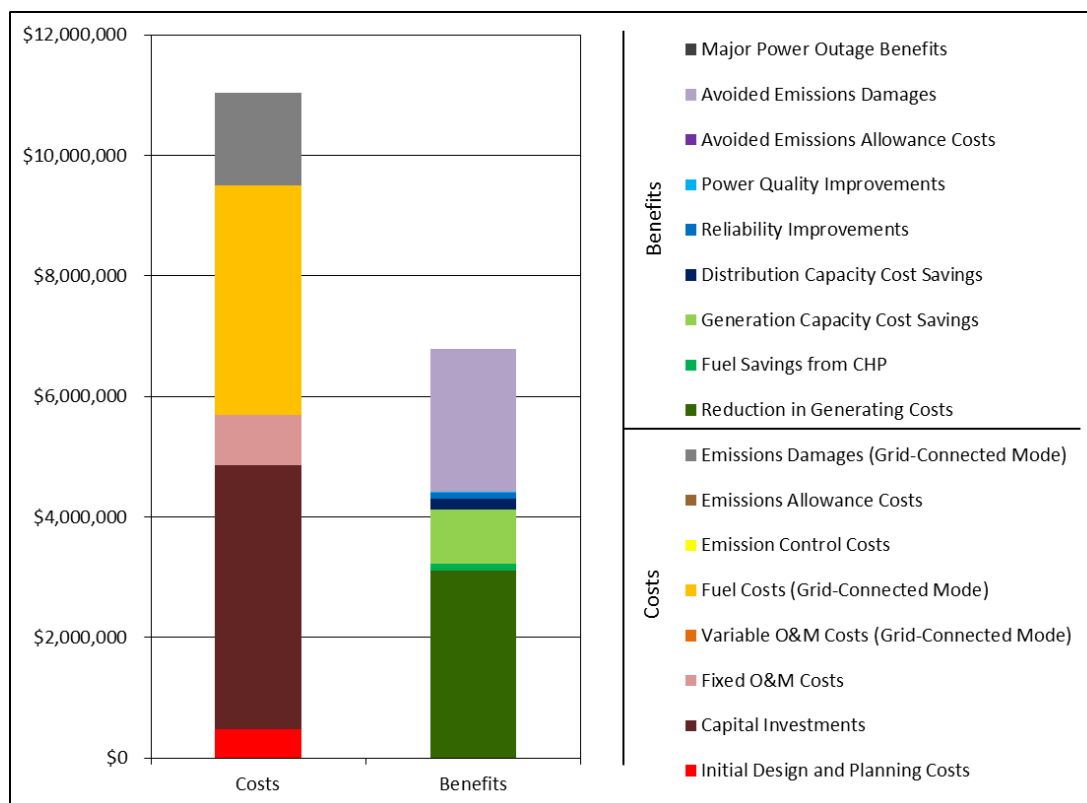
Figure 1 and Table 2 present the detailed results of the Scenario 1 analysis.

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<sup>68</sup> The New York State Department of Public Service (DPS) requires utilities delivering electricity in New York State to collect and regularly submit information regarding electric service interruptions. The reporting system specifies 10 cause categories: major storms; tree contacts; overloads; operating errors; equipment failures; accidents; prearranged interruptions; customers equipment; lightning; and unknown (there are an additional seven cause codes used exclusively for Consolidated Edison’s underground network system). Reliability metrics can be calculated in two ways: including all outages, which indicates the actual experience of a utility’s customers; and excluding outages caused by major storms, which is more indicative of the frequency and duration of outages within the utility’s control. In estimating the reliability benefits of a microgrid, the BCA employs metrics that exclude outages caused by major storms. The BCA classifies outages caused by major storms or other events beyond a utility’s control as “major power outages,” and evaluates the benefits of avoiding such outages separately.



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



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

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
<b>Costs</b>		
Initial Design and Planning	\$475,000	\$41,900
Capital Investments	\$4,390,000	\$349,000
Fixed O&M	\$823,000	\$72,600
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$3,810,000	\$336,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$1,550,000	\$101,000
<b>Total Costs</b>	<b>\$11,000,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$3,110,000	\$274,000
Fuel Savings from CHP	\$107,000	\$9,480
Generation Capacity Cost Savings	\$898,000	\$79,200
Distribution Capacity Cost Savings	\$183,000	\$16,100
Reliability Improvements	\$102,000	\$9,020
Power Quality Improvements	\$19,400	\$1,710
Avoided Emissions Allowance Costs	\$1,530	\$135
Avoided Emissions Damages	\$2,360,000	\$154,000
Major Power Outage Benefits	\$0	\$0
<b>Total Benefits</b>	<b>\$6,790,000</b>	
<b>Net Benefits</b>	<b>-\$4,260,000</b>	
<b>Benefit/Cost Ratio</b>	<b>0.6</b>	
<b>Internal Rate of Return</b>	<b>-19.7%</b>	

### *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.<sup>69</sup> The present value of the project's capital costs is estimated at approximately \$4.4 million. Significant investments (about \$2.5 million) are devoted to grid improvements. Other significant capital expenditures are required for the eight CHP units that would supply the majority of the microgrid's production, as well as the PV arrays distributed throughout the microgrid service area.

<sup>69</sup> The project's consultants note that this estimate is based on the costs of developing the power purchase agreement (PPA), negotiating other contracts, and arranging financing and insurance. It represents an average cost estimate; the actual costs ultimately incurred may be higher or lower, depending on the complexity of the site.

The present value of the microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at \$823,000, or about \$72,600 annually.

### *Variable Costs*

The most significant variable cost associated with the proposed project is the cost of natural gas for the 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.<sup>70</sup> The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately \$3.8 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 fuel-based generators are estimated at approximately \$101,000 annually. These damages are primarily attributable to the emission of CO<sub>2</sub>. Over a 20-year operating period, the present value of emissions damages is estimated at approximately \$1.6 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 \$3.1 million. This estimate takes into account both the electricity that the microgrid's CHP units and PV arrays would produce, as well as an anticipated reduction in annual electricity use at the facilities the microgrid would serve.<sup>71</sup> Cost savings would also result from fuel savings due to the combined heat and power systems. The BCA estimates the present value of fuel savings over the 20-year operating period to be approximately \$107,000. These reductions in demand for electricity from bulk energy suppliers and heating fuel would also avoid emissions of CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and particulate matter, yielding emissions allowance cost savings with a present value of approximately \$1,500 and avoided emissions damages with a present value of approximately \$2.4 million.<sup>72</sup>

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

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<sup>70</sup> 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.

<sup>71</sup> The project's consultants anticipate an annual reduction in electricity consumption of approximately four percent due to energy efficiency upgrades included with the microgrid.

<sup>72</sup> Following the New York Public Service Commission's (PSC) guidance for benefit cost analysis, the model values emissions of CO<sub>2</sub> 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<sub>2</sub> and NO<sub>x</sub> 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.<sup>73</sup> The analysis estimates the impact on available generating capacity to be approximately 0.60 MW per year, based primarily on estimates of output from the new CHP units. In addition, the project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by an additional 0.19 MW as a result of new demand response capabilities. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately \$898,000 over a 20-year operating period. The present value of the project's potential distribution capacity benefits is estimated to be approximately \$183,000.

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

### *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 \$9,000 per year, with a present value of \$102,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:<sup>74</sup>

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.<sup>75</sup>

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.<sup>76</sup> 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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<sup>73</sup> 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.

<sup>74</sup> [www.icecalculator.com](http://www.icecalculator.com).

<sup>75</sup> SAIFI and CAIDI values were provided by the project team for Consolidated Edison.

<sup>76</sup> <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. Specifically, the project team foresees 0.156 power quality events per year at all facilities. The model estimates the present value of this benefit to be approximately \$19,400 over a 20-year operating period.

### *Summary*

The analysis of Scenario 1 yields a benefit/cost ratio of 0.6; i.e., the estimate of project benefits is about 60 percent 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.<sup>77,78</sup>

The proposed microgrid project would serve a number of critical facilities during an extended outage. The project's consultants indicate that at present, four of these facilities possess backup generators, and several additional facilities would rent backup generators in the event of an outage. Table 3 summarizes the estimated cost of operating these generators, assuming 24-hour operation; the estimate of daily operating costs includes the cost of fuel as well as other daily costs of operation. Table 3 also indicates the loss in service capabilities that occurs while relying on these units, and the loss in service capabilities that would occur should these units fail. In all cases, there is a 15 percent chance that the backup generator would fail.

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<sup>77</sup> 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.

<sup>78</sup> 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.

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

FACILITY	ONGOING OPERATING COSTS (\$/DAY)	PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE	
		WITH BACKUP POWER	WITHOUT BACKUP POWER
Village Hall and Police HQ*	N/A**	40%	90%
Monte Nido Treatment Facility*	\$22	40%	100%
Irvington High School and Middle School*	\$998	30%	100%
Department of Public Works*	\$52	0%	30%
Firehouse	\$360	10%	30%
Ambulance Corps	\$500	80%	90%
Senior Center	\$360	0%	90%
Natural Fit Pharmacy	\$175	30%	60%
Geordane's Food Market	\$150	50%	80%
Lambros Service Center	\$175	10%	100%
Irvington Public Library	\$150	40%	90%
* Existing backup generator			
** Generator costs grouped with other ongoing costs required while on backup power.			

Facilities would incur a variety of costs for emergency measures necessitated by power outages. The analysis incorporates the following emergency costs specified by the project team:

- Although the police headquarters is equipped with a backup generator, starting and maintaining the generator would entail one-time costs of \$2,400 and daily costs of \$2,400.
- Even with backup power, the eating disorder treatment facility would evacuate patients and secure alternative housing for them, at a one-time cost of \$10,000 and a daily cost of \$18,200. These costs would also apply during a complete loss of power.
- The firehouse would incur costs for overtime pay (\$2,400 per day).
- The ambulance service would incur one-time costs for alternative storage of drugs (during hot and cold seasons).
- The senior center would incur costs for evacuating and relocating visitors (\$1,500).
- The miscellaneous Main Street businesses and library would incur a variety of costs. For instance, the pharmacy would need to move temperature-sensitive medicines to an alternative location (a one-time cost of \$2,500); the food market would need to move perishables to an alternative location and pay overtime (at an estimated cost of \$7,500); and the bank would need to hire additional security at an estimated cost of \$500 per day.

In addition to these costs, the economic consequences of a major power outage depend on the value of the services the facilities of interest provide. Where possible, the analysis applies site-specific information recommended by the project consultants:

- The consultants highlighted the potential use of the public schools and senior center as places of refuge during a major power outage. Considered together, the facilities are capable of providing shelter for 3,348 individuals. The total value of services per day is based on the capacity of the shelter facilities multiplied by the American Red Cross estimate of the cost of providing overnight shelter (\$50/person/day).
- The daily value of services at Monte Nido (about \$13,400) is based on the daily per-patient cost of treatment (\$956) times the 14 patients typically living at the facility.<sup>79</sup>

For several other facilities, the analysis applies the Department of Energy's ICE Calculator to estimate the cost of a loss of service. These facilities include the Irvington Public Library, Geordane's Market, Sunnyside Federal Bank, Natural Fit Pharmacy, Lambros Service Center, the Cardinal O'Connor School and Immaculate Conception Church, Irvington Department of Public Works, and additional Main Street businesses.<sup>80</sup> Consistent with the information provided by the project team, the analysis assumes that all facilities require a full 24 hours of service per day.

The remaining facilities include several emergency management services: the police station; the firehouse; and the Ambulance Corps. The analysis calculates the impact of an outage on these services using standard FEMA methodologies.

Based on the estimated value of service as well as the backup power capabilities and operational features of the facilities, the analysis estimates that in the absence of a microgrid, the average cost of an outage is approximately \$236,000 per day.

### *Summary*

Figure 2 and Table 3 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 1.7 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.

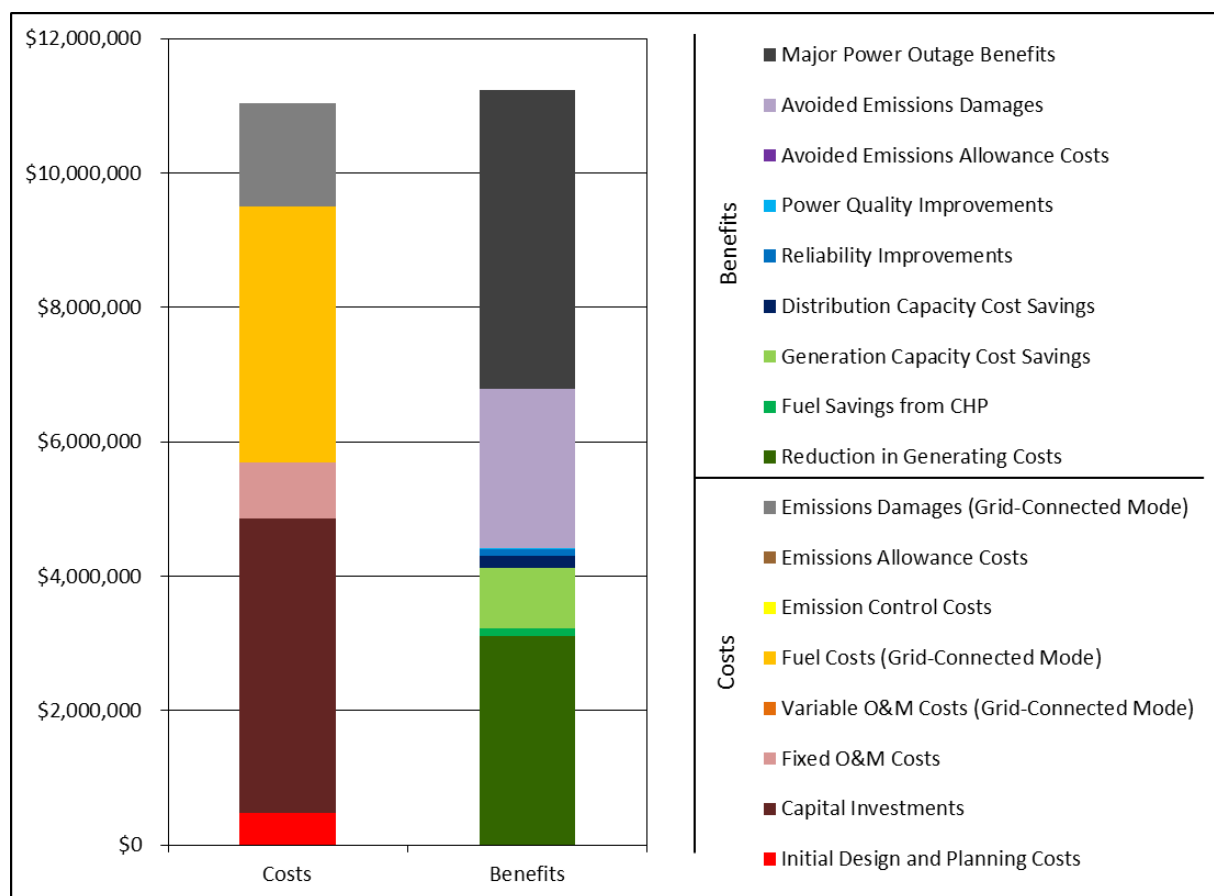
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<sup>79</sup> The daily cost of patient treatment is based on information found at

<http://www.lohud.com/story/news/2014/05/31/center-eating-disorders-open-irvington/9829525/>.

<sup>80</sup> A modification to the Irvington team's initial proposal added a miscellaneous set of small Main Street businesses to the microgrid circuit. Lacking more specific information, the analysis assumes that these businesses are consistent with the profile of the other miscellaneous commercial facilities, i.e., no backup generation capability and an 88 percent service loss when no backup power is available.

**Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 1.7 Days/Year; 7 Percent Discount Rate)**





**Table 3. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 1.7 Days/Year; 7 Percent Discount Rate)**

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
<b>Costs</b>		
Initial Design and Planning	\$475,000	\$41,900
Capital Investments	\$4,390,000	\$349,000
Fixed O&M	\$823,000	\$72,600
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$3,810,000	\$336,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$1,550,000	\$101,000
<b>Total Costs</b>	<b>\$11,000,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$3,110,000	\$274,000
Fuel Savings from CHP	\$107,000	\$9,480
Generation Capacity Cost Savings	\$898,000	\$79,200
Distribution Capacity Cost Savings	\$183,000	\$16,100
Reliability Improvements	\$102,000	\$9,020
Power Quality Improvements	\$19,400	\$1,710
Avoided Emissions Allowance Costs	\$1,530	\$135
Avoided Emissions Damages	\$2,360,000	\$154,000
Major Power Outage Benefits	\$4,440,000	\$392,000
<b>Total Benefits</b>	<b>\$11,200,000</b>	
<b>Net Benefits</b>	<b>\$184,000</b>	
<b>Benefit/Cost Ratio</b>	<b>1.0</b>	
<b>Internal Rate of Return</b>	<b>6.9%</b>	

## APPENDIX E: CONSOLIDATED EDISON COMMENTS AND RESPONSES

Following the completion of the feasibility analysis, the project team received additional comments from Consolidated Edison upon their full review. The Consolidated Edison comments, and the project team's responses are below.

### Consolidated Edison Comments and Project Team Responses

#### NY Prize Community – Irvington

Characteristic	Con Edison Observation	Project Team Comment
Number of PCC	6 PCC	-
CHP capacity	571 kW	-
PV capacity	175 kW	This figure is actually 168 kW
Storage capacity	95 kW/190 kWh	-
Existing Load	2,487 kW (peak)	The peak demand is 2,487, however the load is actually 6,032,464 kWh/yr or 689 kW on average
Load support by Microgrid (%)	34% (with battery), 30% (w/o battery)	Actual annual production from resources is 4,311,498 kWh, or 71% of the load. The battery is a grid resource with capacity support, but should not be considered a production device for load
Control system details	Wireless microgrid controller	-
Black-Start Capability	Yes	-
Ownership model/suggestions	Third- party ownership	-
New Feeders/distribution lines	Maybe	-

## Utility Comments – Irvington

Topic	Con Edison Observation	Project Team Comment
Relative ease of interconnection?	Difficult. 6 PCC	Although there are a number of PCCs, the technical approach is identical in each. Interconnection study on one is highly replicable to the other five.
Adhere to guidance of utility?	Yes. Focused on one of the two possible microgrid discussed.	-
Working within existing tariffs/rates/specs?	Wants a new wheeling charge tariff (similar to offset or net-metering)	The microgrid will not be sending energy to the ConEd grid. We see no need for special tariff.
Area station benefits?	No	The project team would suggest that the microgrid does offer area station benefits, because a 0.5 MW reducing in load on the substation would extend its lifetime – T&D deferment. In addition, microgrid resources can help reduce peak demand, variability from other PV within the substation area, and support CVR, voltage, VAR, and frequency.
Local area benefits?	No	The project team would suggest that the microgrid will offer local area benefits, because the microgrid cuts emissions as a benefit to society.
Additional comments?	- No equipment in this project qualifies for SC-11 or offset tariff since everything is low voltage.	-

## APPENDIX F: ACRONYM GLOSSARY

- BTU – British Thermal Unit
- BCA – Benefit-cost analysis
- 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