5 - Village of Port Jefferson

Notice

NY Prize Village of Port Jefferson Community Microgrid Stage 1 Feasibility Study

Source: Google Maps

Prepared for: **The Village of Port Jefferson**

Prepared by: **Global Common, LLC**

GE Energy Consulting

D&B Engineers and Architects

Burns Engineering

August 31, 2016

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Foreword

This report was prepared for the Village of Port Jefferson by Global Common (GC), General Electric International, Inc. ("GEII"); acting through its Energy Consulting Group ("GE Energy Consulting") based in Schenectady, NY, D&B Engineers (D&B), and Burns Engineering (Burns) and submitted to the NYSERDA. Questions and any correspondence concerning this document should be referred to:

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EXECUTIVE SUMMARY

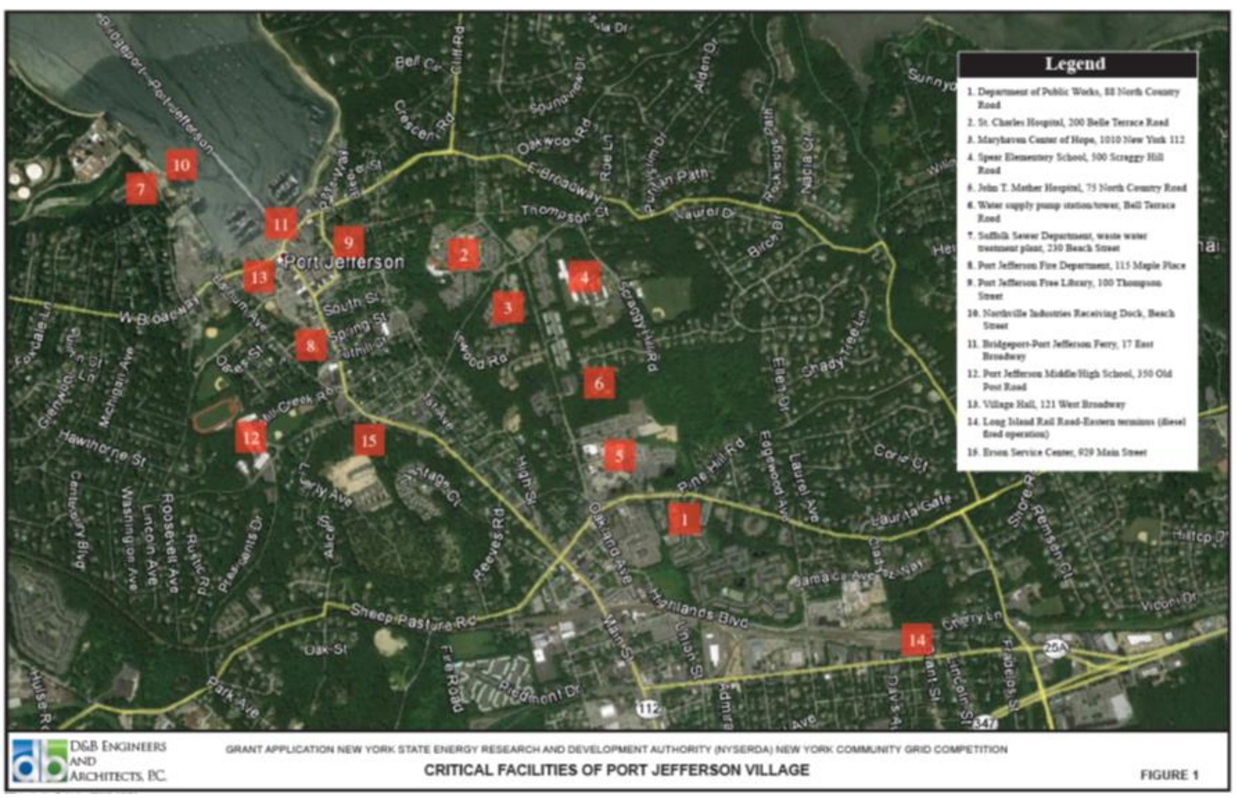
Project Overview

The Village of Port Jefferson is located on Port Jefferson Harbor, an inlet of the Long Island Sound, on the north shore of Long Island, about 65 miles east of New York City. The 2010 Census population was 7,750. A photo of downtown Port Jefferson and the harbor is shown below.

Port Jefferson has numerous facilities that are critical not only to the village, but also to all of central Long Island. These include:

- St. Charles Hospital
- John T. Mather Hospital
- Suffolk County Water Authority
- Suffolk Sewer Department
- Spear Elementary School
- Port Jefferson Middle/High School
- Village Hall
- Port Jefferson Fire Department
- Department of Public Works

A map showing the locations of the critical facilities in Port Jefferson is shown below.



In addition to the listed facilities, numerous small commercial establishments that are critical to maintaining a functioning community, especially during power outages, exist in downtown Port Jefferson. These include a gas station, pharmacy, grocery stores, post office, restaurants and many other shops and stores.

Port Jefferson is also a transportation hub for central Long Island. The Port Jefferson-Bridgeport Ferry, which can carry over 80 cars, provides the only emergency evacuation route from Long Island within 60 miles. The terminus of the Long Island Rail Road line that connects to Penn Station in New York is also in Port Jefferson, and a number of critical roads connect Port Jefferson the other parts of Long Island.

Finally, the Northville Industries fuel-receiving terminal is located in Port Jefferson. This is the major receiving point for fuel for central Long Island.

Need for the Project

Port Jefferson has experienced widespread and extended power outages as a result of extreme weather events, including Hurricanes Sandy and Irene and other storms, and major bulk system outages such as the Northeastern Blackout in August 2003. These events resulted in significant economic loss, threats to life and safety, and disruptions to public and commercial services.

St. Charles Hospital, a regional hospital with 231 beds, lost grid power for 10 days following Hurricane Irene, and had to move 18 ventilator-dependent patients to another unit in the hospital in the middle of the night due to a failure of a back-up generator. Mather Hospital, which also serves areas throughout Suffolk County, has 248 beds, lost power for 47 hours following Hurricane Sandy; although Mather has a back-up generator, the back-up system cannot power diagnostic equipment, cooling or chilled water.

Downtown Port Jefferson also includes a number of other critical facilities, including the Suffolk County Water Authority (SCWA) water supply and treatment facility, which supplies about 13,000 people; the Suffolk Sewer Department wastewater treatment plant, which serves about 7,000 people; the fire department, village hall, elementary, middle and high schools, a gas station, and numerous small commercial establishments.

Loads

A summary of the microgrid loads is presented in the table below.

As shown, the peak non-coincident microgrid load is 8,916 kW, which includes the critical facilities and about 3,576 kW for small commercial establishments and residences in downtown Port Jefferson. In addition, St. Charles and Mather Hospitals combined use about 178,000 MMBtu per year of natural gas.

We estimate that the microgrid will include approximately 250 small commercial establishments, as well as about 1,300 residences near the downtown area. These establishments include a pharmacy, gas station, grocery store, the Port Jefferson-Bridgeport Ferry, and numerous restaurants, shops and stores. These smaller commercial and residential establishments use over 17 million kWh of electric energy per year. Hence, the Port Jefferson microgrid will enable continued normal life and economic activity in a large section of downtown Port Jefferson during outages to the main grid. The project will also provide electric and thermal energy to the hospitals at all times, allowing the hospitals to maintain critical medical services for populations throughout large areas of central Suffolk County.

Facility Name	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)
Department of Public Works	97	0.045
St. Charles Hospital	10,722	1.932
Spear Elementary School	419	0.130
John T. Mather Hospital	11,924	1.959
Suffolk County Water Authority	16	0.007
Suffolk Sewer Department	1,612	0.659
Port Jefferson Middle/High School	784	0.223
Village Hall	71	0.024
SCWA Water Supply and Treatment	657	0.311
Port Jefferson Fire Department	158	0.050
Non-Critical Load	**17,748**	**3.576**
Total	**44,206**	**8.916**

Distributed Energy Resources (DERs)

The project will include the following new DERs:

DER	Facility Name	Capacity (kW)
CCHP	John T. Mather Hospital	1600
CCHP	St. Charles Hospital	1600
Reciprocating engine	Location TBD	2,000
Solar PV	PJ Middle/High School	200
Battery storage	Wastewater treatment plant	250
Battery storage	Water supply facility	300
Thermal Storage	John T. Mather Hospital	469
Absorption Chiller	John T. Mather Hospital	313
Absorption Chiller	St. Charles Hospital	313
Demand Response	Various	206

Note: All new generation will be gas fired.

As shown, the project will include two new 89-ton absorption chillers at St. Charles and Mather Hospitals that will reduce the peak microgrid load by approximately 626 kW, and a new thermal storage system at Mather Hospital that will reduce peak load by 469 kW.

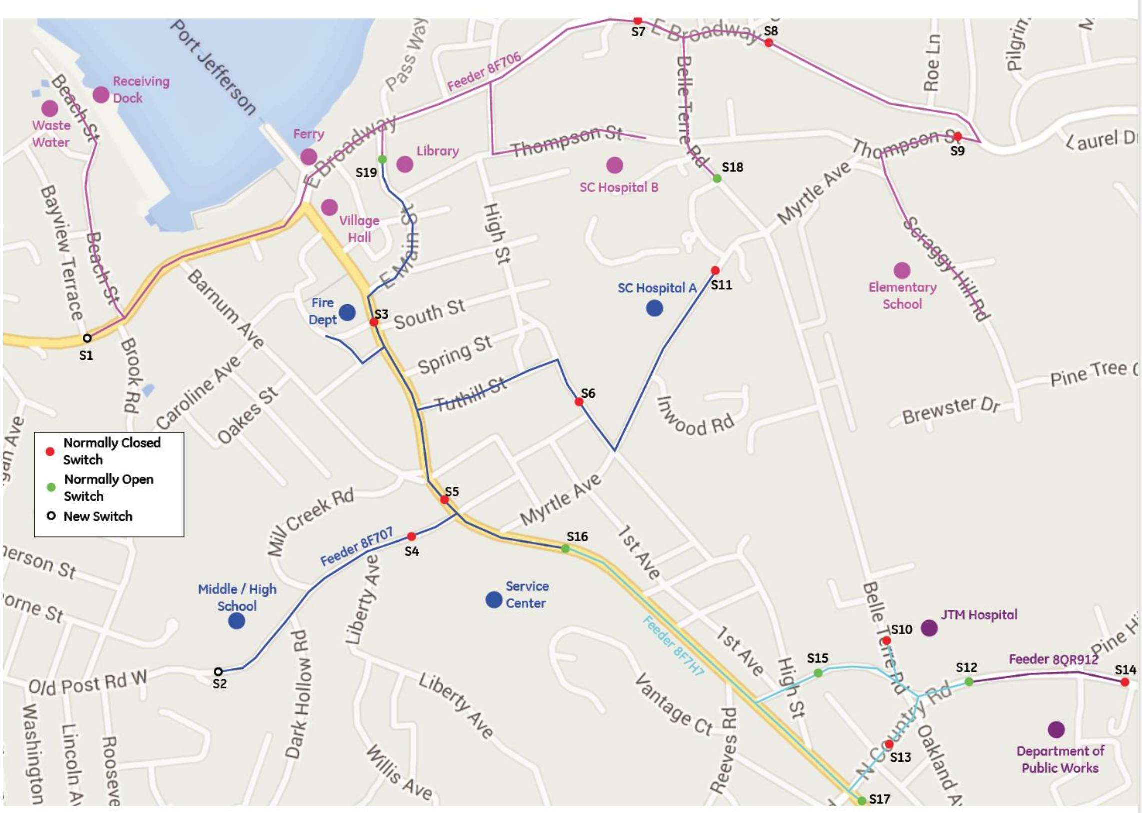
Mather is proceeding with installation of the thermal storage system independently, with partial funding from PSEG-LI. The PSEG Long Island Thermal Storage rebate is intended to promote the installation of thermal storage systems capable of shifting the power associated with conventional chilled water systems from the peak period [summer days] to the off peak period [nighttime]. This includes chillers, pumps, fans, cooling towers, and other associated equipment typically in use during the peak period for conventional cooling. The rebate is not intended to cover the cost for or account for any energy savings resulting from other operational changes that may be proposed (i.e. chilled water reset, system optimization, etc.) Mather Hospital expects to receive a rebate of $1.5 million out of a total project cost of $2.62 million.

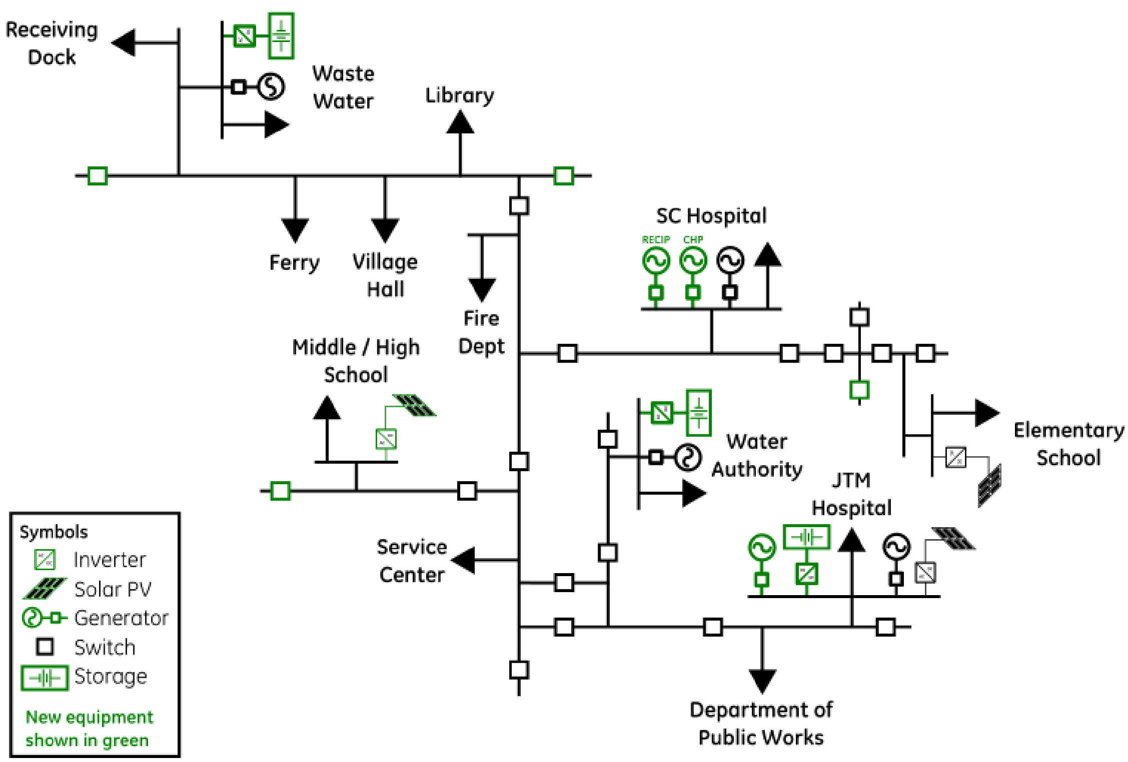
The microgrid will also include 3,150 kW of existing back up generation located at the hospitals, WWTP, and water supply facility, and 98 kW of existing solar PV at Mather Hospital and Spear Elementary School. Thus, total microgrid capacity, comprising of the new DERs (including battery and thermal storage and absorption chillers), and existing generation capacity, plus peak load reduction, will be 10,499 kW, as listed in Table 1-2.

The CCHP and electric generating units will all use pipeline gas supplied by National Grid (NG). The NG rate tariff that would apply to the electric generating plant includes a Value Added Charge (VAC) that depends on the spark spread in each hourly interval that the plant is operating. (The VAC does not apply to the CCHP units, which procure gas under a different tariff.) When the LBMP is high and the gas commodity cost is relatively low, as often happens during warm weather on LI, the spark spreads, and hence VAC charges, can be very high. However, the electric only plant would still be required to power the microgrid if the macrogrid is out of service.

Electrical Layout

The DERs will supply energy behind the meter, and utilize the existing PSEG-LI distribution system. A circuit diagram with switching points, and a one-line diagram showing the DERs are shown below.


Receiving Dock
Waste Water
Ferry
Library
Village Hall
Fire Dept
SC Hospital B
SC Hospital A
Elementary School
Middle / High School
Service Center
JTM Hospital
Department of Public Works
Feeder 8F706
Feeder 8F707
Feeder 8F7H7
Feeder 8QR912
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
Normally Closed Switch
Normally Open Switch
New Switch
Port Jefferson
E Broadway
Thompson St
Belle Terre Rd
Myrtle Ave
Scraggy Hill Rd
Laurel Dr
Pine Tree
Brewster Dr
Inwood Rd
High St
E Main St
South St
Spring St
Tuthill St
Barnum Ave
Caroline Ave
Oakes St
Brook Rd
Beach St
Bayview Terrace
Mill Creek Rd
Liberty Ave
Dark Hollow Rd
Willis Ave
Old Post Rd W
1st Ave
Vantage Ct
Reeves Rd
N Country Rd
Oakland Ave
Roe Ln
Pass Way


Receiving Dock
Waste Water
Library
Ferry
Village Hall
Fire Dept
SC Hospital
RECIP
CHP
Middle / High School
Water Authority
JTM Hospital
Elementary School
Service Center
Department of Public Works
Symbols
Inverter
Solar PV
Generator
Switch
Storage
New equipment shown in green

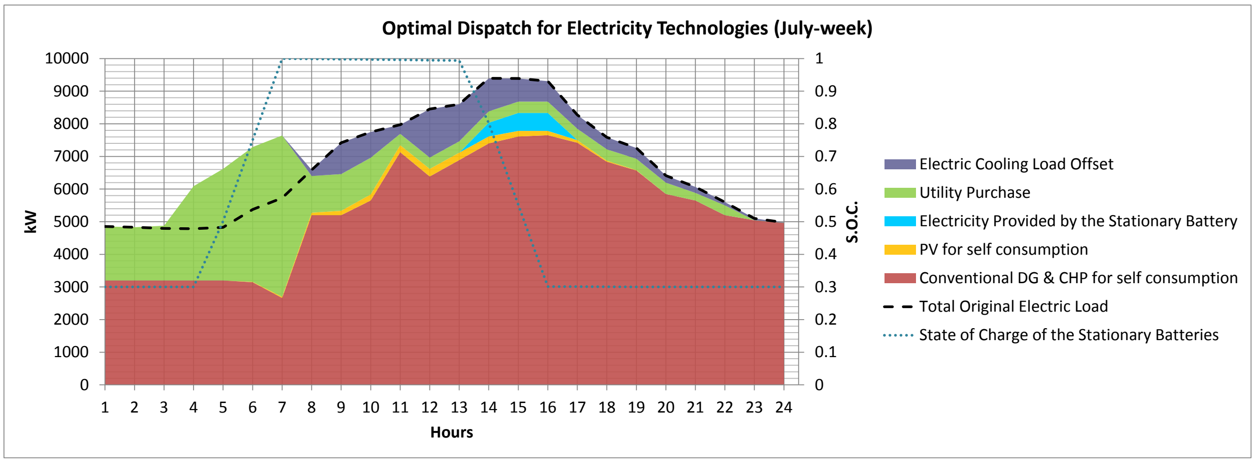
As shown in these figures, use of the existing distribution system will allow the DERs to connect with all the critical facilities and supply numerous commercial and residential establishments in downtown Port Jefferson.

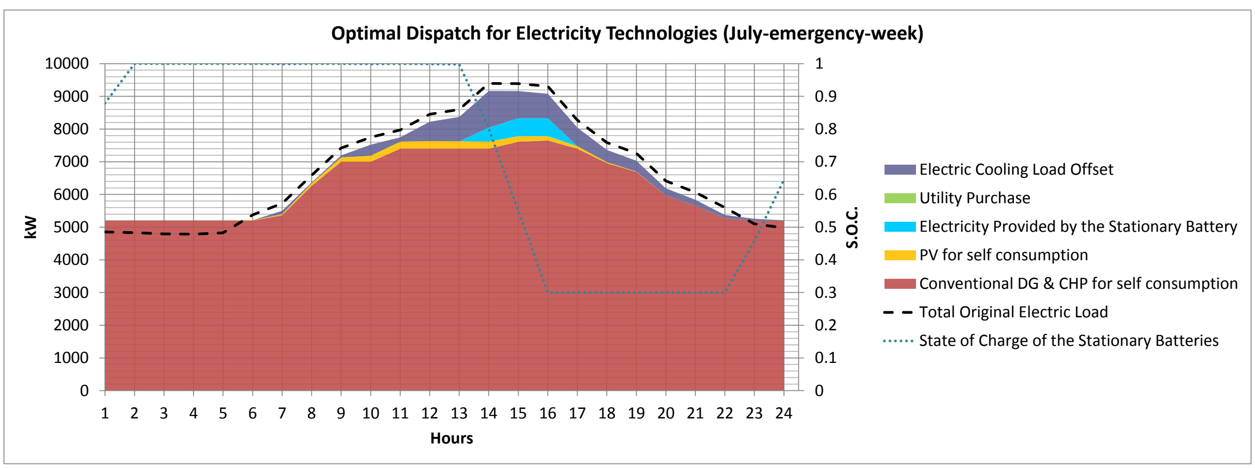
Load and Supply Analysis

We utilized the DER-CAM model to evaluate and project the performance of the DERs. Results are presented below.

Electric Power Dispatch

The figures below shows the theoretical load and supply balance over a weekday of operation on a normal day in July and on an emergency day in July. The DER-CAM model dispatches the generation resources based on the comparative economics of on-site generation versus purchase from the utility.





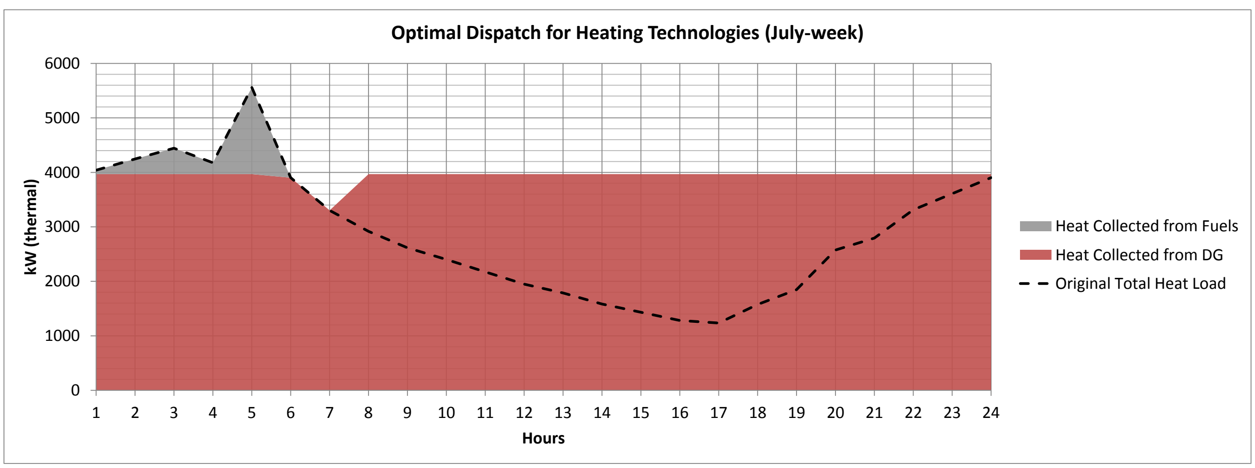
In the above figures, the black dashed line represents the total original electrical load. The burgundy colored area represents the on-site (non-diesel) generation by the microgrid (CCHP + Reciprocating Engine). The yellow colored area is the solar PV production. The lighter blue area is the discharge by the battery electric storage systems. The State of Charge (SOC) of the battery storage is shown by the light blue dotted line and its value is indicated on the right-hand side Y-axis. The green colored area is the additional electric energy purchased from the utility (in connected mode only). The darker purple colored area is the reduction in the original electric load due to use of absorption chillers, which replaces the electric usage by central chillers.

The blank space below the black dashed line on the emergency day profile represents load curtailment applied during the emergency periods. Load curtailment level is (conservatively) set at 5% of the peak load of the three largest facilities in the microgrid.

As shown, during a normal day, the CHP systems would provide baseload power, substantially reducing the amount of power that would otherwise be purchased from the grid throughout the day. The CCHP system will produce approximately 28 million kWh per year, or about 74% of the total annual microgrid energy usage. The batteries, thermal storage, solar and absorption chillers would significantly reduce power purchased during peak periods. We estimate that these systems would reduce peak demand by approximately 1,863kW, or about 25% of the total load. During the emergency day, there is no utility purchase, and all of microgrid load is completely met by on-site generation, including solar PV

Thermal Dispatch – Heating

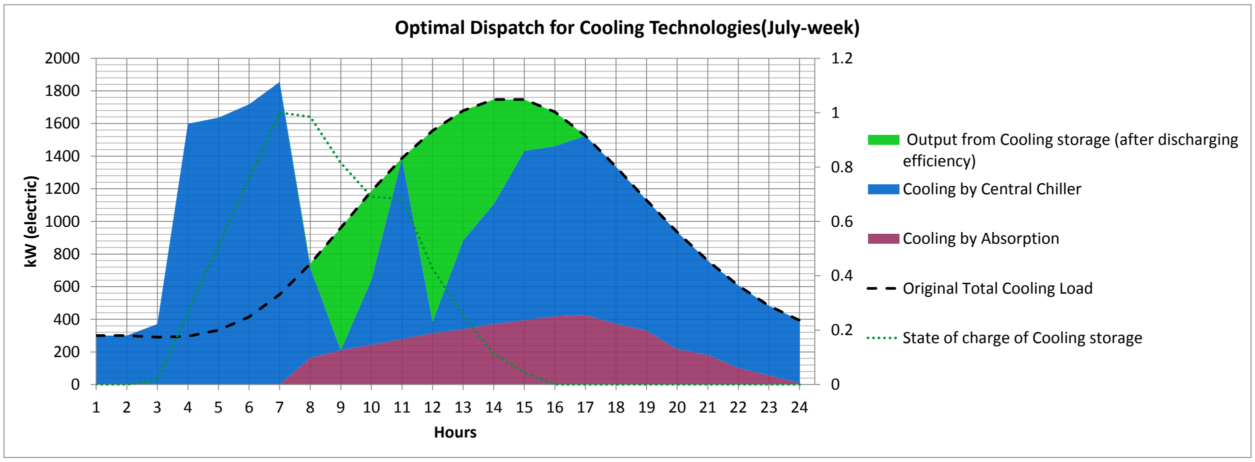
The figure below shows thermal dispatch for heating load during a normal weekday in July. The black dashed line is the microgrid original total heat load. The additional thermal generation going above and beyond the heat load is actually the portion of the thermal energy of the two CCHP units that is utilized to run the two absorption chillers at the two hospitals. As shown, the grey areas represent additional thermal energy that is produced by boilers (i.e., "heat collected from fuels" in the figure below), which in turn is used to produce additional cooling energy by the absorption chillers.



As shown, the waste heat from the CCHP system produces a substantial amount of the thermal energy required for heating, substantially reducing fuel requirements. We estimate that the CCHP system will reduce the total fuel use by approximately 135,000 MMBTUs per year.

Thermal Dispatch – Cooling

The figure below shows thermal dispatch for cooling load during a normal weekday in July. The dotted line is the microgrid original total cooling load. The burgundy colored area is the cooling load that is provided by the absorption chiller. In the early hours of the day, the absorption chiller appears to be operating above the cooling load. The cooling energy produced above the cooling load is actually used to charge the thermal cool storage. The dotted green line indicates the storage level. The solid green area is the storage energy being discharged. As shown, there is a need for additional supply to meet the total cooling load - provided by the central chiller (blue colored area). The blue color area to the left is additional the central chiller energy used to charge the thermal cool storage.



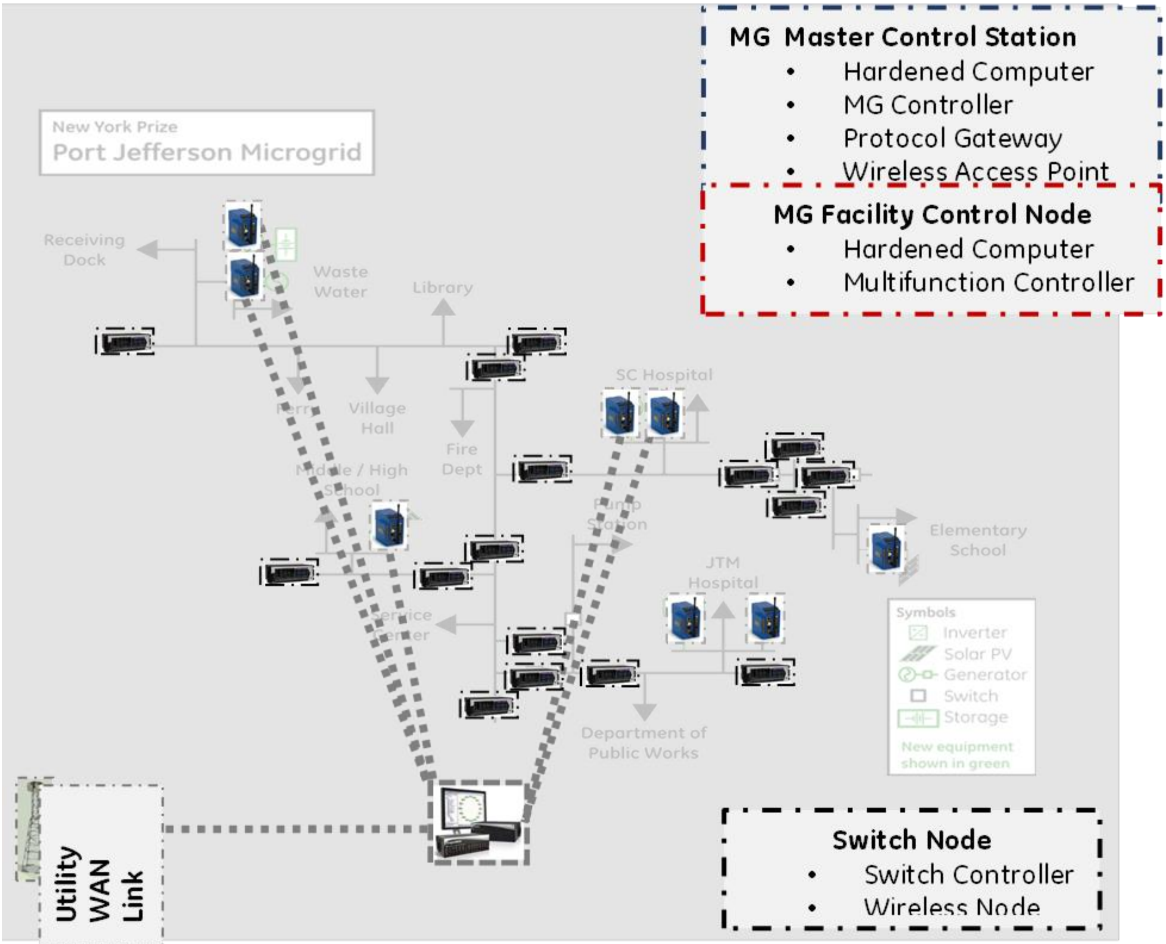
Use of the thermal storage system and absorption chillers will reduce peak load for the microgrid by approximately 1015kW, or about 13% of total peak microgrid load.

Microgrid Controls

The proposed microgrid control architecture consists of four control device types:

- Microgrid Energy Management System (MG EMS) (1 per microgrid)
- Microgrid Master Control Station (1 per microgrid)
- Microgrid Facility Control Node (1 per facility)
- Microgrid Edge Control Node (1 per facility)

The figure below shows control devices for the proposed Port Jefferson microgrid as an overlay on the electrical one-line diagram.



Business Model

We have devised an innovative business model called a "MESCO" to supply energy for the microgrid customers. The MESCO is a modified version of an ESCO that will provide 100% of the energy needs of the microgrid customers both when the main grid is functioning and when it is out of service. The MESCO will own and operate the DERs and purchase energy from the NYISO, and/or other suppliers.

When the main grid is functioning, the MESCO will utilize the DERs and energy purchased from the NYISO to supply energy for the microgrid customers. When the main grid is out of service, the DERs would supply 100% of the energy for all of the microgrid customers, including the peak electric loads. The MESCO will include both "behind the meter" DERs, and utilize the existing PSEG-LI distribution system to distribute energy from DERs to customers that do not have adequate "behind the meter" supply.

The MESCO model could be applied to other microgrid projects.

Project Benefits

A summary of project benefits for various stakeholders is presented below.

Stakeholder	Project Benefits
St. Charles and Mather Hospitals	• Reduce electric energy costs • Reduce or eliminate peak demand charges; currently at $22/kW from June-Sep; • Reduce fuel use for heating • Improve energy reliability and resiliency • No capital investment
Other critical and non-critical facilities	• Reduce electric energy charges • Possibly reduce or eliminate demand charges • Provide reliable power supply during main grid outages • Maintain services for customers and the community during outages to the main grid • Commercial establishments will continue to earn revenue from their business operations during power outages to the main grid • During normal operating conditions, the batteries and thermal storage systems will reduce or eliminate peak demand charges for water supply and waste water treatment plants
Village of Port Jefferson	• Residents and customers will benefit from services provided by critical and non-critical facilities • Maintain power for critical government activities during power outages on the main grid
PSEG-LI	• Project will help reduce need for peaking power and reduce congestion in the load pocket • Project will help assure power is maintained for PSEG-LI customers during outages to the main grid
National Grid	• CCHP system will provide a significant new customer for National Grid, with a high load factor demand profile • New infrastructure to serve the DERs could facilitate gas supplies for other new customers
Suffolk County Residents	• Residents will continue to benefit from services of St. Charles and Mather Hospitals during outages to the main grid
Long Island Residents	• Project will maintain the Port Jefferson as a key transportation hub during outages to the main grid
Environment	• Project will reduce air emissions by using more efficient CCHP technology to supply both electric and thermal energy • Project will reduce emissions due to dispatch of kerosene fueled peaking plants in Holtsville
NY State	• Project would represent an innovative and financially viable microgrid and business model that could be replicated in other areas
Project investors, developers and lenders	• Will receive positive returns on investment, commensurate with project risk • Private investors and lenders will gain experience with an advanced microgrid that could enable similar future investments
Vendors and contractors	• Will generate new business by providing equipment and services • Will gain valuable experience in cutting edge project that could be applied to future microgrid projects

Financial Analyses

Preliminary financial projections are shown below. These estimates are based on currently available data and assumptions, and would need to be updated during Stage 2 based on more detailed analyses and concurrence of project stakeholders. The analyses assume that the MESCO will charge St. Charles and Mather Hospitals at their normal PSEG-LI rates for electricity, and provide thermal energy at no charge.

The analyses show sources and uses of funds with and without funding from the NY Prize and PSEG-LI CHP grant programs. It is expected that the PSEG-LI CHP grant program will be finalized shortly.

Sources and Uses of Funds with NY Prize/PSEG-LI Subsidies

Uses	Amount	Sources	Amount
St. Charles CHP	$6,368,000	Equity	$7,725,060
Mather CHP	$6,368,000	Debt	$0
Electric generation	$4,000,000	NY Prize	$7,000,000
Solar	$600,000	PSEG LI CHP Grant	$4,500,000
Battery	$1,320,000	ITC	$180,000
Distribution and controls	$749,060		
Total	**$19,405,060**		**$19,405,060**

Sources and Uses of Funds without NY Prize/PSEG-LI Subsidies

Uses	Amount	Sources	Amount
St. Charles CHP	$6,368,000	Equity	$19,225,060
Mather CHP	$6,368,000	Debt	$0
Electric generation	$4,000,000	NY Prize	$0
Solar	$600,000	PSEG LI CHP Grant	$0
Battery	$1,320,000	ITC	$180,000
Distribution and controls	$749,060		
Total	**$19,405,060**		**$19,405,060**

The tables below show a simplified MESCO income statement, and a comparison of financial performance with and without NY Prize and PSEG-LI grant funding. As shown, the project would produce returns that would likely be able to attract private financing, assuming NY Prize and PSEG-LI funding are provided. However, it is not likely that the project could attract private financing without NY Prize and PSEG-LI funding. We do not believe it is likely the microgrid project could attract over $19 million in private financing based on a 10.1% IRR, given the nature of the project risk profile.

A full financial analysis is needed to determine investments needs, both public and private. It's anticipated this more detailed analysis will occur under a Stage 2 award.

Simplified MESCO Income Statement

Revenue	**$5,120,029**
COGS	
Fuel	$1,417,328
VOM	$731,376
Capacity/ancillary services/other	$164,703
Subtotal	$2,313,407
Gross Profit	**$2,806,622**
%	*54.8%*
SG&A	$530,047
EBITDA	**$2,276,575**

Comparison of Financial Performance

	With NY Prize/PSEG Funding	**Without NY Prize/PSEGLI Funding**
Private investment	$7,725,060	$19,225,060
EBITDA	$2,276,575	$2,276,575
Investor IRR	29.3%	10.1%

BCA Results

IEc performed the BCA analyses based on data provided by the Team in the Microgrid and Facility questionnaires. As shown below, the project would have net benefits of $8.7 million, assuming no grid outages.

BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1A: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$8,720,000	Not Evaluated
Benefit-Cost Ratio	1.1	Not Evaluated
Internal Rate of Return	9.8%	Not Evaluated

Additional Air Emissions Benefits

The BCA calculates the emissions impacts from the microgrid, and estimates the emissions reductions benefits resulting from reducing dispatch of centralized gas-fueled power plants. However, the it does not account for the reduction of emissions from reducing dispatch of other liquid-fueled peaking plants in central Long Island, most notably the 645 MW kerosene-fueled peaking plant in Holtsville, about 11 miles south of Port Jefferson. Since the microgrid DERs would have lower fuel and operating costs than the kerosene-fueled plant in Holtsville, the new DERs would reduce the need to dispatch Holtsville, thus reducing their operating hours and significantly reducing air emissions. These benefits are more significant for the Port Jefferson project than most other locations in NY State because the new DERs in Port Jefferson reduce dispatch of inefficient kerosene-fueled plants, whereas in most other areas, the new microgrid DERs would reduce dispatch of gas-fueled plants, as reflected in the BCA analyses.

Conclusions and Recommendations

We offer the following conclusions and recommendations for proceeding with the Port Jefferson project and promoting other microgrid projects:

Conclusions

1. **A Port Jefferson microgrid is technically feasible and would provide significant economic, environmental and societal benefits.** A microgrid project in Port Jefferson would provide significant financial, environmental and societal benefits for the Village of Port Jefferson, St. Charles and Mather Hospitals, other critical facilities, and central Long Island in general.
2. **The project will have significant net benefits without a major outage.** Results of IEc's analysis for a normal day scenario indicates that if no major power outages occur over the microgrid's assumed 20-year operating life, the project's benefits would exceed its costs with a Net Present Value (NPV) of $8.72 million, resulting in a Benefit-Cost Ratio of 1.1, and an Internal Rate of Return of 9.8%. IEc saw no need to do a scenario with a major power outage.
3. **Energy storage and efficiency provides stability for microgrids and reduces peak demand charges.** A battery storage system can provide stability for the microgrid when operating in island mode, and can help reduce peak demand charges for facilities with "spikey" loads during blue-sky days, such as the Suffolk County Water Authority (SCWA) facility in Port Jefferson.
4. **The Port Jefferson microgrid will benefit utility partners.** The project will benefit PSEG-LI by reducing transmission constraints, and by improving energy reliability and resiliency. The project will also provide two new customers (i.e. the CCHP systems at St. Charles and Mather) for National Grid for gas supply, and the new pipeline reinforcements needed to serve the CCHP systems may stimulate new demand from other customers.
5. **A MESCO is a viable business model for microgrids.** The MESCO, which is a type of ESCO that serves microgrids, would serve microgrid customers during blue-sky days and grid outages. The MESCO would establish Microgrid Energy Services Agreements (MESAs) with its customers that would define terms for sale of 100% of energy and capacity, and assure cash flow for the MESCO. This business model could be used for other microgrid projects.
6. **Some gas and electric utility policies create barriers to microgrids**
    a. PSEG-LI has indicated it may not allow hospitals to maintain supply from two feeders if

they install CCHP systems. Since hospitals value the redundancy provided by dual feeds, this requirement effectively discourages CCHP at hospitals on Long Island. PSEG-LI has told the Team that they may be open to allowing Mather and St. Charles Hospitals to use two-feeder service if the interconnect is designed to assure there will be no back-feed resulting from operation of the CCHP system.

b. PSEG-LI has indicated it does not collect and archive load data at 15-minute intervals. Lack of this data precludes design of microgrid based on actual time-varying demand, and could limit the benefits of the DERs.

c. National Grid imposes value added charges (VACs) on electric generation units that substantially increase fuel costs for electric wholesale generators. The VAC charges are based on the spark spread of the generating units, with higher VACs for higher spark spreads. The VACs erode the returns for electric generation units needed to support microgrids, especially on Long Island, where spark spreads are often higher than in other parts of the state.

Recommendations

1. **The Port Jefferson project should proceed with design, development and financing, subject to support from NYSERDA**.

2. **NYSERDA should continue to provide financial subsidies for microgrids in order to help recognize the value of greater reliability and resiliency**. NYSERDA should continue to provide financial incentives and technical support for development of microgrids. Incentives should include funding for feasibility studies, design and development, and construction funding.

    d. **The lack of a mechanism to assign a monetary value for reliability and resiliency limits microgrid development**. Although the project would provide substantial benefits during grid outages, the value of these benefits is not reflected in the actual price of energy, capacity or other attributes. This limits the potential opportunities for developing microgrid projects in the absence of some type of subsidies.

    e. **The Port Jefferson community microgrid will require government subsidies and/or other incentives to attract private funding.** Incentives could include NYSERDA grants, favorable gas supply tariffs, and/or credits for DER generation or capacity. Some type of subsidy is generally needed for community microgrids on Long Island, since the zonal prices for energy and capacity alone are not sufficient to justify investment in DERs.

    f. **The NY Prize program provides highly valuable funding for early stage design. However, early stage funding is also needed for other microgrid projects in order to expand deployment of microgrids.** The costs to obtain, compile and analyze data from multiple facilities, and design the DERs and controls, and develop a microgrid project, are high in relation to the project size and risk. Government funding is critical for providing early stage capital to perform these tasks, and develop projects to the point where they can attract permanent private project financing.

3. **NYSERDA or local utilities should consider microgrid energy or capacity credits**. NYSERDA or local utilities should consider providing microgrid energy credits and/or capacity payments ("MECs" or "MCAPs"), similar to RECs for renewable energy sources, to provide financial incentives for DERs that support microgrids and are not eligible for RECs under the RPS. The

MECs or MCAPs would be justified in light of the financial, societal and environmental benefits provided by microgrids.

  a. **Zonal capacity prices sometimes do not reflect the need for local peaking power.** The proposed electric generation facility would reduce the need to dispatch the liquid-fueled peaking plant in Holtsville, and help reduce transmission constraints. However, the value of these benefits is not reflected in zonal capacity prices. As a result, the project would not be economically viable without a subsidy, or a power purchase agreement (PPA) with PSEG-LI with a fixed capacity payment that is more than the zonal capacity price.

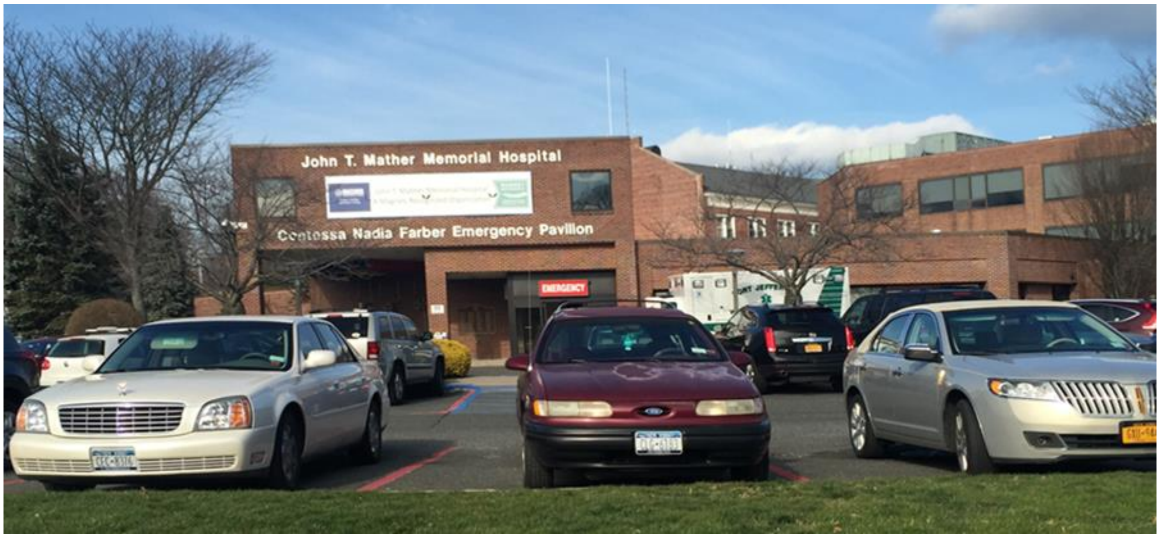
4. **Utilities should eliminate obstacles and create incentives for microgrids**
   a. PSEG-LI is expected to begin offering grants for CHP projects that will help encourage microgrids. However, gas and electric utilities should evaluate new incentives for microgrids to reflect their financial, societal and environmental benefits.
   b. Electric utilities should also expedite measures to harden local distribution infrastructure to support microgrids, and facilitate interconnection policies to streamline deployment of DERs.
   c. Gas utilities should offer favorable microgrid gas supply tariffs, and prioritize infrastructure improvements needed to serve microgrids.
   d. PSEG-LI should allow customers to maintain two feeders when using on-site generation if the interconnect is designed to protect the grid.
   e. PSEG-LI should retain and make available load data needed to properly design DERs.
   f. National Grid should eliminate the value added charge (VAC) that is currently charged to wholesale electric generating facilities.

5. **Continue development of analytical tools.** Government entities should continue development of analytical tools for analyzing microgrids, such as DER-CAM.

6. **Develop appropriate DER pricing**. As part of REV development, the Transmission Service Charges (TSCs) paid by wholesale buyers, and stand-by and demand charges paid by retail customers, may need to be reconsidered and modified in the REV DER pricing. The REV framework includes a pricing mechanism to be applied to DER, called LMP+D. LMP component is based on the NYISO Locational Marginal Pricing. The “D” part of “LMP+D” should reflect the true impact and cost of DER (include those in the microgrid) on the distribution systems. Hence, it is expected that the “D” component is expected to cover all other costs or values not covered by the LMP, such as TSCs and stand-by and demand charges.

Selected Photographs of Critical Facilities and Downtown Port Jefferson

St. Charles Hospital (Power building in rear right in aerial)



John T. Mather Hospital

Downtown Gas Station

Port Jefferson Village Hall

Downtown Post Office

Pharmacy

Infant Jesus Catholic Church and Our Lady of Wisdom Catholic School

First United Methodist Church

Grocery Store

Port Jefferson Ferry

1 DESCRIPTION OF MICROGRID CAPABILITIES

1.1 Minimum Required Capabilities

1.1.1 Critical Facilities

The Village of Port Jefferson is located on Port Jefferson Harbor, an inlet of the Long Island Sound, on the north shore of Long Island, about 65 miles east of New York City. The 2010 Census population was 7,750.

Port Jefferson has experienced widespread and extended power outages as a result of extreme weather events, including hurricanes Sandy and Irene and other storms, and major bulk system outages such as the Northeastern Blackout in August 2003. These events resulted from disruptions to the main PSEG-LI grid, as well as from local distribution outages and resulted in significant economic loss, threats to life and safety, and disruptions to public and commercial services. St. Charles Hospital, with 231 beds, lost power for 10 days following Hurricane Irene, and had to move 18 ventilator-dependent patients to another unit in the hospital in the middle of the night due to a failure of a back-up generator. Mather Hospital, which has 248 beds, lost power for 47 hours following Hurricane Sandy; although Mather has a back-up generator, the back-up system cannot power diagnostic equipment, cooling or chilled water.

PSEG-LI has identified Port Jefferson as one of eight areas on Long Island that should be considered for a microgrid. The hospitals are served by a 13 kV overhead feeder from the Port Jefferson substation. The local generating plant has "limited generation capacity," according to PSEG-LI.

The design will include selected critical facilities located on separate properties within a pre-defined microgrid area. A listing of the potential critical facilities is shown on Figure 1-1, and in Table 1-1 below

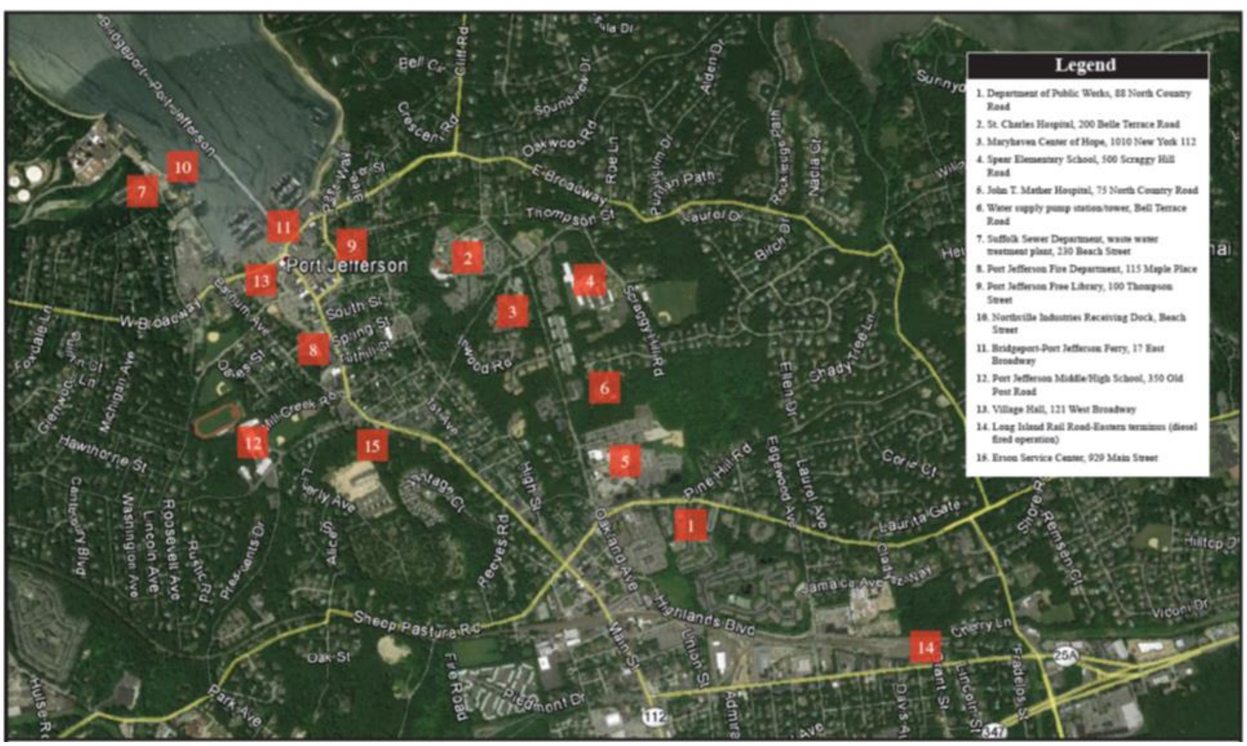


Figure 1-1: Map Showing Critical Facilities in Port Jefferson

Table 1-1: Listing of Potential Critical Facilities in Port Jefferson

Facility Name	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Load Factor	Heating (Therms per year)
Department of Public Works	All Other Industries	96.96	0.05	24.6%	
St. Charles Hospital	Hospital	10,721.63	1.93	63.4%	926,777
Spear Elementary School	School	418.56	0.13	36.8%	
John T. Mather Hospital	Hospital	11,923.60	1.96	69.5%	496,316
Suffolk County Water Authority	Water Supply	16.04	0.01	26.2%	
Suffolk Sewer Department	Waste water treatment	1,612.08	0.66	27.9%	
Port Jefferson Middle/High School	School	783.76	0.22	40.1%	
Village Hall	Community Center	71.10	0.02	33.8%	
SCWA water supply facility	Water Supply	656.80	0.31	24.1%	
Port Jefferson Fire Department	Fire Department	158.00	0.05	36.1%	
Non-Critical Load		17,747.77	3.58	56.7%	

As shown, the total annual electrical energy usage of the microgrid is about 44,000 MWh, and the non-coincident peak load is about 8.9 MW. The total annual thermal load is about 1,421,842 therms, or about 162 therms per hour (16.2 MMBTU/hour). In addition to the critical facilities, the microgrid will serve about 250 small commercial establishments, and about 1,300 residential customers.

The two hospitals in the project are shown in Figure 1-2 below. Mather Hospital has two 60 hp boilers, and an 800 ton and 600 ton electric chiller. St. Charles Hospital has two 300-ton absorption chillers, one 400-ton centrifugal chiller, and one 300 ton centrifugal chiller, as well as three 500 hp boilers (two of which are dual fuel and the third natural gas only).

Although hospitals are equipped with back-up generators to meet minimum loads, the reliability and capacity do not fully meet the hospitals' needs. For example, St. Charles Hospital lost power for 10 days and experienced failure of a back-up generator during Hurricane Irene, and had to move 18 patients on respirators in the middle of the night to another unit that still had back-up power. As another example, the back-up generators at Mather Hospital do not provide cooling or chilled water, or provide power for diagnostic equipment.

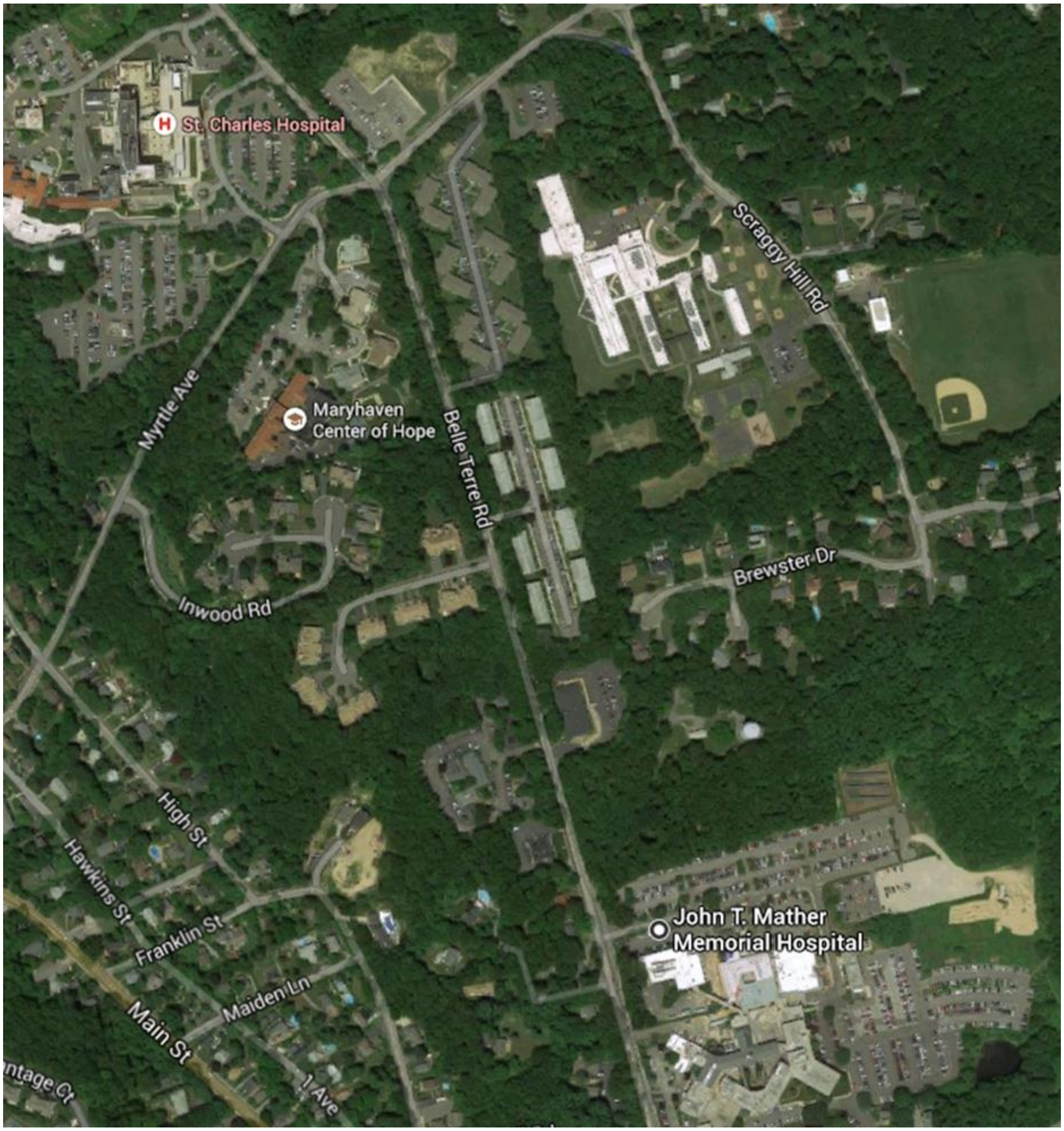


Figure 1-2: Map Showing the Hospital Cluster in Port Jefferson

1.1.2 Primary Generation Source

National Grid has confirmed that it can complete reinforcements needed to supply firm gas for the CCHP units at hospitals by November 2019, and said it is likely that it can supply gas for the electric generating plant. It is likely that NG could provide interruptible gas for the CCHP systems prior to November 2019, which would allow the CCHP plants to commence operations prior to completion of reinforcements, if needed.

Reliability of gas supply during disruptions to the electric grid should not be an issue. National Grid has confirmed that they rely on the gas transmission companies (e.g., Iroquois) to maintain gas pressure, and they do not have any compressors on Long Island. National Grid also confirmed that they have never lost gas supply during any power outage. Iroquois has confirmed that they use gas-powered generators for their compressors, and have back-up power for their system controls. The Iroquois pipeline enters Long Island in Commack, about 15 miles west of Port Jefferson, via an interstate pipeline under the Long Island sound, with a pressure of 700-1,000 psi.

The project team will evaluate firm interruptible gas supply and design the system to minimize cost and assure power would be available for the critical facilities at all times. For example, Mather Hospital currently has an 8,000-gallon diesel storage tank that provides about four days of back-up fuel supply. The hospitals will retain their liquid fuel supply as back-up in case of disruptions of the electric or gas supply. Also, the facilities would remain connected to the PSEG-LI grid and therefore be able to draw additional power from the grid in the event of, for example, a gas supply interruption during normal operating conditions.

The microgrid will also include a 2 MW gas fired reciprocating engine that will have black start capability and have load following capability. Newer natural gas engines can meet the 10-second startup requirements for backup systems, and hence, diesel-fueled engines no longer have an inherent startup/ramp-up capability advantage over the gas engines.

High diesel prices would preclude a diesel-based microgrid from economic operation during normal non-emergency periods. However, the existing back-up diesel generators can still be used as a standalone backup generation (as in their pre-microgrid role) as a last resort in the event of both larger grid and microgrid contingencies.

A summary of the existing and proposed distributed energy resources (DER) is shown below. The project will include a mix of existing and new natural gas-fueled and renewable DER, including CHP or fuel cells, solar power, and energy storage.

Table 1-2: Mix of DER in Port Jefferson Project

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)
Solar (existing)	John T. Mather Hospital	Solar	0.050
Solar (existing)	Spear Elementary School	Solar	0.048
Mather CCHP (new)	Mather's Hospital	Natural Gas	1.600
St Charles CCHP (new)	St. Charles Hospital	Natural Gas	1.600
New Reciprocating Engine (new)	TBD	Natural Gas	2.000
PV (new)	Port Jefferson Middle/ High School	Solar	0.200
Mather Generator 1 (existing)	John T. Mather Hospital	Diesel	0.500
Mather Generator 2 (existing)	John T. Mather Hospital	Diesel	0.500
St Charles Generator 1 (existing)	St. Charles Hospital	Diesel	0.900
St Charles Generator 2 (existing)	St. Charles Hospital	Diesel	0.300
St Charles Generator 3 (existing)	St. Charles Hospital	Diesel	0.250
St Charles Generator 4 (existing)	St. Charles Hospital	Diesel	0.250
St Charles Generator 5 (existing)	St. Charles Hospital	Diesel	0.100
WA Generator 1 (existing)	Suffolk County Water Authority Supply Well	Diesel	0.100
WWTP Generator 1 (existing)	Waste Water Treatment Plant	Diesel	0.250
WWTP Battery (new)	Waste Water Treatment Plant	Electric	0.250
WA Battery (new)	Water Authority	Electric	0.300
Thermal Storage (new)	John T. Mather Hospital	Electric	0.469
New John T. Mather CCHP (Absorption Chiller)	John T. Mather Hospital	Natural Gas	0.313
New St. Charles CCHP (Absorption Chiller)	St. Charles Hospital	Natural Gas	0.313
Total Demand Response	Total System	DR	0.206
Total			**10.499**

As shown, the existing and new DERs will have a combined peak capacity of about 9.7 MW. It should be noted that some of the existing backup generation is not needed during microgrid islanded operation, due to the sufficiency of additional new generation and load curtailment, which is estimated to total 206 kW (97 kW from St. Charles Hospital, 98 kW from John T. Mather Hospital, and 11 kW from Port Jefferson Middle/High School). The project will also include 206 kW of demand response (about 98 kW each at the hospitals, and 11 kW at the High/Middle schools. In addition, the peak electric load will be reduced by two 313 kW equivalent absorption chillers, one at each hospital.

1.1.3 Operation in Grid Connected and Islanded Mode

In Task 2 (described later), the Team evaluates the use of CCHP systems at St. Charles and Mather Hospitals, as well as solar and storage technologies. The new generation systems would supplement the existing 50 kW solar PV system at the Mather Hospital, and the 48 kW solar PV system at Spear Elementary School. Both Mather and St. Charles Hospitals have large parking areas that could be used for additional solar PV arrays. The CCHP units and other on-site systems would operate in both grid connected and islanded mode.

As Table 1-2 shows, between the two hospitals, the WWTP and SCWA Supply Well, there is over 3 MW of existing diesel engines available to the microgrid. To this mix, almost 6 MW of additional new DER will be added to create a reliable and resilient microgrid for the village. This includes 3.2 MW of new CCHP units at the hospitals, and 2 MW electric-only gas engine at another location.

In islanded mode, the generation sources are expected to be available to support the microgrid load. One of the new gas-fired engines (most likely the 2 MW reciprocating engine) is expected to provide a strong voltage reference that would allow inverter-based generation to function in islanded mode. To avoid a collapse of the island, some generators would switch from baseload to frequency control and excess (curtailable) load may be shed to maintain balance. This is further discussed in Section 2.3.6

The Team has considered both grid-connected and islanded mode in the microgrid design, including several possible solutions for the Microgrid Control System. Along with the advanced microgrid controller being developed in a Department of Energy (DOE) project by GE, National Renewable Energy Laboratory (NREL) and others, a set of commercial platforms are also available as candidate solutions. The available commercial microgrid control platforms vary in functionality. A complete control solution will typically be comprised of an integrated suite of both hardware and software components. Depending on the microgrid site use cases, the control solution will often require some level of custom code development or configuration scripting to support integration with electric distribution equipment, the building energy management systems (BEMS), controllable loads, and generation assets within the microgrid, the ISO control center, as well as the utility enterprise systems which include energy management systems (EMS), distribution management system (DMS), and outage management systems (OMS). More detail on the control and communications design for Port Jefferson is provided in Section 2.5.

1.1.4 Intentional Islanding

Energy from the DERs will be distributed to the end users using the existing PSEG-LI distribution system, which will be hardened in areas where there is a risk of tree damage. The microgrid will include a number of switches that will open up to form an island if the main grid is out of service. A map showing the microgrid feeders and switches is shown in Section 2.1.

Islanding is the situation where distributed generation or a microgrid continues energizing a feeder, or a portion of a feeder, when the normal utility source is disconnected. For a microgrid to sustain an islanded subsystem for any extended duration, the real and reactive power output of the generation must match the demand of that subsystem, at the time that the event occurs. Exact real and reactive power equilibrium on a subsystem is improbable without some means of control. If there is a mismatch, the subsystem voltage and frequency will go outside of the normal range, and cause the distributed generation (DG) to be tripped on over- or under-frequency or voltage protection. The amount of time required for voltage or frequency excursion to trip the DG is a function of the mismatch, parameters of the circuit, as well as the trip points used. Without active voltage and frequency regulation controls providing stabilization, an island is very unlikely to remain in continuous operation for long. The Team will consider switching technologies that would allow the microgrid to seamlessly and quickly transition to islanded mode, and also incorporate the appropriate communications and controls technologies that would allow the microgrid to remain electrically viable and persist for the duration of the emergency (subject to fuel availability).

The current concept includes several points of interconnection (POI) with the PSEG-LI distribution feeders at various locations within the Port Jefferson area. When these points are disconnected, an intentional island would be formed. To sustain the island, the microgrid logic controller would shed load (if necessary), and actively monitor and control voltage and frequency in the area. Some machines will operate as baseload generation, and others (perhaps some of the existing diesel engines at the hospital) will operate in load-following mode to maintain load-generation balance in "real time."

1.1.5 Automatic Separation from Grid

The design will include power and communication equipment necessary to separate from the grid in the microgrid design. Furthermore, strategies for re-connecting and the equipment necessary to accomplish these strategies are also considered. As discussed, the Port Jefferson microgrid will have several points of interconnection to the utility grid. When the utility source is lost, the controller monitoring voltage at the POIs would initiate the transition process from grid-connected to islanded mode. The specific nature of the transition is discussed later in Section 2.1 along with power and communication equipment necessary to facilitate the transition. Furthermore, strategies for re-connecting and the equipment necessary to accomplish these strategies are also considered.

1.1.6 Requirements for Maintenance, Renewables and Energy Storage

The system will be designed to accommodate all manufacturers' maintenance requirements and intermittent renewable generation dynamics.

The Team has explored the possibility of installing roof-top PV on the buildings. The amount of will be about 3% of the microgrid peak demand and an even less percentage of the energy. However, steps will be taken to ensure that the microgrid generation has the range and flexibility to mitigate the expected variability of the PV generation. The project will also include 550 kW of energy storage, which will help stabilize the microgrid in islanded mode, and shave energy peaks during normal conditions. The project will also include 2 MW of dispatchable electric generation to ensure that the system can provide reliable energy on a 24/7 basis.

Most routine maintenance can be accomplished during off peak periods, eliminating the possibility of incurring peak demand penalties from system down-time. More lengthy maintenance can be scheduled for off peak hours.

The maintenance plan will adhere to and comply with manufacturer's requirements for scheduled maintenance intervals for all generation. In addition, the Team will consider reliability-centered maintenance (RCM) strategies that focus more attention on critical pieces of equipment that could affect the microgrid operation (such as rotating machines, transfer switches, breakers) but will recommend periods during the day, week, and year when routine maintenance would be less likely to coincide with an outage event. This is a data driven task that is likely to become more effective given a longer operating history.

1.1.7 Load Following

The current generation portfolio in Port Jefferson includes several existing diesel units at the hospitals, 50 kW of solar PV at Spear Elementary School, and 48 kW of solar PV at Mather Hospital. The project will also include a total of 3.2 MW of new CCHP units at the hospitals, and a 2 MW electric generation unit, most likely at the DPW facility.

Diesel engines are the best choice for load following applications for systems in this size range as they can ramp nearly instantaneously in response to sudden changes in demand. Gas engine may also be suitable for load-following, depending on their configuration. A microgrid can rely on slower-responding technologies such as lean gas engines, but employ diesel generators for load-following when islanded. Alternatively, some rich burn gas engines can easily follow changes in load without affecting frequency, and are therefore well suited for islanded systems.

In connected mode (parallel to the grid), microgrid generation resources would typically not be required to regulate frequency or voltage or follow load. These services are provided by generators under governor control. However, in islanded mode, microgrid resources must switch from baseload power control to frequency control and the bus voltage must be controlled either by a generator's voltage regulator or by some supervisory control (such as a microgrid controller). To avoid a collapse of the island, some generators would switch from baseload to frequency control; some voltage regulators would switch from power factor control to bus voltage regulation; and excess loads should be shed to maintain balance. With multiple DERs of various types, and controllable loads in an area, a microgrid control system may be preferable for successful islanded operation. The team will explore these operational issues in the analysis tasks.

When considering the load/generation mix, several classifications of load may be considered. Generally, these classifications fall into critical, discretionary, and deferrable. At a minimum, the generation and storage mix must be sufficient to meet critical load at all times, i.e. the microgrid will be sized to meet the critical load (constituting the baseload) at all times during normal and emergency periods. The microgrid will attempt to meet the discretionary load during the emergency period, provided there is sufficient supply from internal generation. However, in a variety of likely circumstances, available generation might exceed critical load. In such cases, additional load may be served, but sufficient controllability must be incorporated in the design to shed load if the need arises. In a contingency, the microgrid will incrementally shed discretionary loads until load and supply balance is achieved. Curtailable load is the load that will be immediately dropped at the onset of the interruption of power delivery from the larger grid. Additionally, some load has flexibility to be scheduled which adds an additional layer of control to the load/generation mix. If storage is feasible for the design, the load/generation mix will also consider charge/discharge needs for the storage system.

While the islanded operation of the microgrid was the primary driver for determining the generation and load mix, size and operating modes and import/export in grid-connected mode were also evaluated. The import/export of power to and from the microgrid was determined from the Load & Supply Analysis in Task 2 and comparison of variable costs of microgrid generation with the applicable hourly prices to buy from or sell to the larger grid.

Dispatch of internal generation was based on both economic (i.e., efficiency) and reliability considerations, with the least expensive generation resource running as baseload and incrementally more expensive resources running in cycling or peaking mode, and stacked on top of the baseload generation (i.e., microgrid’s merit order curve).

1.1.8 Two-Way Communication and Control

The Team considered several design options for this task. Important information was requested from the utilities and facilities, which provided information on in-place networks and protocols that possibly could be leveraged in support of this requirement (e.g. leverage for cost saving and interoperability purposes).

The first step was to determine if the microgrid solution would leverage existing networks or if there was a need to design and deploy new communications systems. Once the network platform was identified the Team selected platform and protocol compatible monitoring services as well as security services to satisfy the cyber security protection functions.

The Team evaluated the use of existing communications systems in two important areas.

Cost Savings and Interoperability:

Reuse of existing communications systems can provide cost savings as the microgrid developer will not be required to deploy an entirely new communications fabric. Individual network segments or complete reuse of the communications system can be applied and significant cost savings can be achieved. Additionally, where reuse is leveraged, protocols and data models can be selected to achieve maximum interoperability and performance.

Security and Resilience:

There is a trade-off between cost savings acquired via reuse of existing communications systems and the reduced security and resilience attributes in older communications technology and design approaches. This will be analyzed, and cost and security considerations will be balanced to accommodate the site-specific functional requirements.

Maximum weather resilience and performance is achieved when underground fiber optic networks are deployed. Additional surety can be obtained by creating redundant fiber rings and including two-way communications. The use of fiber, redundant networks, and underground deployment makes this the most reliable and resilient method, but it is also the most costly option. The generation portfolio for the microgrid and potential use cases during connected and islanded modes would go a long way in determining the performance requirements for the communications infrastructure.

Cyber security addresses protection against hacking and malicious intent. The team will consider options such as: modern hardware platforms and network nodes that incorporate device level authentication and authorization; adding security services to the microgrid control nodes and control center to address encryption of data at rest and data in motion; and adding a security architecture that applies defense in depth design principles which includes segmenting of data and system components across different levels of security zones to offer a hierarchy of authorization constraints and system access barriers. Note that cyber security services can be added as a security layer on top of existing communications when reusing networks but cannot change the existing physical security, resilience or performance limitations of the existing networks or device nodes.

1.1.9 Power to Diverse Group of Customers

The proposed microgrid will serve the facilities identified in Table 1-1 based on the cost of providing service, importance of providing power to the critical facility, and alternatives to connection to the microgrid. These facilities include the two major hospitals, water supply, waste water treatment plant, fire station, Department of Public Works facility, and a number of locations that can provide shelter for the population and operations center for first responders and public safety. The microgrid will also serve approximately 250 small commercial establishments and approximately 1,300 residences in downtown Port Jefferson. In addition, the microgrid will benefit populations far beyond the downtown area that utilize the critical facilities and commercial establishments.

The microgrid service area is a major employment center. The microgrid will reduce or eliminate the need to shut down facilities during regional power outages, eliminating the costs associated with lost productivity.

The Port Jefferson Fire department is comprised of five companies with a membership of approximately 107 personnel. The Fire Department responds to over 400 calls each year. During a recent storm on August 15, 2015, the Fire Department responded to approximately 40 incidents in a four-hour period.

The Fire Department is responsible for numerous nearby critical facilities, including National Grid Power Electrical Generation Station (Gas & Oil) Tosco Petroleum Pipeline Intake Tilcon Aggregates Terminal.

Information on the microgrid feasibility assessment as well as progress and outputs of Stage 2 and Stage 3 activities will be made available for public informational purposes. This public outreach aspect will raise awareness around the interrelated topics of resiliency planning, energy efficiency and renewable energy.

1.1.10 Uninterruptable Fuel Supply

The project will utilize National Grid's pipeline natural gas to supply the electrical and CCHP systems. Reliability of gas supply during disruptions to the electric grid should not be an issue. National Grid has confirmed that they rely on the gas transmission companies (e.g., Iroquois) to maintain gas pressure, and they do not have any compressors on Long Island. National Grid also confirmed that they have never stopped gas supply during any power outage. Iroquois has confirmed that they use gas-powered generators for their compressors, and have back-up power for their system controls. The Iroquois pipeline enters Long Island in Commack, about 15 miles west of Port Jefferson, via an interstate pipeline under the Long Island sound, with a pressure of 700 to 1,000 psi.

1.1.11 Resiliency to Forces of Nature

Port Jefferson, like many other communities on Long Island, is exposed to major storm events such as Super-storm Sandy and Hurricane Irene, as well winter storms. Wind, flooding, ice and snow-related damage from these events have the potential to cause extended power outages for critical facilities. The microgrid will mitigate the impact of the power outage hazard by providing a redundant, resilient generation and delivery infrastructure. The system also has the potential to relieve loading on T&D driven by high utilization of air conditioning during peak hours in hot summer months.

In Stage 2, the Team will develop a resilient design that incorporates hardening strategies commonly practiced by systems engineers in areas exposed to storms and outage events. One method to reduce outage frequency is to replace older style un-insulated open wire primary conductors with spacer cable. These conductors have the advantage of a compact design reducing exposure to tree related damage and are supported by a messenger wire further reducing the likelihood of conductor damage. Another alternative is to use tree wire, which has covering that can mitigate tree-contact faults. Use of extreme wind and ice-loading construction for overhead lines will also be considered.

Where appropriate, we may also utilize flood avoidance and flood control measures applied to generators, transformers, and switchgear. Flood avoidance and flood control measures include the use of submersible equipment, flood walls, pumping equipment, watertight enclosures, and elevated construction. The Team will also consider fault-tolerant and self-healing network designs, redundant supply or reconfigurable supply where it makes sense, remote monitoring and diagnostic equipment and other smart distribution design measures.

1.1.12 Black-Start Capability

The proposed microgrid will be designed to have black start capabilities. It will be designed to be automatic after either a specified time frame of sustained utility outage and/or based on a command from the microgrid operator to transfer from grid-connected to microgrid operations. The on-site power systems will have the ability to start and operate using battery power and UPS devices and controls to start from a state of zero power to a state of sustained power production as matched to the microgrid load. Based on criticality and necessity, certain critical loads will be given a priority during black-start operation.

The two major hospitals have existing backup generators. Mather Hospital has 2x350 kW reciprocating engines. St. Charles hospital has a number of reciprocating engines with a total capacity of 1,800 kW.

The microgrid will include backup generators with capacities greater than 200 kW. The smaller generators would remain as standalone backups, since the benefit of connecting the small generators would not be worth the cost for system integration and automatic control interface needed to enable command based dispatch

The project will also include CCHP at both hospitals, which would also have black start capability.

1.2 Preferable Microgrid Capabilities

1.2.1 Operational Capabilities

In Task 2, the Team explored the application of advanced automation and control technologies to enable enhanced visualization, monitoring, control and interaction. The ultimate goal of “advanced, innovative technologies” is to enable safe, reliable, economic operation of the microgrid, in both connected and islanded mode. Technologies considered during the analysis included: distributed energy resources, including demand response, energy efficiency measures and energy storage; smart grid and distribution automation technologies, such as transfer switches, and automatic fault location isolation and service restoration (FLISR) schemes to ensure reliability; smart relays, adaptive protection, special protection schemes.

Strategic placement of field devices can enhance the flexibility and innate reliability of the microgrid area, whether it is in connected or islanded mode. Reclosers, sectionalizers, and fuses are the mainstays of conventional utility overcurrent protection schemes. Digital sensors and measurement devices, such as transformer monitors, remote fault sensors, and Advanced Metering Infrastructure (AMI)/Smart Meters all help to provide additional situational awareness to the both the utility operations center and the microgrid control system. During storm operations and post-storm recovery, increased situational awareness provides faster detection of fault conditions to allow operators to respond more rapidly – both through automation and dispatch of field crews. Distribution Supervisory Control and Data

Acquisition (D-SCADA) and Integrated DMS/OMS are emerging technologies that provide the operator interface for monitoring remote sensors, as well as the control fabric for communication with switching devices on the distribution system. When the microgrid is in islanded mode, it is possible for a mature microgrid controllers to take on features of a DMS/OMS, monitoring the system for fault events and automatically isolating faulted areas and reconfiguring the system so that as little of the load is affected as possible. In the Stage 2 design, the Team will assess the existing Smart Grid – Distribution Automation (SG-DA) investment and plans by the utility and determine, conceptually, how they impact the microgrid operations, and what additions may be feasible.

1.2.2 Active Network Control System

The Team is evaluating the current set of available commercial microgrid controllers. A best of breed selection will be made to obtain alignment with the microgrid site's requirements. From our recent microgrid studies we are aware that available commercial microgrid controllers primarily support various levels of the most fundamental operating functions such as; load shedding, optimal dispatch, integration of renewables or energy storage, forecast and scheduling, and basic situational awareness. Advanced functions like deep control integration with external SCADA or DMS systems or deep monitoring integration with AMI and other data collection and analysis systems is typically a custom developed adapter built to support a specific microgrid use case and system configuration. Section 2.5 provides a fuller characterization of the microgrid active network control system.

1.2.3 Clean Power Supply Sources

The project's functional design will be based on the generation resource mix determined by the availability and potential benefit and will be based on desired environmental requirements.

The Team has considered all opportunities to incorporate clean and renewable resources into the generation mix for the microgrid. Since space is limited and land is very expensive, CCHP offers an attractive option for providing electric and thermal energy for the hospitals. National Grid has confirmed that it can supply enough natural gas to power the CCHP systems. The feasibility analysis evaluated a 1,600 kW CCHP plant at each hospital to supply the hospitals' thermal loads and a portion of the electrical load with clean natural gas. In addition, a 2,000 kW natural gas reciprocating engine is planned at DPW.

Mather Hospital has 48 kW of existing solar PV, and Spear Elementary School has 50 kW of existing solar PV. Although land is limited and very expensive, there may be opportunities to utilize additional solar PV in hospital parking areas, on rooftops and/or in some open space areas that are not zoned for commercial or residential use. The project will also include 550 kW of Battery Energy Storage at the WWTP and the Water Authority, and 470 kW of thermal storage at Mather Hospital.

1.2.4 Energy Efficiency and Other Demand Response

Mather Hospital has implemented numerous energy efficiency measures with help from NYSERDA/ARRA grants, including installing sensors, replacing motors, new LED lighting, and other measures. These include:

- Occupancy sensors in corridors, conference rooms and offices throughout the hospital
- Replace motors with high efficiency units on various mechanical equipment

- Variable Speed Drive on existing central cooling plant 600 ton Carrier centrifugal chiller
- Plate and Frame Heat Exchanger for free cooling during shoulder seasons
- 50 KW fixed tilt ground mounted Solar Array
- Retrofit existing fluorescent lighting throughout the hospital with more efficient ballasts and lamps
- Replace existing outdoor parking lot lighting with high efficient LED fixtures
- Retrofit existing central plant heating boilers from #4 fuel oil to natural gas (with #2 backup).
- Replacement of the controls with high efficiency burners was also included in this project.
- Replace existing HP boilers which are used for Central Sterile, Dietary and SaniPak loads with high efficient natural gas fired boilers – (In progress)
- Programmed through BMS reset control of each heating hot water zone to outside air temperature
- Replace all existing hospital fluorescent light fixtures with high efficiency 2 x 2 LED type fixtures. This followed the previous lighting upgrade which took place years earlier – in progress

The school district has also implemented energy efficiency programs, also funded in part by NYSERDA, that reduce energy consumption by about 396,000 kWh per year, saving the school district about $74,000 per year.

The Team will explore new additional opportunities for energy efficiency. For example, Mather Hospital would also like to implement a “demand control ventilation” system that would reduce peak power demand by trimming air handlers.

The designed microgrid will include demand response functionalities for scheduling and control of the demand response resources included in the microgrid facilities. This study considered the demand response options by working together with the facility owners/managers to identify potential demand response resources (curtailable and discretionary loads) and their size and location, and take them into consideration in the functional design of the control and communications infrastructure. The project also incorporates demand response/load curtailment, roughly equal to 5% of peak loads of the three largest facilities.

The microgrid has the ability to provide generation/load reduction to support the grid during critical periods as an alternative to distribution-system reinforcement and potentially receive; payments for islanding as a demand response (“DR”) service, payments for exporting power as a generation service, and payments for maintaining critical loads during a larger system outage. A contract could call for immediate response in local crises, not just to reduce peak system demand. Short-term markets for local service could be local voltage/VAR support, short-term substation relief, and emergency services (e.g., agreements to make agreed-upon energy exports or to assume prescribed load shapes). Through distribution support services, the microgrid could provide grid restoration services that are more flexible than typical black-start capabilities and ultimately, ensure local reliability, circuit by circuit, across the larger grid. All of these different market constructs need to be discussed with PSEG-LI, and an appropriate mix of services agreed to in order to support both PSEG-LI and microgrid participant requirements.

This study will consider demand response options, both within the utility programs and also in NYISO markets, by working together with the facility owners/managers to identify potential demand response resources (curtailable and discretionary loads) and their size and location, and take them into consideration in the functional design of the control and communications infrastructure.

The Team met with NYISO representatives to discuss the potential for NYISO market participation by microgrids and behind the meter DG. NYISO is still working on the applicable market rules. The GE Team will maintain the relationship with NYISO and monitor on-going developments and impact on the Port Jefferson Community Microgrid. Based on the latest information, as the project moves on, the team will explore ways for the proposed microgrid to actively participate in the NYISO's energy, capacity, and ancillary services markets.

1.2.5 Installation, Operations and Maintenance and Communications

The Team is coordinating with PSEG-LI and the Village to determine how to incorporate any new distribution infrastructure into the existing grid. Underground lines are generally more reliable and resilient than overhead lines, but may not be feasible in some places, particularly historical districts and congested areas. Also, the cost of undergrounding could be 5-10 times the cost of equivalent overhead construction (depending on the type and size). In any case, above ground distribution lines will be hardened to assure reliability and resiliency of the microgrid. Given the options available for modern microgrid design, the existing infrastructure will often be the differentiating factor in design decisions. Considerations such as the interconnecting existing distribution construction and topology will govern many of the design decisions. When feasible, ease of maintenance and installation as well as operational synergy will be factored into design decisions. However, it should be noted that primary microgrid design criteria such as stability and resiliency will generally have priority over operations/maintenance concerns.

The Team worked with the utility to develop an understanding of the relevant features of the electric distribution system and identify the current distribution network challenges in terms of parsing out a microgrid out of the current grid and ensuring that the larger grid will not be adversely impacted.

The type and the configuration of the underlying electric network of the microgrid is highly dependent on the current distribution system, locations and distances of the microgrid facilities on the feeders, and the technical requirements that need to be considered in the functional design of the microgrid electrical infrastructure. A very important consideration is the overall cost of various grid type options. The Team developed a design that interconnected sections of various feeders and isolated other sections so that primarily critical facilities could be served by the microgrid generation. This is detailed in Section 2.1.1.

1.2.6 Coordination with REV

The Team will take into account the latest REV developments in considering various business models and operational modes of the microgrid within the REV framework. In particular, the Team will describe the options for microgrid's operation during the blue sky days across the possible distribution system platform (DSP) and trading in the animated market, that most likely may involve dynamic trading (including buy and sell of power and demand resources) both at retail/distribution system level and also at NYISO/transmission system level. We understand that details of REV framework will keep evolving, which we will take into account in our development of the microgrid functionalities.

The Team has identified a number of key issues that need to be addressed that could impede development of the microgrid. A key potential obstacle involves utility franchise rules that prohibit on site generators from providing power to other loads located across public rights of way. This concern could be addressed by having the utility own and operate the microgrid distribution system. However, in this case, the customers would still be obligated to pay PSEG-LI delivery and demand charges.

Another issue involves devising mechanisms for sale of excess of energy from the microgrid to the market. Because of economies of scale, it may be economical to oversize new DERs to supply not only critical facilities, but also to generate revenue taking advantage of market opportunities for sale of energy, capacity and ancillary services.

A third issue involves PSEG-LI's policy regarding the number of feeders. In particular, PSEG-LI has stated that it would not allow hospitals to have two feeders if they install on-site generation. PSEG-LI is concerned that back feeding could occur from the hospital that could disrupt the main grid. However, since hospitals are concerned about the risk of losing grid power if they only have one feeder, this PSEG-LI policy effectively discourages on site generation at the hospitals. The team has discussed this issue with several technology providers and believes that monitoring and control technology (such as reverse power flow relays) could be applied to reduce the risk of back-feeding. However, further discussions with PSEG-LI are needed to understand the technical and philosophical hurdles. The team has sent an RFI to PSEG-LI and will engage the in discussions as a follow-up.

A final obstacle involves the business structure for owning and operating the microgrid. The DERs and distribution system will require resources and expertise that do not currently reside in the critical facilities or the Town to operate and maintain the facilities. If the facilities are owned by a public or non-profit entity, they would not benefit from significant tax credits for renewable energy resources. A possible solution to these issues would be to have the DERs owned and operated by a third party, and have PSEG-LI own and maintain any new distribution systems.

1.2.7 Comprehensive Cost/Benefit Analysis

In Task 4, the Team provided input needed for the NYSERDA cost/benefit analysis tool to evaluate both the net societal benefits and also the costs and benefits from the perspectives of the various stakeholders.

PSEG-LI would benefit from the project in several ways. The new DERs would reduce the need for additional peaking power to serve this area, and/or free up existing peaking capacity to serve other loads. To the extent that the new gas-fired co-generation at the hospitals offsets the need for operation of existing liquid-fueled peaking units in PSEG-LI's Brookhaven Load area (e.g. in Holtsville), the project would reduce fuel costs and air emissions. PSEG-LI may also be able to purchase excess peaking power from the new DER, if needed, at a lower cost than the cost of operating existing liquid fueled peaking plants.

The microgrid may also help reduce congestion in the Port Jefferson area, which has occurred when demand exceeds capacity. For example, the New York Times reported on August 14, 2014 that traders have routinely made millions of dollars trading congestion contracts linked to congestion between Northport and Port Jefferson. Finally, PSEG-LI would benefit from fees for providing new circuits needed to connect the microgrid.

The project could offer a green energy rate to local customers who are interested in supporting green energy, perhaps through a community solar project located in the hospital cluster.

The Project team will also consider additional sources of revenue such as participation of the microgrid as "virtual plant" in utility demand response programs, and also in NYISO's energy, capacity, and ancillary markets. In addition, the team will also explore any renewable energy credits and tax incentives applicable to the microgrid.

On the cost side, the Team identified (a) various costs elements, covering the design, development, and deployment of the microgrid, capital costs of various components, fuel, variable operations and maintenance (VOM), and fixed operations and maintenance (FOM) cost of generation and demand side resources, (b) costs of the electrical network infrastructure, (c) costs of the control and communications infrastructure.

On the benefit side, the Team identified various potential revenue sources such as utility demand side programs, and those from participating as a virtual plant in the NYISO wholesale market. Additional benefits include estimation of avoided costs of power interruptions for different facilities within the microgrid. See Chapter 4 for more detail on the cost/benefit analysis.

1.2.8 Leverage Private Capital

The Team designed the project and structured the financing to produce returns on investment and debt coverage that will attract private financing needed to complete the project. The team also evaluated different ownership models that will help attract third party funding. The full financial analysis will determine the amount of private funding needed to supplement any NYSERDA funding, and produce acceptable returns and risk for the private investors. A full financial analysis is needed to determine investments needs, both public and private. It is anticipated this detailed analysis will occur under a Stage 2 award.

The Benefit Cost Analysis (BCA) includes potential benefits and costs from various perspectives, including the microgrid as a single entity, and also from the viewpoint of the facility owners and the utility.

In addition, the BCA includes the societal net benefits/costs. The Team's contributions reflect lessons from the original NYSERDA five-Site study which included consideration of various financial benefit and cost streams, and was supplanted by accounting for other non-tangible benefits and costs, including environmental benefits and avoided interruption costs. The latter, which is more difficult to quantify, were estimated based on available benchmarks depending on the classification of the facility's type, critical loads impacted, number of persons impacted, and the duration of emergency period.

1.2.9 Tangible Community Benefits

The Project will benefit the community both by providing added reliability and resiliency for microgrid participants, and potentially reducing energy costs for the village.

The specific facilities to be served will be determined in other tasks of the feasibility study. Providing reliable energy for these facilities during outages to the main grid will also benefit Port Jefferson and surrounding communities by assuring that the Village can continue to provide critical services, including effective emergency response and recovery, during outages to the main grid. The system will also mitigate seasonal brownouts related to high utilization of air conditioning during peak hours in hot summer months, which in the past has caused businesses to close.

1.2.10 Innovation That Strengthens the Power Grid

The Team will consider the options for interaction of the microgrid with the surrounding power grid, including both the distribution utility and the NYISO. The interaction with the surrounding grid across a Distribution System Platform (DSP) through market animation is a major aspect of the New York REV.

For instance, one possible innovation that may be considered within the REV framework is optimal economic operation of the resilient microgrid during blue sky days (i.e., during normal, non-emergency periods), by participation in the utility demand response programs and also NYISO's energy, ancillary services, and capacity markets.

An active and dynamic scheduling of microgrid operations that would maximize the economic efficiency and technical reliability of the microgrid and the surrounding system will require both technical innovations and also reform of regulatory and policy regime that would enable market participation. The Team will elaborate on needed innovations and requirements that would enable such market participation. These may include complementary hardware that would provide more flexibility, such as integrated energy storage, and the smart scheduling software.

The Team will describe the actionable information that would need to be made available to customers for economically efficient and technically reliable operation and scheduling of the microgrid generation. These include real-time load and supply status of the microgrid and the underlying variable costs of operations and the applicable seller and buyer prices on the DSP and/or NYISO. It should also be noted that such actionable information, although accessible to customers when requested or queried, would function and used mostly in the background in automated microgrid systems.

2 DEVELOP PRELIMINARY TECHNICAL DESIGN COSTS AND CONFIGURATION

2.1 Proposed Microgrid Infrastructure and Operations

2.1.1 Simplified **Equipment Layout Diagram and One-Line**

Figure 2-1 below shows a simplified layout of the Port Jefferson microgrid. The microgrid is formed by interconnecting a number of facilities using the existing utility infrastructure as shown in Figure 2-1. The design uses portions of four distribution circuits from two substations and relies on new and existing switches to isolate non-critical portions and interconnect generation sources and loads. The critical microgrid loads include 2 hospitals, a fire station, a public works facility, three water supply and facilities, and a number of other critical and community support facilities. The majority of the power will come from natural gas generators located at St Charles and Mather Hospitals.

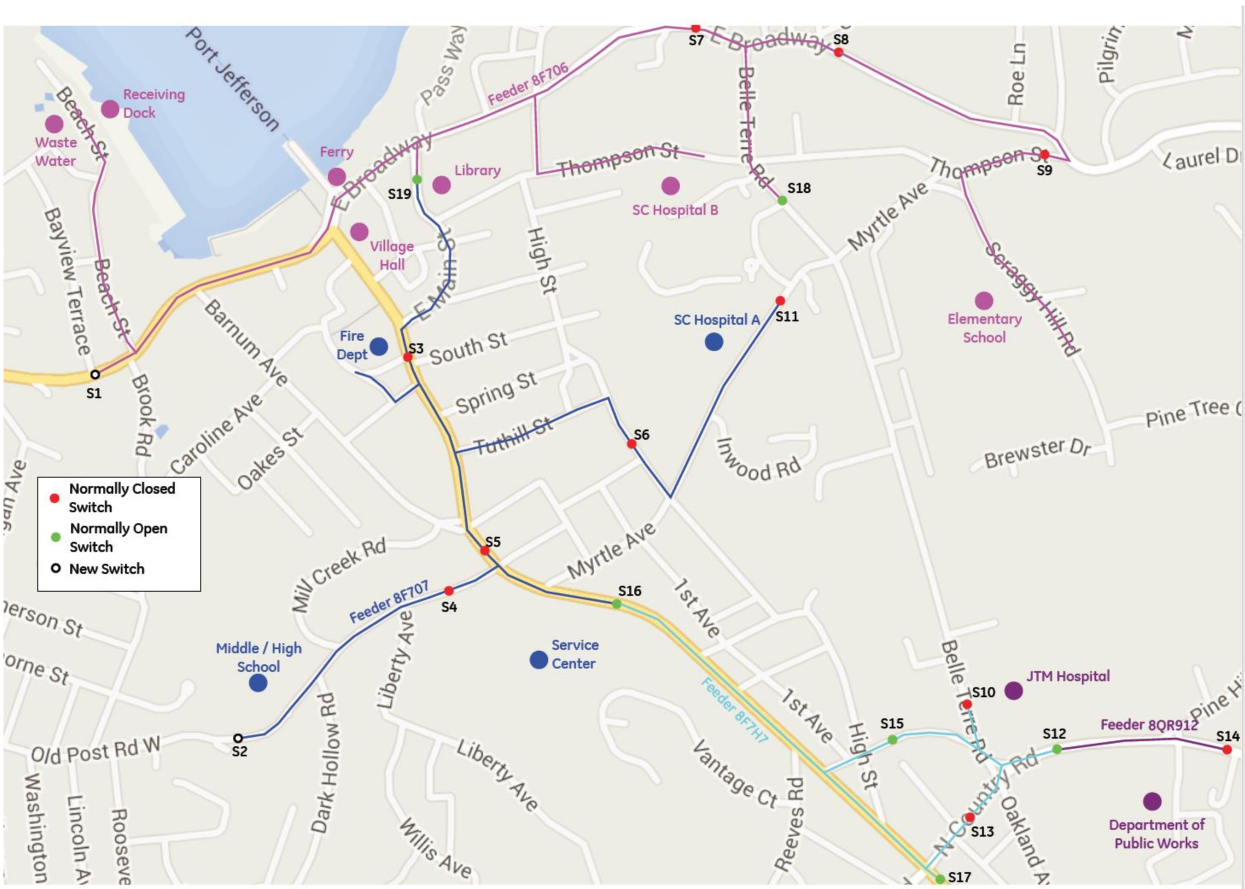


Figure 2-1: Simplified Layout of Port Jefferson Microgrid Showing Facilities and Routing of Electrical Connections

Figure 2-2 below shows a simplified one-line diagram with the location of the distributed energy resources (DERs) and the utility interconnection points. Due to the distances between facilities, the microgrid design makes heavy use of the existing utility infrastructure.

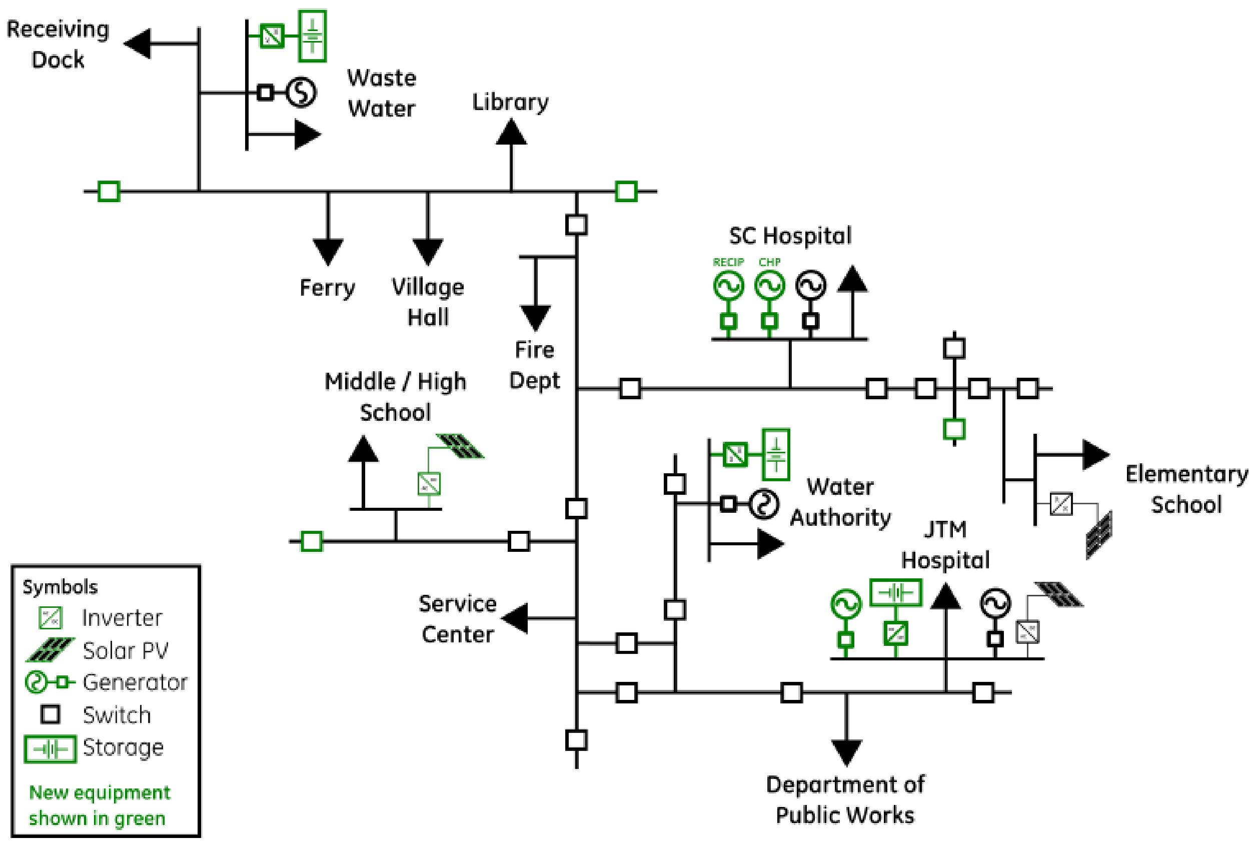


Figure 2-2: Port Jefferson Microgrid One-Line Diagram Showing Generation Sources and Major Equipment

To facilitate isolation of the microgrid system from the larger utility grid, four new switches will be installed and some existing switches will be upgraded to remote operating capability. Other new additions include a CCHP and a Reciprocating Engine at St. Charles Hospital, a CCHP and thermal cool/ice storage at John T. Mather Hospital, and electric batteries at the Waste Water Treatment Plant and the Water Authority, and new PV installation at Port Jefferson Middle School.

2.1.2 Operation under Normal and Emergency Conditions

Normal Conditions

Under normal conditions, the facilities that will be part of the microgrid are fed by four feeders out of two substations on PSEG-LI's distribution system. Use of DER (including storage) will be determined by a combination of local usage needs (such as CCHP thermal load) and economic optimizations. Economic factors considered in the optimal dispatch of the DER during normal conditions versus power purchase from the utility include DER fuel costs, applicable utility rate that currently include energy delivery charges and monthly demand charges, and the supplier market prices which reflect the NYISO wholesale energy prices. The energy storage units, particularly the thermal cool storage at Mather will be dispatched or scheduled to minimize the demand charges during on peak periods.

Emergency Conditions

Under emergency conditions, the facilities will be isolated from the local distribution system using the switches shown in Figure 2-2. The facilities in the above figure as well as all local load attached to the distribution infrastructure being used by the microgrid will be fed by microgrid sources. The load and supply analysis using the DER-CAM model shows that the microgrid peak load during the month of July (the month with highest load) would be completely met by the microgrid based generation during an emergency (grid outage) period. In addition to the power output by the microgrid CCHPs and the reciprocating engines, other resources that either provide power or reduce the load include the electric battery storage systems, the thermal storage, load curtailment that is at least equal to 5% of peak load of the three largest facilities, and also the solar PV generation. However, the microgrid can meet its peak load without relying on the solar PV generation, and hence, the microgrid generation sizing is actually conservative.

The transition to islanded mode is triggered when the microgrid controller senses loss of voltage or frequency at the POI(s). Switches at the boundary of the microgrid would open to isolate the facilities, and generation within microgrid facilities would go offline, in accordance with anti-islanding protection procedures. Backup diesel generation at the hospitals and the WWTP would come online with ten seconds to serve critical loads. Facility loads connected to battery storage can continue to be energized during the transition. Once the facilities are isolated from the grid, natural gas engines, including CCHP, would restart in self-synchronized mode to begin supplying facility loads. Switches within the microgrid can then be closed in to pick up additional load as generation sources are synchronized. Simultaneously, backup may be ramped down if no longer needed. Once the island is stable and active, PV would reconnect and begin generating. During islanded operation, the microgrid controller would actively monitor voltage and frequency in the island. Some loads designated as curtailable may be shed, and backup diesel generation might remain online or be brought online to maintain stable operation.

In cases when the grid is stressed but there is no forced outage, “seamless” transition (in a few cycles) to islanded microgrid mode is possible with advanced controller functions. In this scenario the natural gas generators would remain online during the transition, and the microgrid controller would shed load if necessary. The battery energy storage enables seamless transition by allowing connected loads to essentially ride-through a grid outage.

2.2 Load Characterization

2.2.1 Description of Electric and Thermal Loads

The microgrid electrical load in Port Jefferson, in addition to the loads of originally identified critical facilities, also includes load of other facilities that are on the same distribution feeders powered by the microgrid. Instead of switching off these additional loads, which are a mix of residential and commercial loads, it was decided that these loads will not be separated from the microgrid during emergency periods. In other words, the microgrid will power a significant section of the town during an emergency enabling continuation of daily life and economic activity during larger grid outages.

The Port Jefferson microgrid also includes thermal heating and cooling loads of both John T Mather and St Charles hospital. The 1.6 MW CCHP units at the two hospitals will cover a substantial portion of heating load in the winter and cooling load in the summer. Any shortfalls in meeting the heating and cooling loads will be met by additional energy from boilers in the winter and boilers and central chiller in the summer.

The table below summarizes the microgrid electrical and thermal loads.

Table 2-1: Monthly Microgrid Electrical, Heating, and Cooling Load

	Electrical Load		Heating Load		Cooling Load	
	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)
JAN	3,509,064	6,590	5,062,825	11,159	171,156	503
FEB	3,588,142	7,460	5,969,107	15,049	171,156	556
MAR	3,642,724	6,917	3,981,963	8,328	171,156	503
APR	3,286,734	6,347	3,123,695	7,275	297,235	831
MAY	3,307,905	6,213	2,511,137	5,736	621,246	1,692
JUN	3,969,879	7,565	2,999,423	7,281	1,753,109	4,902
JUL	4,137,514	7,646	2,222,897	5,559	2,887,148	7,862
AUG	4,224,156	7,788	2,451,643	5,898	2,610,388	7,108
SEP	3,739,114	7,326	2,780,903	6,355	1,294,094	3,618
OCT	3,521,028	6,452	2,986,092	6,922	371,488	1,093
NOV	3,317,432	6,483	3,816,076	8,616	263,484	793
DEC	3,962,611	7,466	3,790,497	8,498	171,156	503
Year	**44,206,302**	**7,788**	**41,696,256**	**15,049**	**10,782,815**	**7,862**

2.2.2 Hourly Profile of Loads

The main sources of electrical and thermal load data for critical facilities are the information collected from the utility billing statements of the critical facilities. However, since the project team decided to include in the microgrid other non-critical loads that happen to be on the same feeder(s) as the originally identified critical loads, the entire aggregated feeder load had to be modeled. The information provided by the PSEG-LI was used to estimate the annual peak load of the microgrid and to estimate the annual energy demand on the microgrid. Consequently, a 12 x 24 (month x hour) load shape was developed, resulting in an annual peak load of entire microgrid.

The total annual heating and cooling load of the hospitals were also projected over 12 x 24 load shapes. The heating load daily profiles were based on the DER-CAM database's typical hospital load shape, and the cooling load daily profiles were based on seasonal load shapes developed by EPRI for each region of the USA by customer class and for different end uses.[1]

The microgrid's 12 x 24 electrical and thermal load profiles in tabular and graphical forms are provided in the following tables and charts.

The charts in Figure 2-3 to Figure 2-8 show weekday and weekend profiles for microgrid electrical, heating, and cooling loads.

[1] http://loadshape.epri.com/enduse

Table 2-2: Microgrid 12x24 Electrical Load (kW)

Day-type	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
weekday	JAN	3561	3541	3595	3682	3855	4282	4336	4694	5611	5632	5637	5904	5939	6590	6551	6500	5770	5382	5415	4990	4919	4675	3806	3558
weekday	FEB	3958	3973	4058	4185	4353	4840	4894	5327	6457	6455	6442	6805	6755	7460	7449	7444	6638	6168	6064	5491	5385	5063	4040	3964
weekday	MAR	3712	3674	3752	3897	4079	4547	4818	5313	5870	5871	5873	6179	6198	6917	6904	6870	5938	5485	5464	4943	4669	4211	3762	3743
weekday	APR	3566	3552	3566	3578	3622	4026	4347	4831	5348	5395	5444	5716	5729	6281	6347	6330	5521	5093	5011	4484	4236	3931	3572	3564
weekday	MAY	3457	3429	3411	3447	3619	4068	4395	4735	5134	5243	5298	5545	5639	6193	6213	6189	5476	5067	5017	4588	4289	3996	3655	3587
weekday	JUN	4299	4387	4331	4283	4411	4944	5248	5593	6190	6383	6507	6834	6859	7565	7531	7401	6571	6163	6101	5603	5327	4988	4513	4403
weekday	JUL	4555	4530	4506	4489	4491	4960	5177	5849	6459	6564	6584	6896	6920	7646	7643	7637	6749	6255	6129	5479	5306	4994	4618	4581
weekday	AUG	4425	4399	4396	4446	4632	5259	5516	6038	6521	6528	6576	6972	7058	7772	7788	7743	6900	6377	6280	5655	5479	5128	4601	4454
weekday	SEP	4060	4040	4177	4162	4203	4639	4939	5340	5972	6048	6103	6466	6508	7308	7326	7291	6351	5862	5808	5187	4949	4610	4175	4084
weekday	OCT	3835	3822	3811	3829	3872	4293	4664	5069	5547	5588	5931	6002	5934	6439	6452	6413	5679	5242	5151	4726	4416	4177	3883	3856
weekday	NOV	3688	3663	3661	3667	3778	4137	4401	4863	5651	5645	5678	5940	5939	6483	6449	6389	5692	5286	5152	4735	4651	4396	3665	3584
weekday	DEC	3980	3974	4024	4128	4353	4825	4890	5324	6420	6480	6492	6800	6777	7466	7439	7424	6614	6154	6009	5481	5375	5068	4114	4005
weekend	JAN	3479	3490	3547	3588	3633	3895	3905	3937	4523	4525	4510	4777	4802	5447	5348	5311	4622	4300	4296	3824	3824	3810	3508	3512
weekend	FEB	3910	3921	3975	4112	4126	4444	4480	4513	5225	5236	5213	5539	5500	6246	6037	6039	5278	4857	4807	4363	4331	4292	3937	3969
weekend	MAR	3607	3608	3652	3710	3744	4065	4066	4157	4742	4765	4734	5037	5023	5660	5604	5581	4849	4493	4511	3994	3981	3975	3645	3636
weekend	APR	3356	3344	3339	3363	3338	3604	3640	3809	4251	4554	4582	4916	4950	5483	5386	5403	4753	4467	4427	3936	3885	3897	3586	3576
weekend	MAY	3321	3325	3335	3344	3403	3687	3736	3903	4305	4315	4315	4571	4584	5051	4987	4993	4365	3965	3892	3561	3529	3520	3266	3256
weekend	JUN	4232	4206	4203	4199	4232	4575	4603	4788	5287	5384	5487	5838	5889	6477	6383	6374	5681	5336	5295	4782	4674	4616	4263	4238
weekend	JUL	4162	4120	4116	4123	4180	4526	4537	4777	5288	5442	5432	5746	5752	6312	6326	6335	5616	5336	5222	4769	4696	4645	4261	4190
weekend	AUG	4325	4296	4289	4341	4377	4745	4903	5085	5564	5609	5672	6026	6043	6677	6556	6505	5807	5480	5368	4871	4773	4725	4423	4365
weekend	SEP	3789	3782	3801	3821	3808	4182	4231	4402	4947	4975	5014	5351	5322	5978	5961	5994	5222	4945	4898	4334	4269	4244	3910	3787
weekend	OCT	3596	3514	3514	3504	3535	3826	3886	4025	4393	4413	4450	4691	4724	5205	5233	5259	4752	4503	4518	4126	4062	4025	3768	3710
weekend	NOV	3476	3451	3231	3160	3182	3425	3486	3571	4085	4087	4099	4349	4759	5223	5080	5091	4199	3936	3889	3474	3432	3415	3153	3146
weekend	DEC	3939	3934	3941	3947	4005	4306	4381	4465	5117	5127	5158	5477	5486	6224	6055	6032	5317	4931	4879	4362	4334	4309	3977	3969

Table 2-3: Microgrid 12x24 Heating Load (kW)

Day-Type	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
weekday	JAN	7,692	7,930	8,114	8,235	7,898	11,159	8,514	7,589	6,770	6,233	5,773	5,438	5,211	5,040	4,837	4,769	4,968	5,130	5,382	5,561	6,280	6,498	7,018	7,361
weekday	FEB	10,267	10,462	10,717	10,999	10,441	15,049	11,362	9,599	8,632	8,076	7,532	7,121	6,901	6,671	6,393	6,275	6,245	6,636	7,098	7,407	8,368	8,751	9,471	9,830
weekday	MAR	6,257	6,393	6,551	6,370	8,328	7,749	6,304	5,572	5,150	4,798	4,554	4,339	4,173	3,990	3,831	3,776	3,779	4,078	4,411	4,876	5,197	5,551	5,849	6,015
weekday	APR	5,139	5,256	5,362	5,022	7,275	5,333	4,455	4,040	3,830	3,629	3,488	3,353	3,259	3,119	3,027	2,956	2,961	3,324	3,610	4,171	4,324	4,748	4,921	5,050
weekday	MAY	4,280	4,374	4,476	4,201	5,736	4,167	3,492	3,175	2,984	2,844	2,715	2,626	2,542	2,434	2,316	2,244	2,221	2,524	2,752	3,331	3,508	3,908	4,081	4,203
weekday	JUN	5,713	5,902	6,090	5,720	7,281	5,240	4,406	3,965	3,577	3,377	3,194	3,006	2,813	2,566	2,301	2,166	2,125	2,604	2,879	3,807	4,101	4,760	5,081	5,349
weekday	JUL	4,040	4,246	4,444	4,176	5,559	3,902	3,303	2,917	2,617	2,401	2,174	1,949	1,786	1,583	1,433	1,281	1,235	1,575	1,848	2,575	2,795	3,314	3,608	3,904
weekday	AUG	4,344	4,510	4,676	4,397	5,898	4,094	3,344	2,913	2,601	2,402	2,183	1,976	1,832	1,670	1,521	1,432	1,342	1,660	1,909	2,504	2,745	3,293	3,598	3,954
weekday	SEP	5,014	5,114	5,213	4,874	6,355	4,724	4,043	3,621	3,309	3,086	2,928	2,792	2,688	2,556	2,460	2,430	2,463	2,945	3,241	3,848	4,014	4,483	4,679	4,819
weekday	OCT	5,033	5,133	5,219	4,898	6,922	5,121	4,469	4,002	3,665	3,389	3,194	3,026	2,894	2,747	2,653	2,637	2,718	3,204	3,402	3,907	4,040	4,460	4,619	4,745
weekday	NOV	6,198	6,336	6,445	6,452	6,515	8,616	6,524	5,637	5,096	4,753	4,467	4,264	4,114	3,950	3,806	3,781	4,025	4,199	4,501	4,721	5,214	5,416	5,853	6,081
weekday	DEC	5,836	5,959	6,002	6,173	5,764	8,498	6,344	5,515	5,019	4,762	4,523	4,288	4,148	4,045	3,910	3,860	3,973	4,031	4,177	4,347	4,875	5,077	5,526	5,779
weekend	JAN	8,164	8,412	8,674	8,912	8,605	8,767	7,953	9,242	7,788	6,961	6,517	6,218	5,918	5,743	5,549	4,857	5,000	5,252	6,171	6,440	7,245	7,619	8,373	8,513
weekend	FEB	10,395	10,584	10,825	11,121	10,793	10,875	9,646	11,004	9,763	8,821	8,304	7,915	7,711	7,473	7,238	6,283	6,441	7,023	8,129	8,529	9,527	10,002	10,761	11,218
weekend	MAR	6,232	6,357	6,473	6,418	6,385	5,888	5,965	6,112	5,569	5,146	4,873	4,710	4,518	4,408	4,063	3,652	3,730	4,292	4,866	5,345	5,721	6,096	6,416	6,584
weekend	APR	5,487	5,579	5,662	5,415	5,403	4,551	5,413	4,977	4,553	4,305	4,145	4,027	3,940	3,825	3,284	3,175	3,233	3,861	4,159	4,722	4,872	5,274	5,458	5,602
weekend	MAY	4,346	4,436	4,501	4,298	4,314	3,474	3,914	3,536	3,144	2,927	2,796	2,663	2,554	2,429	2,147	2,127	2,164	2,682	2,903	3,448	3,606	3,974	4,102	4,202
weekend	JUN	5,957	6,134	6,299	6,022	6,034	4,745	4,901	4,419	3,988	3,765	3,576	3,400	3,269	3,095	2,629	2,518	2,559	3,160	3,463	4,309	4,605	5,251	5,527	5,739
weekend	JUL	4,296	4,505	4,784	4,635	4,705	3,670	3,851	3,468	3,054	2,846	2,697	2,546	2,415	2,308	1,895	1,764	1,763	2,287	2,540	3,243	3,441	3,917	4,133	4,380
weekend	AUG	5,313	5,509	5,660	5,387	5,425	4,259	4,463	4,099	3,635	3,444	3,286	3,161	2,967	3,004	2,443	2,341	2,378	3,076	3,600	4,441	4,715	5,281	5,588	5,866
weekend	SEP	4,903	4,996	5,085	4,862	4,841	3,918	4,435	4,152	3,706	3,518	3,358	3,233	3,119	2,987	2,583	2,530	2,631	3,331	3,672	4,249	4,382	4,822	4,996	5,130
weekend	OCT	4,885	4,973	5,060	4,860	4,861	4,031	4,525	4,148	3,711	3,454	3,332	3,232	3,170	3,041	2,697	2,664	2,838	3,573	3,809	4,332	4,489	4,905	5,082	5,216
weekend	NOV	6,135	6,351	6,601	6,501	6,346	6,139	5,576	6,243	5,514	5,022	4,734	4,519	4,353	4,199	4,015	3,656	3,898	4,240	4,769	5,071	5,558	5,791	6,224	6,394
weekend	DEC	5,709	5,830	5,976	6,083	6,057	6,005	5,341	6,261	5,565	4,943	4,620	4,403	4,248	4,140	4,068	3,551	3,736	3,921	4,465	4,655	5,222	5,431	5,748	5,911

Table 2-4: Microgrid 12x24 Cooling Load (kW)

Day-type	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
weekday	JAN	95	95	97	102	112	126	147	176	218	272	334	397	453	491	503	488	446	388	325	265	213	171	138	114
weekday	FEB	105	105	107	113	124	139	162	195	241	300	369	439	500	542	556	539	493	429	359	293	236	189	152	126
weekday	MAR	95	95	97	102	112	126	147	176	218	272	334	397	453	491	503	488	446	388	325	265	213	171	138	114
weekday	APR	143	143	138	141	159	198	262	352	457	564	660	740	799	831	831	795	726	635	538	445	361	289	230	187
weekday	MAY	290	290	281	287	323	402	534	717	931	1148	1344	1506	1626	1692	1691	1618	1477	1292	1094	905	735	588	468	381
weekday	JUN	841	841	814	831	935	1165	1548	2077	2697	3326	3894	4364	4711	4902	4900	4687	4279	3745	3171	2623	2130	1704	1355	1105
weekday	JUL	1348	1348	1306	1333	1500	1869	2483	3331	4327	5335	6247	7001	7556	7862	7860	7518	6864	6006	5086	4207	3417	2732	2174	1773
weekday	AUG	1219	1219	1180	1205	1356	1690	2245	3012	3912	4824	5648	6329	6832	7108	7107	6797	6206	5431	4599	3804	3089	2471	1965	1603
weekday	SEP	621	621	601	614	690	860	1143	1533	1991	2455	2875	3222	3478	3618	3617	3460	3159	2764	2341	1936	1572	1258	1000	816
weekday	OCT	206	206	210	222	243	274	318	383	473	590	725	862	983	1065	1093	1059	969	843	706	576	463	371	299	248
weekday	NOV	150	150	152	161	177	199	231	278	344	428	526	626	713	773	793	768	703	612	512	418	336	270	217	180
weekday	DEC	95	95	97	102	112	126	147	176	218	272	334	397	453	491	503	488	446	388	325	265	213	171	138	114
weekend	JAN	87	87	89	93	99	106	114	123	136	155	181	211	238	256	263	259	247	232	214	195	173	150	127	106
weekend	FEB	97	97	98	103	110	117	126	136	150	171	200	233	263	283	291	286	273	256	237	215	191	166	141	117
weekend	MAR	87	87	89	93	99	106	114	123	136	155	181	211	238	256	263	259	247	232	214	195	173	150	127	106
weekend	APR	151	151	147	145	151	169	206	261	330	398	457	502	533	550	551	534	503	461	413	363	312	262	216	179
weekend	MAY	307	307	300	296	307	344	419	532	671	810	930	1022	1086	1120	1121	1087	1023	938	841	739	635	533	440	364
weekend	JUN	888	888	869	858	889	998	1214	1542	1943	2348	2695	2962	3146	3246	3249	3151	2964	2717	2438	2142	1840	1544	1274	1055
weekend	JUL	1425	1425	1394	1376	1426	1601	1948	2474	3117	3766	4323	4751	5047	5206	5211	5053	4754	4358	3910	3436	2952	2477	2043	1692
weekend	AUG	1288	1288	1261	1244	1289	1447	1761	2236	2818	3405	3909	4295	4563	4707	4711	4569	4298	3940	3535	3107	2669	2239	1847	1530
weekend	SEP	656	656	642	633	656	737	896	1138	1435	1733	1990	2186	2323	2396	2398	2326	2188	2006	1799	1581	1358	1140	940	779
weekend	OCT	190	190	193	202	215	230	247	267	294	336	393	457	516	556	571	562	537	503	465	423	376	326	276	230
weekend	NOV	138	138	140	147	156	167	179	193	214	244	285	332	374	404	415	408	390	365	338	307	273	237	200	167
weekend	DEC	87	87	89	93	99	106	114	123	136	155	181	211	238	256	263	259	247	232	214	195	173	150	127	106

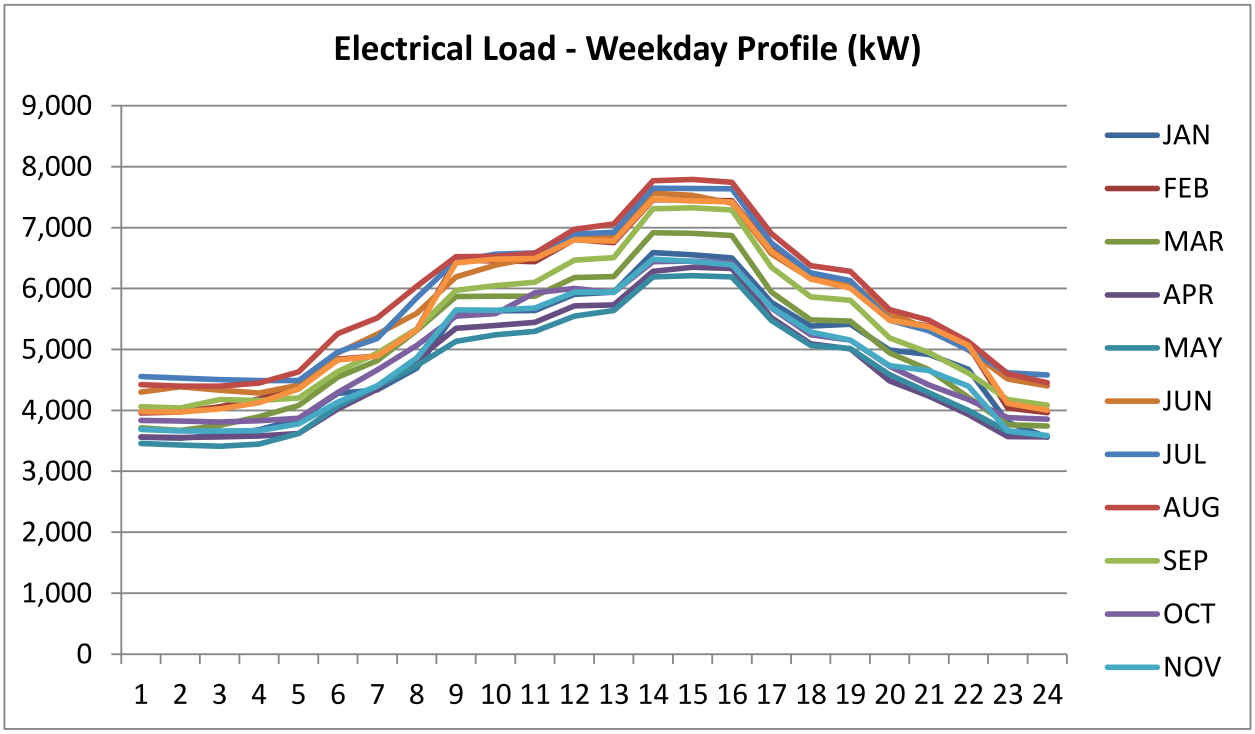


Figure 2-3: Microgrid Weekday Electrical Load Profile (kW)

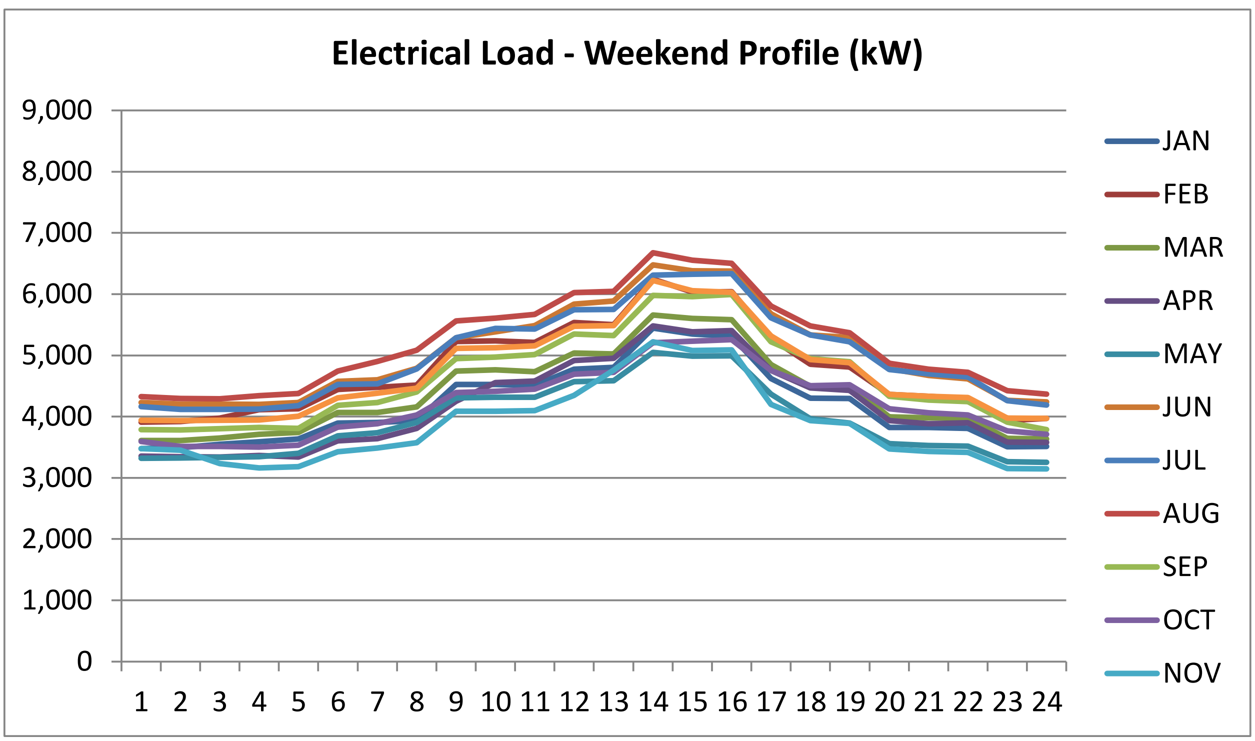


Figure 2-4: Microgrid Weekend Electrical Load Profile (kW)

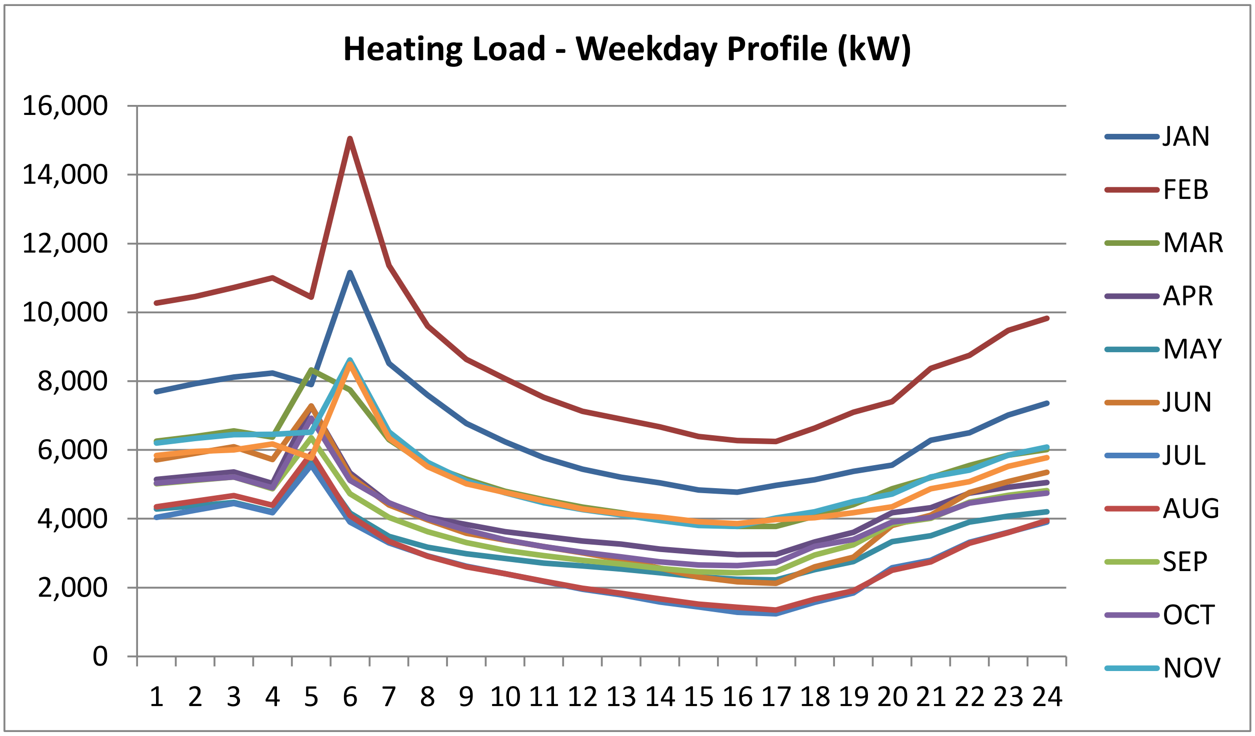


Figure 2-5: Microgrid Weekday Heating Load Profile (kW)

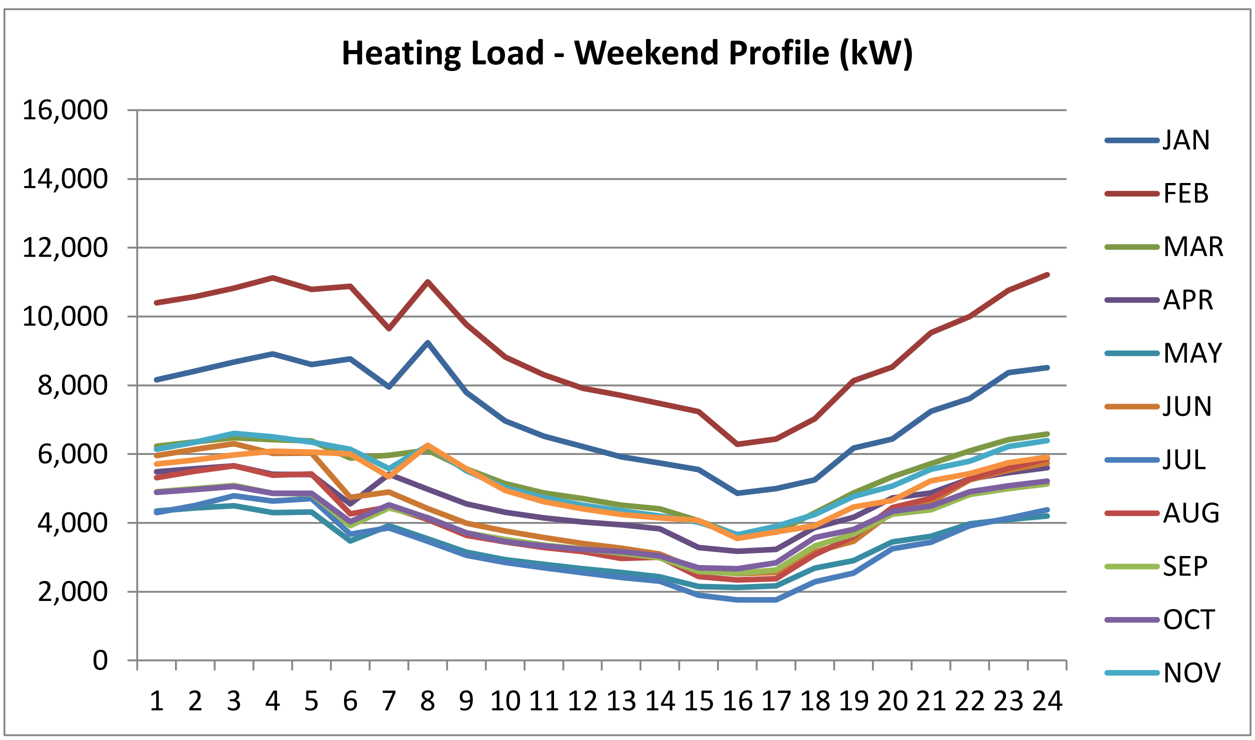


Figure 2-6: Microgrid Weekend Heating Load Profile (kW)

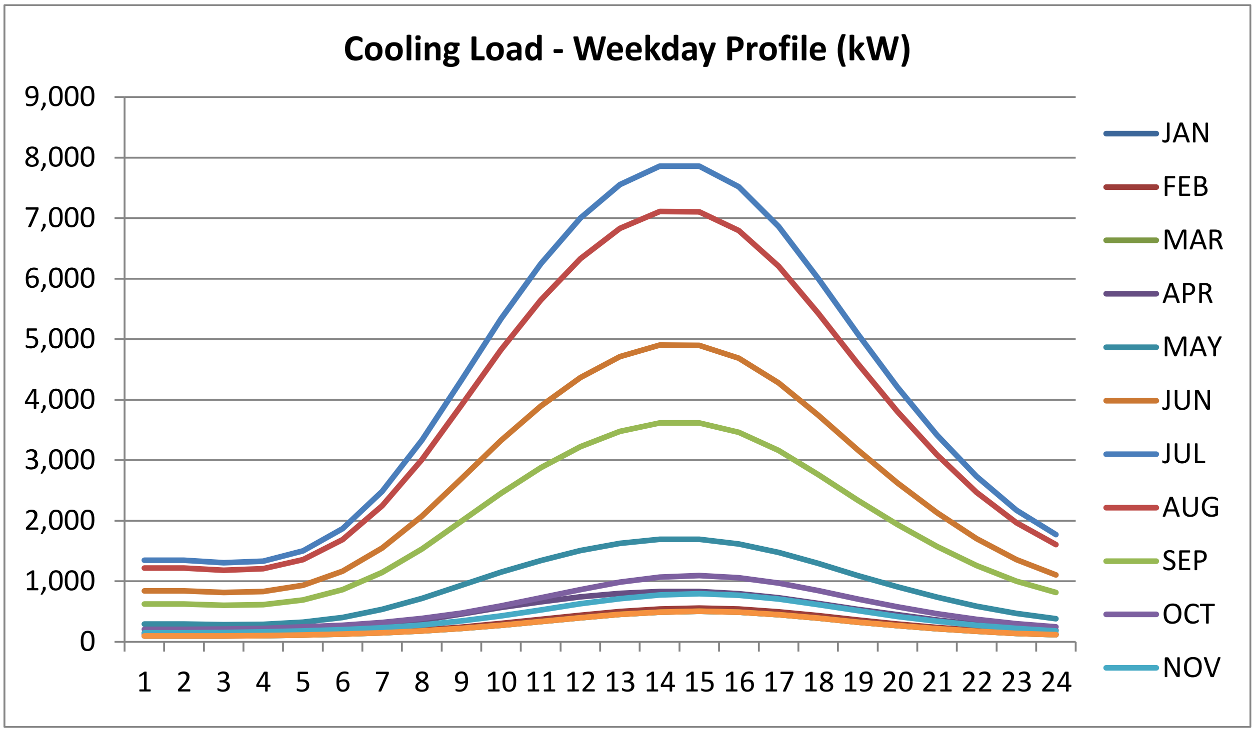


Figure 2-7: Microgrid Weekday Cooling Load Profile (kW)

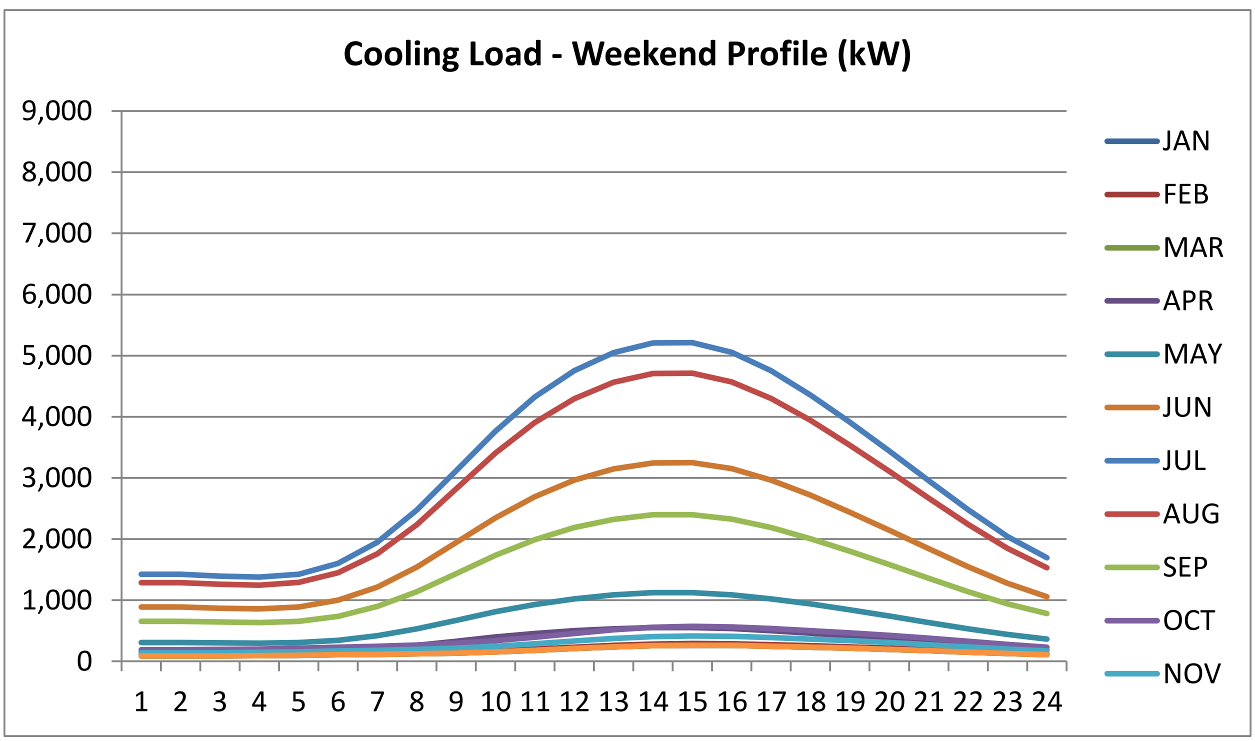


Figure 2-8: Microgrid Weekend Cooling Load Profile (kW)

2.2.3 Description of Sizing of Loads

The microgrid total electrical load is based on the sum of all the loads of individual critical facilities to be served by the microgrid, plus the additional non-critical loads connected to the microgrid feeders, as listed in Table 2-5 below.

The sum of the non-coincident peak loads in Table 2-5 is 8,917 kW, which is significantly higher than the estimated coincident peak load of 7,788 kW (which occurs in July as shown earlier in Table 2-1). The coincident peak load is used for planning the microgrid generation.

The thermal loads serviced by the microgrid are limited to the thermal heating and cooling loads of the John T. Mather and St. Charles hospitals, which are mostly met by the new CCHP units located in those hospitals.

Table 2-5: Summary of Microgrid Electrical, Heating, and Cooling Load

Port Jefferson		Electrical Load		Heating Load		Cooling Load	
ID	Facility	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)
1	Department of Public Works	96,960	45				
2	St. Charles Hospital	10,721,628	1,932	27,154,332	8,678	6,161,609	3,729
3	Spear Elementary School	418,560	130				
4	John T. Mather Hospital	11,923,603	1,959	14,541,923	6,371	4,621,207	4,158
5	Suffolk County Water Authority	16,038	7				
6	Suffolk Sewer Department	1,612,080	659				
7	Port Jefferson Middle/High School	783,763	223				
8	Village Hall (PJ Data C + PJ Data C)	71,100	24				
9	SCWA (Water Supply & Treatment)	656,800	311				
10	Port Jefferson Fire Department	158,000	50				
11	Extra Feeder Load	17,747,770	3,576				
	Total	44,206,302	8,916	41,696,255	15,049	10,782,816	7,887

* Sum of non-coincident peak loads

2.3 Distributed Energy Resources Characterization

2.3.1 DER and Thermal Generation Resources

The following table lists the existing and proposed (in bold font) generation resources in the microgrid.

Table 2-6 Existing and New Microgrid DER

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)
Existing Solar PV	John T. Mather Hospital	Solar	0.050
Existing Solar PV	Spear Elementary School	Solar	0.048
Existing Mather Generator 1	John T. Mather Hospital	Diesel	0.500
Existing Mather Generator 2	John T. Mather Hospital	Diesel	0.500
Existing St. Charles Generator 1	St. Charles Hospital	Diesel	0.900
Existing St. Charles Generator 2	St. Charles Hospital	Diesel	0.300
Existing St. Charles Generator 3	St. Charles Hospital	Diesel	0.250
Existing St. Charles Generator 4	St. Charles Hospital	Diesel	0.250
Existing St. Charles Generator 5	St. Charles Hospital	Diesel	0.100
Existing WA Generator	Suffolk County Water Authority Supply Well	Diesel	0.100
Existing WWTP Generator	Waste Water Treatment Plant	Diesel	0.250
New Mather CCHP	**John T. Mather Hospital**	**Natural Gas**	**1.600**
New St. Charles CCHP	**St. Charles Hospital**	**Natural Gas**	**1.600**
New Mather CCHP (Absorption Chiller)	**John T. Mather Hospital**	**Natural Gas**	**0.313**
New St. Charles CCHP (Absorption Chiller)	**St. Charles Hospital**	**Natural Gas**	**0.313**
New Reciprocating Engine	**St. Charles Hospital**	**Natural Gas**	**2.000**
New Solar PV	**PJ Middle/High School**	**Solar**	**0.200**
New WWTP Electric Battery	**Waste Water Treatment Plant**	**Electric**	**0.250 MW (1.000 MWh)**
New WA Electric Battery	**Water Authority**	**Electric**	**0.300 MW (1.200 MWh)**
New Mather Thermal Storage	**John T. Mather Hospital**	**Electric**	**0.469 MW (4.690 MWh)**

2.3.2 New DER and Thermal Generation

New generation resources and their locations are listed in bold font in Table 2-6. The majority of the generation is natural gas fueled. A 1.6 MW natural gas fueled CCHP will be located at John T. Mather hospital, and a 1.6 MW CCHP as well as another 2.0 MW natural gas reciprocating engine generator will be located at St. Charles Hospital.

The microgrid facilities contain a number of diesel fueled standby generators totaling 3.2 MW. The largest concentrations of diesel generation are at John T. Mather Hospital with 1 MW of standby diesel generation, and St. Charles Hospital with 1.8 MW of standby generation. The existing diesel units are not expected to run for any significant amount of time - even during emergency periods - since they will not be needed to meet the microgrid load in islanded mode, and they will also be too costly to run during grid connected mode.

In addition to the dispatchable generation listed above, the microgrid will contain roughly 2.6 MW of storage. Two electric battery systems are proposed: a 250 kW system to be located at the waste water treatment plant, and a 300 kW system to be located at the water authority facility. In addition, a unique feature of this microgrid is 1.16 MW of thermal cooling storage that will be located at John T. Mather Hospital.

Port Jefferson's microgrid will include a total of 298 kW of solar PV, which includes 200 kW of new solar PV to be located at the Middle School. The existing solar PV includes a 50 kW system located at John T. Mather Hospital and a 48 kW system located at the Elementary School.

The DERs are shown on each facility's load bus on the one-line diagram in Figure 2-2. The details of the in-facility wiring are omitted at this point.

2.3.3 Adequacy of DERs and Thermal Generation Resources

The DER-CAM model takes into consideration the 12-month x 24-hour daily average electrical and thermal profiles of the aggregate loads of the facilities in the Port Jefferson microgrid.

The solar energy (based on the solar irradiance profile in Islip Airport, NY) is available during on-peak hours.

Figure 2-9 provides a view of the "theoretical" load and supply balance over a weekday of operation on a normal day in the month of July. The DER-CAM model dispatches all the generation resources based on the comparative economics of on-site generation versus purchase from the utility. As can be seen, power is purchased from the utility during off-peak hours (there is a demand charge during on-peak hours). However, we have imposed a requirement that the CCHPs run for a minimum number of hours, during which they can modulate between a set minimum load and their maximum load.

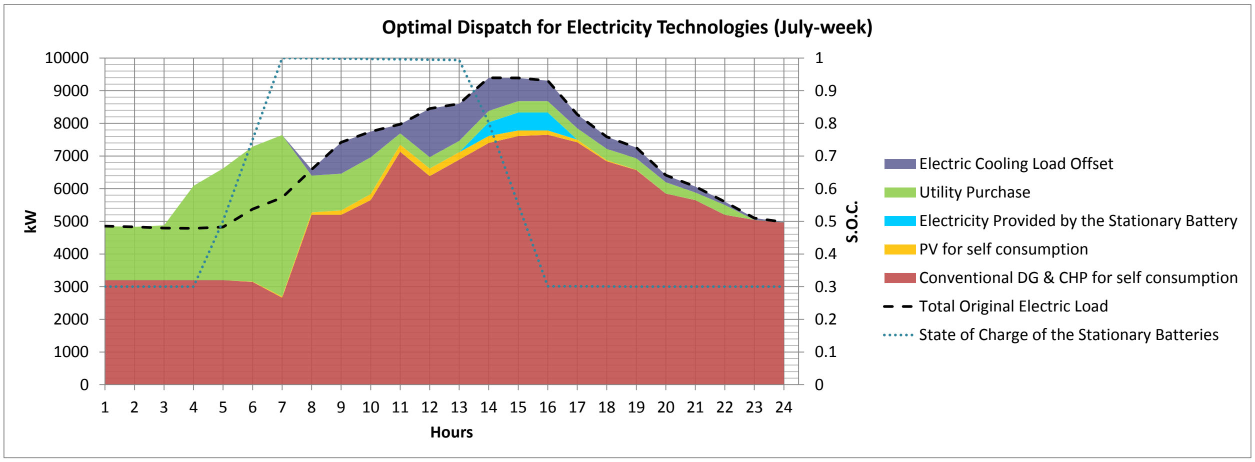


Figure 2-9: Microgrid Generation Stack to Meet Electrical Load – July Normal Weekday

In the above figure, the black dashed line represents the total original electrical load. The burgundy colored area represents the on-site (non-diesel) generation by the microgrid (CCHP + Reciprocating Engine). The yellow colored area is the solar PV production. The lighter blue area is the discharge by the battery electric storage systems. The State of Charge (SOC) of the battery storage is shown by the light blue dotted line and its value is indicated on the right-hand side Y-axis. The green colored area is the additional electric energy purchased from the utility. The darker purple colored area is the reduction in the original electric load due to use of absorption chillers, which replaces the electric usage by central chillers. The CCHP units were set to run as baseload all year round. However, the relative economics of on-site generation based on the microgrid resource efficiencies and fuel costs versus the electricity purchase from the grid with its energy delivery and market rates, and the demand charge rates, determines the dispatch of the reciprocating engine.

The total electrical load appears to be greater than the amount estimated. This is simply due to representation of the cooling load in the hospitals in the DER-CAM model as the load of electric central chillers. In DER-CAM, cooling loads are expressed in electricity needed to serve the cooling demand.

Figure 2-10 shows the microgrid operation during an emergency weekday in July (the month with the highest microgrid load based on the assumed load shape. As can be observed, there is no utility purchase, and all microgrid load is met by on-site generation, including solar PV. The blank space below the black dashed line represents load curtailment applied during the emergency periods. Load curtailment level is set at 5% of the peak load of the three largest facilities in the microgrid. It is believed that higher levels of load curtailment are achievable, but since the largest two facilities are hospitals, a conservative 5% level was selected.

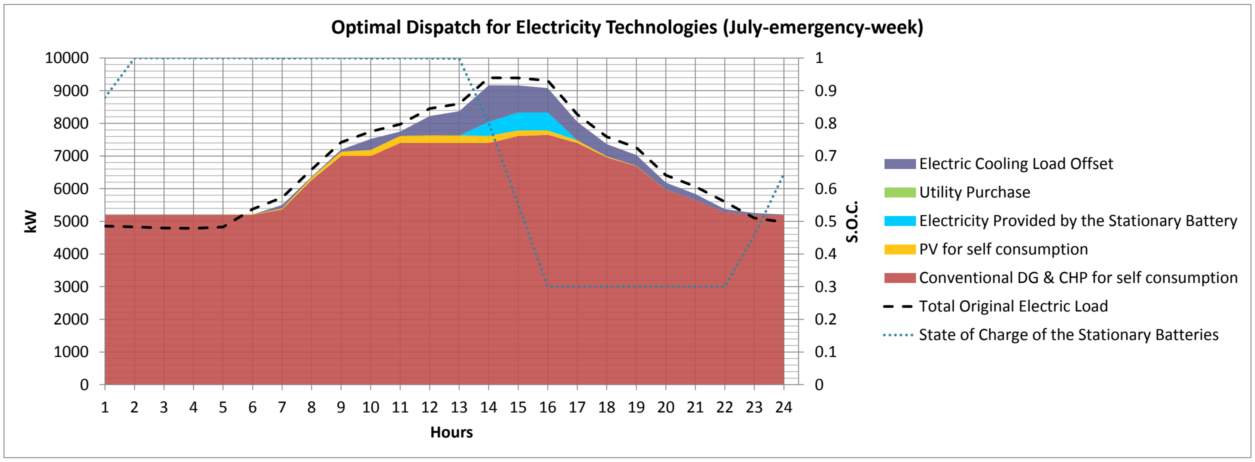


Figure 2-10: Microgrid Generation Stack to Meet Electrical Load – July Emergency Weekday

Figure 2-11 shows thermal dispatch for heating load during a normal weekday in July. The black dashed line is the microgrid original total heat load. The additional thermal generation going above and beyond the heat load is actually the portion of the thermal energy of the two CCHP units that is utilized to run the two absorption chillers at the two hospitals. As shown, the grey areas represent additional thermal energy that is produced by boilers (i.e., "heat collected from fuels" in the figure below), which in turn is used to produce additional cooling energy by the absorption chillers.

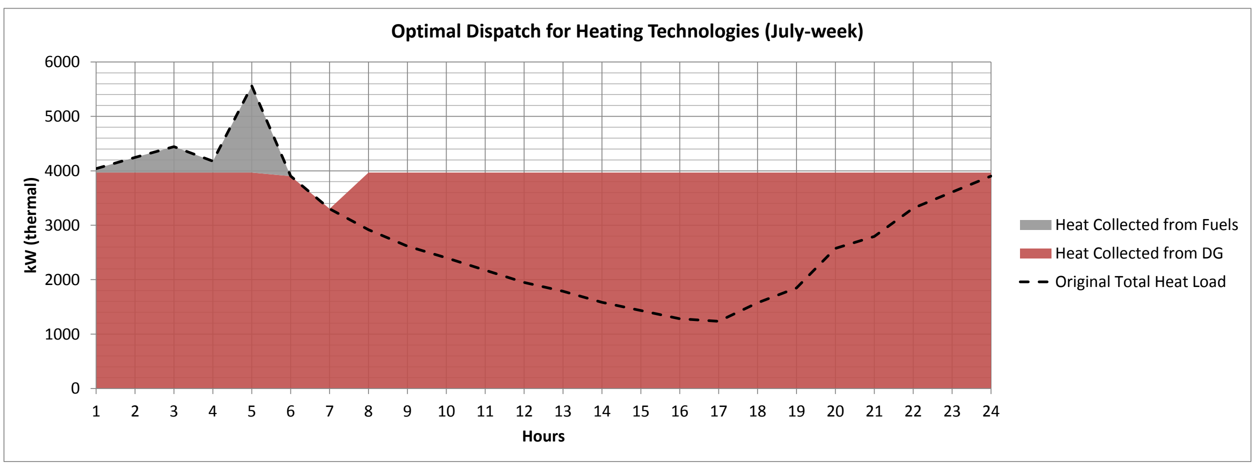


Figure 2-11: Microgrid Thermal Dispatch to Meet Heating Load – July Normal Weekday

Figure 2-12 shows thermal dispatch for cooling load during a normal weekday in July. The black dashed line is the microgrid original total cooling load. Note that in DER-CAM, the cooling load size is not based on the final cooling energy output. It is actually based on the equivalent electric input of central dispatch that will provide that amount of thermal energy, and hence reflects the assumed Coefficient of Performance (COP), which we have assumed to be 4.5.

The burgundy colored area is the cooling load that is provided by the absorption chiller. In the early hours of the day, the absorption chiller appears to be operating above the cooling load. The cooling energy produced above the cooling load is actually used to charge the thermal cool storage. The dotted green line indicates the storage level. The solid green area is the storage energy being discharged. As shown, there is a need for additional supply to meet the total cooling load - provided by the central chiller (blue colored area). The blue color area to the left is additional central chiller energy used to charge the thermal cool storage.

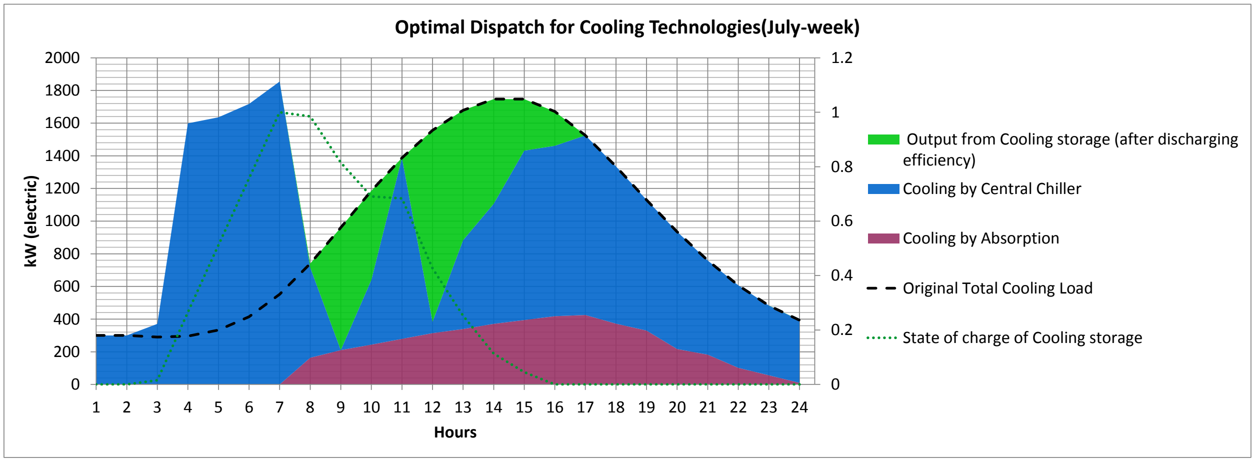


Figure 2-12: Microgrid Thermal Dispatch to Meet Cooling Load – July Normal Weekday

2.3.4 Resiliency of Resources to the Forces of Nature

The new CCHP units and the reciprocating engine will be installed above the flood plane at the hospitals and therefore will be protected from most severe weather incidents, and flooding. According to the EPA Catalog of CHP technologies,[2] natural gas engine CHP units have an availability of about 98% for units sized 800-9000 kW, a forced outage rate of less than 1%, and a scheduled outage rate of about 1.5%. The CCHP units and the reciprocating engine and the electric battery storage systems and thermal cool storage, along with the backup generation at the microgrid facilities constitute a collective power system with very high reliability that is insulated from the forces of nature. The expected forced-outage rate of the entire power plant will be analyzed in Stage 2.

According to the information from the facilities and the utility, natural gas supply has proven to be extremely resilient during past major events. Therefore, supply to the CCHP units is not expected to be interrupted in most emergencies (barring seismic activity or sabotage). The possibility of these events is remote enough to preclude consideration of propane tanks, CNG, or LNG.

The roof-top PV panels are at some risk of being partially or completely covered with snow cover during 4-5 months of the year. However, the contribution of these panels to the overall power profile is not substantial enough to warrant additional action besides an occasional cleaning during these months. The existing backup generation at both sites is more than enough to compensate for any energy lost due to snow cover on PV panels.

2.3.5 Description of Fuel Sources for DER

The primary source of energy for the Port Jefferson microgrid is the natural gas generation located at John D. Mather and St. Charles Hospitals, and the electric only generation. National Grid has notified our team that they will provide the needed infrastructure to supply natural gas for the CCHP plants at St. Charles and Mather by November 2019.

[2] http://www.epa.gov/sites/production/files/2015-07/documents/catalog_of_chp_technologies.pdf

2.3.6 Description Operational Capabilities of DER

In connected mode (parallel to the grid), microgrid generation resources would not be required to regulate frequency, and would likely have a small role if any in voltage regulation. These services are provided by the bulk power system and the surrounding distribution system. However, in islanded mode, microgrid resources will need to provide for power balance/frequency control and reactive power balance/voltage control.

New York State and PSEG-LI interconnection requirements with respect to voltage and frequency response will apply to the microgrid generation when it is in grid-connected mode. Whenever voltage or frequency at the POI are outside the allowable bands, the microgrid controller should initiate a disconnect sequence. However, the microgrid generation and control system have the ability to ride-through grid events and regulate voltage and frequency at the POI to help in fault recovery. This action can be coordinated with the utility operations center if needed.

Any of the diesel standby generators are capable of operating without the presence of the distribution system. That ability makes them ideal candidates for black start application. These generators will have the ability to maintain real and reactive power balance and can maintain frequency and voltage. Most have the capacity for partial load operation within a range (minimum/maximum capacity ratings). However, upgrades to control and protection equipment may be necessary to allow the generators to feed the larger grid. The battery energy storage can also be used to black start the microgrid generation.

Some types of generators are more capable of providing frequency control than others. For the Port Jefferson microgrid, some assets will provide baseload power while other assets would switch to frequency control mode. The CCHP units tend to be better suited to baseload operation than frequency control. For this reason, the majority of fast frequency regulation will come from the 2.0 MW natural gas reciprocating engine as well as the battery storage units. To augment this frequency regulation, load may need to be controlled. Additionally, it may be necessary for solar production to be curtailed or for some backup diesel generation to be brought online. The specific demands for power matching/frequency regulation will be determined through study, and the microgrid controller will manage assets in response to changing conditions.

Unlike power matching/frequency regulation where some generators are better suited to respond quickly to changes in real power, most generators are capable providing VARs and reacting quickly to changes in voltage. Traditionally, a few types of generator controls are available: voltage control, VAr control and power factor control. For the Port Jefferson microgrid, some combination of these modes will be employed depending on the asset type. For example, the natural gas generator will likely be in voltage control mode to provide voltage regulation/reactive power balance and to support voltage during a fault to allow the protection system to operate correctly. The CCHP units may be used in VAr control mode to supply a reactive power base, and the PV and battery inverters may be in power factor control to smooth voltage variations due to intermittent power output. As with the power balance/frequency control, the specific roles of the different generation assets will be determined through study, and the microgrid controller will manage these assets in response to changing conditions.

While the PV will likely have some advanced functionality such as Volt/VAR control, the dispatchable generation and storage will likely be used to perform the majority of frequency/voltage control. Further study will indicate if the PV will need to be curtailed to maintain stability in islanded operation.

2.4 Electrical and Thermal Infrastructure Characterization

2.4.1 High-Level Description of Electrical Infrastructure

Due to the distances between microgrid facilities and the difficulty in isolating critical and non-critical loads in an emergency, the Port Jefferson microgrid will heavily leverage the existing utility infrastructure. To facilitate isolation of the microgrid system from the larger utility grid, four new switches will be installed and some existing switches will be upgraded to remote operating capability. The proposed new infrastructure (as well as the existing utility infrastructure) is shown in Figure 2-2.

As shown in Figure 2-1, the proposed microgrid will isolate from the grid in 5 locations labeled S1, S2, S8, S9 and S15. Additionally, a number of normally open switching points will be automatically closed during microgrid formation. These locations are S12, S16, S19 and S22.

To detect abnormal conditions, and to detect when the grid has returned to normal, CTs/PTs will be installed at the isolations points. To achieve the appropriate selectivity/sensitivity, it is likely that some combination of direct instrumentation of isolation points and transfer trip will be used. The appropriate configuration will be determined through further study.

Since the CCHP units at each hospital will serve the heating and cooling requirements at their own facilities, relying on the current thermal networks and conduits, there is no need for additional development of thermal network in the Port Jefferson microgrid.

2.4.2 **Resiliency of Electrical and Thermal Infrastructure**

The proposed microgrid loads are currently served by overhead distribution lines. The largest risks to the electrical infrastructure are: 1) a widespread transmission outage, such as the 2003 Northeast blackout, 2) failure of the 8F substation, such as during a catastrophic weather event or transformer failure, 3) storm surge and flooding leading to shut down. However, PSEG-LI has stated that during past hurricane events, the overhead lines that were free of vegetation were not severely unaffected, but some substations were compromised. Due to the lack of vegetation (trees), the OH system near the coastline can actually be more resilient during flooding events than UG systems.

While the proposed microgrid infrastructure is relatively free of trees or other obstructions that typically cause distribution line outages, some susceptible portions of the circuit may need to be hardened to ensure reliability, particularly along Myrtle Ave and along Belle Terre Rd near the hospitals. This could include measures such as aggressive tree-trimming, removal of danger and hazard trees, use of upgraded poles and cross-arms, use of tree wire, compact construction, or selective use of space cable. PSEG-LI is currently has a widespread program to harden infrastructure in the area post-Sandy. Any efforts on behalf of the microgrid will be coordinated with PSEG-LI.

During a widespread emergency (such as a blackout or substation transformer failure), the microgrid infrastructure would likely not be significantly affected and would be able to form an island. The gas supply line is also resilient, and will allow the microgrid to be operational for as long as capacity exists. The backup diesel generation at the water supply plant has enough storage for two days of continuous operation consistent with SCWA policy, and can be resupplied as needed. The major risk to the microgrid infrastructure is a seismic event or tornado that might damage sections of existing distribution system that the microgrid intends to utilize.

2.4.3 Description of **Microgrid Interconnection to the Grid**

Figure 2-2 shows the points of interconnection with the Port Jefferson distribution system. When not in islanded mode, the microgrid will be fed normally through the radial feeder system. When entering islanded mode, the microgrid will isolate from the utility system via automatic switching operations as shown in Figure 2-2 and described in Section 2.4.1.

While the single 2.0 MW natural gas unit will be a rotating machine, the high penetration of inverter-based generation and storage may complicate traditional protection systems based on high currents under faulted conditions. Additionally, since the microgrid infrastructure will be used in conjunction with utility infrastructure under normal conditions, the protection system elements will likely need multiple set-points /configurations.

In addition to overcurrent protection (Functions 50/51), the microgrid protection scheme will likely employ some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

2.5 Microgrid and Building Controls Characterization

2.5.1 System Control Architecture Description

The proposed microgrid control architecture consists of four control device types:

- **Microgrid Energy Management System** (MG EMS) (1 per microgrid)

  The MG EMS orchestrates all control actions as well as provides the utility interface. It serves as a main microgrid configuration and dashboard station. For instance, a station operator is able to provide scheduling policies through its web interface. The data historian and possibly other data bases are stored at MG EMS which also provides analytics applications.

- **Microgrid Master Control Station** (1 per microgrid)

  Master Control Station is a hardened computer that hosts critical real-time monitoring and control services. It performs forecasting, optimization and dispatch functions.

- **Microgrid Facility Control Node** (1 per facility)

  Facility Control Node coordinates control across multiple buildings composing a specific facility. This controller abstraction is utilized also for any building in the microgrid with local control functions, i.e. a building that hosts a generation unit or building management system (BEMS). Most facility control nodes would also be hardened industrial computers.

- **Microgrid Edge Control Node** (1 per facility)

  Edge Control Node is an automation controller or a feeder management relay with a direct switching interface to loads in a building. This is typically a multifunction controller/IED providing automation and physical interface to switchgear and sensors.

Figure 2-13 shows control devices for the proposed Port Jefferson microgrid as an overlay on the electrical one-line diagram.

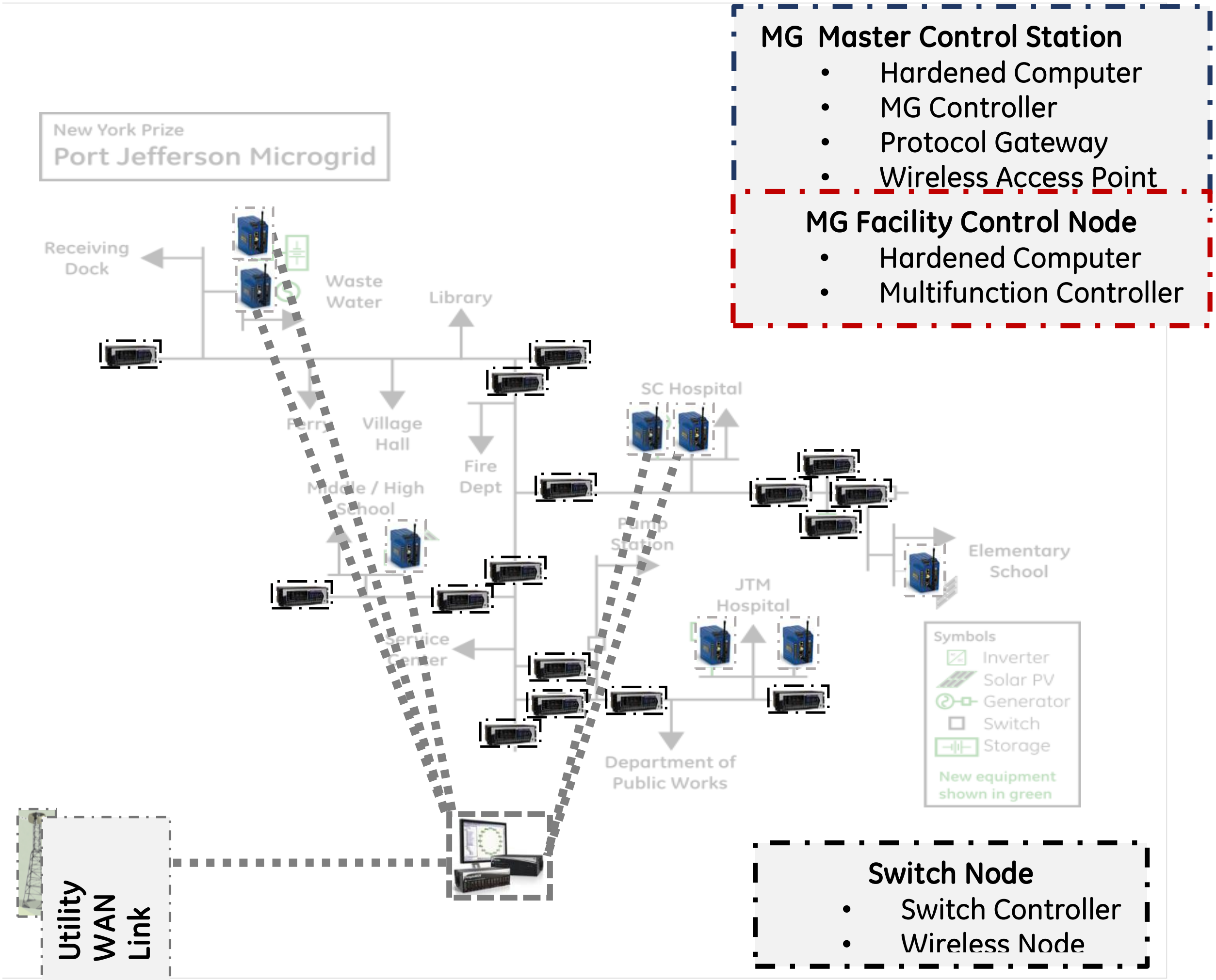


Figure 2-13 Port Jefferson Microgrid Electrical One-Line Diagram with Control and Communications Overlay

The microgrid master control station performs economic optimization, i.e. it periodically determines a combination of generation units to bring on or keep on such that the total cost of operation is minimal. This includes the CCHP units and the gas engine, the solar PV units, storage units, and even the backup generation, which will be tied into the control system with Edge Control Nodes. The start/stop commands as well as optimal set points for real power, and sometimes even for reactive power, are sent to each generation unit. In addition to regulating the generation units a primary task of the Microgrid Master Control Station is to coordinate the switching devices at the boundary of the microgrid. To simplify Figure 2-3 these communication links are not shown.

Both old and new generation units are expected to be equipped with microprocessor-based controllers that can regulate either the natural-gas engines or the inverter-based power conditioning systems. During a typical operation, while a unit is in standby or parallel modes, the controller issues power set-points, while continuously adjusting the engine speed to optimize efficiency.

The local controller devices can interface with the hierarchical control system via Modbus communications. This interface would be used to communicate necessary information between a microgrid facility control node and the local controller of the generation unit located in that facility. The facility control node would act as Modbus master, and the local controller would act as the Modbus slave, sometimes called a remote transmitter unit. The master device initiates all communication, sending commands or requests for information. The local controller would relay all of the AC power related information back to the facility control node including the voltage, current, frequency, and power factor. Thus, this interface will allow the microgrid control system to individually start, stop, and change the set point of any microgrid generation unit, as well as read all of its inputs and outputs.

The microgrid master controller will likely include load management in the economic optimization of microgrid assets. In such cases, it will communicate with building energy management systems to determine and set load set points. At this point it is not clear which facilities have energy management systems and which will be included in microgrid optimization. In terms of peak demand, primary candidates are St. Charles and John T. Mather hospitals. We recommend that the microgrid control architecture be built on one of the open software control platforms such as Tridium JACE (Java Application Control Engine). Such a platform can be used to control a variety of BEMS systems, HVAC and DDC devices. This platform supports most of the open protocols for building automation systems sector such as LonWorks, BACnet, and Modbus.

2.5.2 Services That Could Be Provided By the Microgrid

Automatically connecting to and disconnecting from the grid

At all times in grid connected mode, the microgrid control scheme must maintain enough generation, to supply the critical microgrid loads. When an event occurs, the microgrid control system would initiate a sequence of operations to transition from grid-connected to islanded mode. This was described earlier in Section 0. Seamless transition during an unplanned event is not foreseen due to current interconnection rules governing DER operation. However, it is conceivable that a planned seamless transition can be achieved.

The formation of a microgrid generally proceeds as follows:

- Detect abnormal conditions
- Isolate microgrid from utility system
- Isolate uninterruptable microgrid from rest of microgrid
- Stabilize generation and uninterruptable loads
- Add loads and generation to core microgrid

Note: some steps may be performed in parallel.

The steps listed above are a combination of predetermined operating procedures and automated control actions. For example, during the planning stages, the load and generation that makes up the core or uninterruptable microgrid will be determined and the sectionalizing scheme that isolates the core microgrid will be established. When an abnormal condition is detected (or and isolation signal is given), relay operations will then automatically perform the topology reconfiguration. At the same time, generation controls must be sufficiently flexible to survive a disturbance that may be associated with the abnormal grid condition that requires the microgrid to go into islanded mode. Actions such as the addition of loads and generation to the core microgrid may be manual.

Automatic disconnection: At the points of interconnection, the microgrid will sense abnormal grid conditions such as loss of voltage (on all feeds) and automatically isolate from the larger utility system. Using the isolation switches (shown in Figure 2-2), the utility infrastructure will reconfigure to detach from the substation feed and to remove portions of the feeders that do not contain critical facilities. Further study will determine if the individual isolation points will determine the need to disconnect, or if a signal will be sent from the microgrid controller. To achieve the appropriate selectivity / sensitivity, a combination of direct detection of abnormal conditions and transfer trip will likely be used.

Automatic connection: The microgrid will also be capable of automatically reconnecting to the grid if desired. If automatic reconnection is desired, when the microgrid senses that the utility feed has returned to normal (generally for a period of time), the microgrid will sense the phase and magnitude of the voltage main utility interconnection point. Using either active or passive synchronization, the microgrid controller may close the breaker that ties the microgrid to the utility system. After the main microgrid core is reconnected to the utility system, the rest of the loads can be reconnected to the larger system.

At the time of reconnection, the net load to the system from the microgrid will be minimal. The microgrid can coordinate the return of the additional microgrid loads to normal status with the utility to avoid undue stress on the recovering grid. Depending on the final design of the microgrid, this return to normal may be a combination of automatic and manual operations.

Load shedding schemes

Load management is also integral in islanded mode and in the transition to islanded mode. During microgrid formation, load will likely be shed to allow seamless transition for the uninterruptable loads on the microgrid. Once the microgrid is established, controllable loads may be used in much the same was spinning reserve generation. The three largest facilities in the microgrid are slated to provide about 5% of their peak load as load curtailment resource during emergencies. The amount of load curtailment could be set at higher level (i.e., 10% of peak load for instance), but a conservative 5% level was selected since the two largest facilities are hospitals and hence subject to stricter critical load requirements.

Black start and load addition

During an unplanned event, the microgrid must be capable of black-starting or energizing without an existing power system. Many grid-forming generators can be used for black-starting. Once the generator has been started and the core microgrid formed, the formation of the microgrid may proceed normally.

The standby diesel generators located at St. Charles Hospital are good candidates for black start due to their close proximity to the bulk of the natural gas generation. As standby units, these generators are generally capable of operating without a grid connection (maintaining voltage and frequency); however, some upgrades to protection / control equipment may be necessary to allow connection to the larger grid. Additionally, the battery storage systems can be used for black start without the standby generators.

Once black start power is provided, natural gas and CCHP units located at John T. Mather and St. Charles Hospitals can come online and provide power to the larger microgrid. Finally, if the grid stability is sufficient, the PV units located at City Hall and the YMCA can connect to the grid.

While the microgrid has a large amount of storage proposed which can be used for black start, the location of the standby diesel generators at St. Charles Hospital make them better candidates for black start. Further, by alleviating the need to maintain the minimum charge that would be needed for black start from storage, the operation of the storage under normal conditions (in grid-connected mode) is simplified/more efficient.

Performing economic dispatch and load following

The Port Jefferson microgrid will provide load following during emergency periods utilizing the new CCHP units and reciprocating engine and existing backup generation if needed.

The economic dispatch of the microgrid plant during emergency periods will be performed by the microgrid controller and energy management system, based on the amount of generation needed to balance the time varying net load (i.e., load minus solar generation), and the microgrid generation unit efficiencies and constraints, fuel prices, and variable operations and maintenance (VOM) costs.

During normal/blue sky days, the CCHP units are expected to run as baseload, providing both electrical and thermal energy to the hospitals. The reciprocating engine will be dispatched based on the comparison if its marginal costs of operation and the price of electricity purchase from the larger grid. Other drivers include the structure of the electricity delivery charges (such as daily on-peak or monthly demand charges). It is plausible to assume that at some future point in time, a more complex decision process will determine the microgrid resource dispatch during normal days, more likely based on the relative economic costs of on-site generation versus purchase from the utility, or a future LMP+D pricing system being discussed by REV working groups, or even sales to the larger grid or NYISO, subject to applicable future REV framework. The trade-off between on-site generation and utility purchase is demonstrated in the DER-CAM modeling. Although simplified compared to actual operations, the DER-CAM model illustrates how utility purchases vary with time, and shows their dependency on relative energy costs of on-site generation versus utility purchases, and the influence of utility monthly and daily on-peak demand charges.

Demand response

The same load resources that are available for load curtailment are also available for demand response. The initial plan is to have at least 5% of the microgrid peak load be curtailable during a long-term emergency when the microgrid goes into islanded mode. However, the same load resources can be used as demand response during normal/blue sky days. The 5% of peak load of the combined facilities is about 206 kW, and should be available as demand response during normal days. The demand response resources can be utilized in various utility price-based or event-based demand response programs in the future, such as critical peak pricing (CPP) or critical peak rebates (CPR), or even as part of a portfolio of aggregated demand response resources under management of third party demand response providers who participate in the NYISO demand response and load management programs.

Storage optimization

The proposed Port Jefferson microgrid contains 550 kW of battery storage and 600 tons (455kW) of thermal storage. In grid connected mode the storage systems will be scheduled based on applicable electricity rates and prices subject to their operational limitations. The main value of storage systems will be to reduce the total cost of electricity consumption. They will accomplish this by charging during low price hours (usually during off-peak periods) and discharging during high price hours (usually during on-peak periods). Furthermore, more complex algorithms, such as those used in DER-CAM will be employed to time the discharge of the storage systems to minimize the applicable utility demand charges.

In fact, one of the earliest experiments in optimal scheduling of thermal heat and cool[3] and heat[4] storage was managed and performed (under funding by NYSERDA, EPRI, ESEERCo, NYSEG, and Con Edison) by one of the lead technical consultants on this project. The experiment involved remote control of heat and cool storage using a complex but fast algorithm that used projected need of commercial facilities in the experiment, and next day's hourly real time prices (RPT) and weather forecast, to set the thermal storage schedule on a 4 hour ahead basis.

In islanded mode, the storage will generally be optimized for fast frequency control and to support dispatch of other generation assets. Storage can minimize the variability due to PV, help conventional generation maintain minimum loading requirements, provide power while units are coming online, reduce the need for baseload generation such as the CCHP nits to respond to changes in load, and provide a variety of service that will greatly increase the flexibility of the microgrid assets.

Maintaining frequency and voltage

For the Port Jefferson microgrid, a large portion of the generation will be natural gas and storage. This will provide base-load generation, but it will also be used to manage fluctuations in load as well as variation in power output caused by solar. If additional control is needed, curtailable load may be used to help maintain the microgrid frequency, and PV generation may be curtailed or taken offline. The microgrid controller will assign the load-generation mix based on what is needed to satisfy the primary control objectives. The CCHP will be used primarily as base load generation.

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[3] "Automatic Control of Thermal Electric Storage (Cool) under Real-Time Pricing", NYERDA, 1994, Lead Author: Bahman Daryanian: https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB96195151.xhtml

[4] "Automatic Control of Thermal Electric Storage (Heat) under Real-Time Pricing", NYERDA, 1995, Lead Author: Bahman Daryanian: https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB96198023.xhtml

For reactive power/voltage control, all generators may be used. The microgrid controller will determine the appropriate control modes (voltage, pf control, VAR control, etc.) and set-points for the various microgrid assets.

PV observability and controllability; forecasting

PV production will be monitored by the microgrid controller and data will be communicated and stored so that it is available to microgrid operators and owners through a web interface. The controls and communications interface is shown in Figure 2-13. The total nameplate capacity of PV installations is 298 kW, less than 5% of peak load.

Given the size of PV relative to firm generation, forecasting is probably unnecessary. The load-generation balance and stable operation of the microgrid is planned without dependency on solar PV. The microgrid controller will monitor PV production and will 1) balance PV variability with fast-acting generation resources, 2) use load resources to offset variability, 3) if necessary, curtail PV production when it goes beyond a percentage of the online load.

Coordination of protection settings

When the microgrid is in islanded mode, some key protection functions will be under the purview of the microgrid controller. Where fault current is insufficient to ensure that secure, safe, dependable, reliable operation of protection systems (such as fuses), the Team may consider another layer of protection that predicated on transfer trip signals from the controller.

While the microgrid will contain some rotating machines, traditional protection schemes based on high fault currents may be inappropriate when in islanded mode due to the high penetration of inverter based generation and storage. While fuses are a low cost option for overcurrent protection, coordination the protection schemes between grid-connected and islanded mode may require relays capable of being switched between multiple modes or set-points.

In addition to Instantaneous/Timed Overcurrent protection (Functions 50P/50G/51P/51G), the microgrid protection scheme will employ some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

Selling energy and ancillary services

Subject to evolving NY REV framework, the NYISO market rules applicable to microgrids and distributed generation, and enabling technology (to allow back-feeding in the network), it is expected that the distributed generation within the Port Jefferson microgrid can sell energy into the larger grid though the Distribution System Platform (DSPP) model being developed within REV, but also participate in the NYISO energy, ancillary services, and capacity markets.

The details of qualifications for selling energy to the utility, and the requirements for NYISO participation are to be determined within the REV process and NYISO market design development. From a theoretical perspective, the on-site generation would sell energy at times when applicable Locational Marginal Price + Distribution Component (LMP + D) are higher than the marginal cost of on-site generation.

The ancillary services, including regulation up and down and spinning and non-spinning reserve can also be provided by the on-site generation subject to future market rules.

And finally, subject to qualification, on-site generation can participate in NYISO capacity auctions, and if they clear the market, they can be paid the applicable NYISO capacity prices.

Data logging features

According to the control architecture presented above, data logging is both local (at microgrid facility control nodes) and global (at microgrid master control station). These controllers, typically industrial PCs, record system data at regular intervals of time. A Human Machine Interface client for accessing data through a web interface exists at least at the master control station.

The data is stored in a round robin database that overwrites oldest values. The standard storage solutions (e.g. 1TB) are sufficient to store data for at least a full year. Depending on the devices that a facility control nodes regulates, such a node may be equipped with an event recorder that captures asynchronous events with high time resolution. This allows for fast, sub-second, data collecting and analysis.

2.5.3 Resiliency of Microgrid and Building Controls

The standard industrial-grade control and communication devices can withstand extreme operational temperature range of -40^{o} C to +70^{o} C. In addition, they are often enclosed in rugged aluminum chassis tested for shock and vibration according to military standards. Control boxes will also be elevated for flood avoidance.

2.6 IT/Telecommunications Infrastructure Characterization

2.6.1 Information Technology

Due to the lack of existing dedicated communication infrastructure (e.g. fiber optic network), for the microgrid communications backbone we are proposing a wireless field network as shown in the Figure 2-13.

The Microgrid Master Control Station is a hardened computer hosting monitoring, optimization and control services. It communicates to the utility wide area network through 3G/4G, WiMax, or 900 MHz communication links.

In addition, each microgrid facility is equipped with a Control Node, a hardened computer hosting local control applications with or without BEMS integration. At least the control node at the St. Charles and John T. Mather hospitals will integrate with the existing building management system. Communication with the master control station is achieved through 900 MHz or WiMax field network. The wireless communication links to the switchgear devices are not shown in the figure.

The communications network will provide at least 100 Mbit/s Ethernet which is expected to be sufficient for all monitoring and control applications and for the network of this size. The application-layer protocols will be selected among DNP3, Modbus TCP/IP, Modbus Serial, IEC61850, and Ethernet depending on MG deployed devices (e.g. IED's, PLC, switchgear, relay, sensors, meters, etc.).

2.6.2 Communications

When the lack of communication signals from the utility is set as an abnormal condition, the microgrid can isolate from the utility and thus operate when there is a loss in communications with the utility. From that moment the local generation and load devices are under the control of the microgrid controller.

If the utility communications network is considered external to the microgrid communications network, an interposing server will be utilized to provide for controlled information flow. Firewalls will be utilized between the microgrid network and the interposing server and between the external link and the interposing server to provide enhanced cyber security for this link.

The suggested communication infrastructure design assumes industrial-grade, long range, point-to-multipoint wireless communication with MIMO (Multiple-In, Multiple-Out) antennas that provide robust communications.

3 ASSESSMENT OF MICROGRID'S COMMERCIAL AND FINANCIAL FEASIBILITY

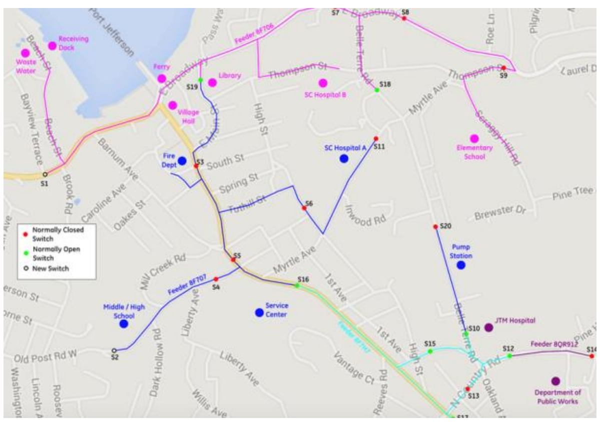
3.1 Commercial Viability – Customers

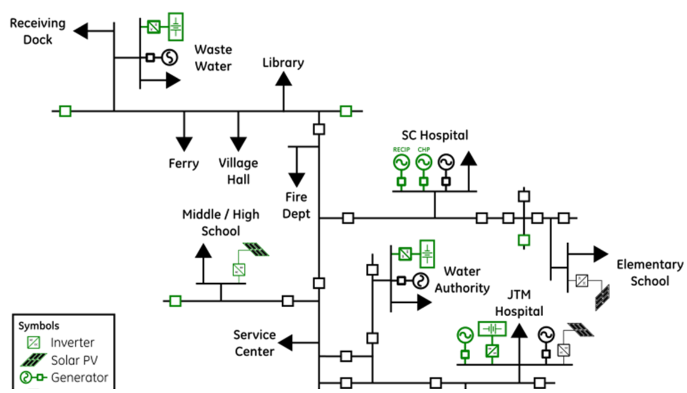
Project Overview

The Village of Port Jefferson is located on Port Jefferson Harbor, an inlet of the Long Island Sound, on the north shore of Long Island, about 65 miles east of New York City. The 2010 Census population was 7,750.

Port Jefferson has experienced widespread and extended power outages as a result of extreme weather events, including Hurricanes Sandy and Irene and other storms, and major bulk system outages such as the Northeastern Blackout in August 2003. These events resulted from disruptions to the main PSEG-LI grid, as well as from local distribution outages and resulted in significant economic loss, threats to life and safety, and disruptions to public and commercial services. St. Charles Hospital, with 231 beds, lost grid power for 10 days following Hurricane Irene, and had to move 18 ventilator-dependent patients to another unit in the hospital in the middle of the night due to a failure of a back-up generator. Mather Hospital, which has 248 beds, lost power for 47 hours following Hurricane Sandy; although Mather has a back-up generator, the back-up system cannot power diagnostic equipment, cooling or chilled water.

A map showing the critical facilities and microgrid circuit and a one-line diagram are shown below. (These are shown in greater detail in Section 2.1.1.)





As shown, the Project will serve 1,300 residences in downtown Port Jefferson. The total non-coincident microgrid load will be about 8.9 MW, which includes the critical facilities shown on the figure and about 3.5 MW of load from small commercial establishments and residences. The project will use portions of the existing above ground feeders to connect these facilities, and install a number of switches that will enable the microgrid to operate in island mode during outages to the main grid. The existing feeders will be hardened in areas where there is significant exposure to vegetation. Hardening measures could include aggressive tree trimming, tree removal, upgraded construction, use of spacer cable etc.

An optimized mix of DERs will provide energy for the microgrid and/or deliver power to the main grid, depending on operating conditions. The DERs include CCHP, electric only gas generation, solar PV, batteries, thermal storage, and existing back up diesel-powered generation.

Responses to specific questions contained in the SOW are presented below.

3.1.1 Individuals Affected By/Associated With Critical Loads

The population of Port Jefferson is approximately 7,500. In addition, the two hospitals in the microgrid have a combined total of more than 539 beds, 4,500 employees, and 65,000 ER cases and 21,000 inpatients admitted on average each year. The Suffolk County Water Authority (SCWA) facility produces and treats nearly 500 million gallons per year, and serves about 13,000 people, and the waste water treatment plant serves approximately 7,000 people.

The microgrid will primarily serve the downtown area of the Village, but will benefit the entire north central area of Long Island by ensuring that St. Charles and Mather hospitals and other commercial establishments can maintain service during outages to the PSEG-LI grid.

3.1.2 Direct/Paid Services Generated By Microgrid

The project assumes the electric generating plant will sell energy, capacity and ancillary services contractually to customers, and/or sell to the NYISO. However, we plan to explore PSEG-LI's interest in a power purchase agreement (PPA) for sale of energy, capacity and ancillary services produced by this facility.

The project will also improve reliability and resiliency of power supply in the Village of Port Jefferson, by reinforcing the downtown distribution system, and providing DERs to serve a number of critical facilities and other local establishments in the event of an outage to the main grid.

3.1.3 Customers Expected To Purchase Services

The microgrid will serve the following critical facilities in the Village of Port Jefferson:

- Department of Public Works
- St. Charles Hospital
- Spear Elementary School
- John T. Mather Hospital
- Suffolk County Water Authority
- Suffolk Sewer Department
- Port Jefferson Middle/High School
- Village Hall
- Port Jefferson Fire Department

In addition, the project will serve approximately 250 small commercial and approximately 1,300 residences in Port Jefferson Village during outages to the PSEG-LI grid.

3.1.4 Other Microgrid Stakeholders

In addition to the many thousands of year-round residents, local businesses as well as thousands of visitors and travelers each year who pass through Port Jefferson to use the ferry will benefit by increased area power reliability and resilience in the event of a protracted grid failure. In addition, thousands of residents outside of Port Jefferson will benefit from maintaining services of Mather and St. Charles hospitals during grid outages; and as stated previously, these hospitals are two of the main hospitals in north central Long Island.

We do not anticipate that customers will experience any negative impacts as a result of the project.

3.1.5 Relationship between Microgrid Owner and Customers

Subject to approval of the stakeholders, the project will be owned by a Microgrid Energy Services Company (MESCO), which is a type of ESCO that serves microgrids. The MESCO will supply energy to the microgrid customers during normal operating conditions and during grid outages. PSEG-LI will continue to own and operate the distribution system. Specific relationships for the various DERs are expected to be as described below:

Normal Conditions

- The CCHP systems will be “behind the meter” and deliver electric and thermal energy to Mather and St. Charles hospitals
- The High and Middle schools will net meter energy from the new solar PV system, and pay a portion of the savings to the MESCO
- SCWA will draw energy from the batteries to reduce peak loads, and pay a fee to the MESCO
- The electric only plant will sell energy, capacity and ancillary services contractually to microgrid customers, and/or to the NYISO

Grid Outages

- The MESCO will sell power produced by the DERs to the microgrid customers at normal energy rates
- The hospitals will have priority on energy used by the microgrid

3.1.6 Customers during Normal Operation vs. Island Operation

Please see response to Question 3.1.5. The electric only plant will offer to sell energy to all microgrid customers (except the hospitals, which will be supplied by the CCHP facilities) during normal conditions. The energy from the electric generating plant would be sold contractually to microgrid customers, and delivered using the PSEG-LI distribution system. The customers would pay standard delivery and demand and other fees to PSEG-LI, and pay the MESCO for the energy. However, the customers would have the option to purchase energy from the MESCO or another ESCO, or continue purchasing from PSEG-LI. If the customers do not elect to purchase energy from the MESCO, the MESCO would sell energy to other customers, or to the NYISO.

During islanded operation, the MESCO will sell power produced by the DERs to the microgrid customers at normal energy rates.

3.1.7 Planned or Executed Contractual Agreements

Please see response to question 3.1.5. The following contracts or agreements are expected:

- It is anticipated that the MESCO will have a long-term agreement with St. Charles and Mather Hospitals to sell electric and thermal energy from the CCHP systems.
- The MESCO will have a Microgrid Energy Services Agreement (MESA) with the Port Jefferson district under which the school will net meter solar energy, and pay the MESCO a fee for a portion of its savings

- The MESCO will have a contract with SCWA for sale of energy from the battery during peak periods
- The MESCO will obtain MESA's with microgrid customers to sell energy from the electric only plant to microgrid customers, or customers outside of Port Jefferson village, using an Internal Bilateral Transaction structure. The MESCO will sell any excess energy, capacity or ancillary services to the NYISO.
- Alternatively, the MESCO will explore establishing a PPA to sell energy and capacity with PSEG-LI. The PPA would contain provisions that would allow the plant to serve the microgrid in the event of an outage to the main grid.
- The MESCO will have a MESA with PSEG-LI to supply power to the microgrid customers during outages to the main grid. The hospitals will have priority on energy delivered to the microgrid during outages on the main grid.

3.1.8 Plan to Solicit and Register Customers

The Team has maintained an ongoing dialogue with Village officials and the hospitals to obtain their input on the key microgrid features. We expect to continue to obtain and incorporate this input into our design, as appropriate. The Team will engage in direct negotiations with the hospitals to develop a mutually agreeable terms for sale of electric and thermal energy.

The MESCO plans to directly approach commercial customers within the microgrid service area that may have an interest in purchasing energy from the electric generating plant. We believe these customers may be interested in purchasing energy from the electric plant, because MESCO could reduce their energy costs. Alternatively, we may partner with an established ESCO to assist in marketing energy, or partner with an energy company, that would help market energy from this facility.

As explained in Question 3.1.7, the MESCO will also approach PSEG-LI regarding the possibility of a long-term PPA for energy and capacity from the electric only plant. However, completion of the electric only generation is not dependent on securing a PPA with PSEG-LI, since this plant could generate adequate revenue from sale to the commercial customers if a PPA cannot be obtained with PSEG-LI.

3.1.9 Other Energy Commodities

Microgrid energy commodities will be predominantly electric but the CCHP system's thermal energy would also be sold to the hospitals.

3.2 Commercial Viability - Value Proposition

3.2.1 Benefits and Costs Realized By Community

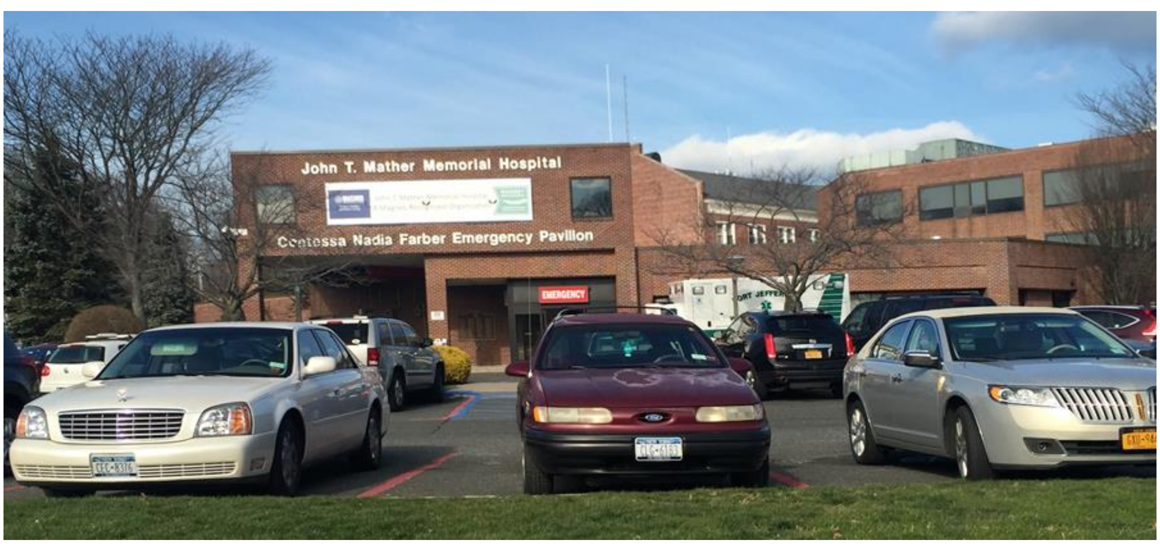
Improved Reliability and Resiliency

Critical and Non-Critical Facilities

The project will improve the reliability and resiliency of power supply for critical facilities connected to the microgrid, as well as other commercial establishments and residences in downtown Port Jefferson. A list of the critical facilities appears in the Task 1 section of the report. As shown earlier in Figure 2-1, the microgrid will include the critical facilities listed in Task 1 (Table 1-1), as well as many commercial establishments and residences in downtown Port Jefferson, including a gas station, grocery store, drug store, and restaurants, among others. Port Jefferson's 7,700 residents rely on these downtown commercial establishments. In addition, thousands of residents in north central Long Island rely on services of Mather and St. Charles hospitals.

The proposed DERs will assure that all of these facilities and establishments will have full power to meet coincident peak demand to operate at full capability during outages to the main grid.

St. Charles and Mather Hospitals



St. Charles Hospital, with 231 beds, lost power for 10 days following Hurricane Irene, and had to move 18 ventilator-dependent patients to another unit in the hospital in the middle of the night due to a failure of a back-up generator. Mather Hospital, which has 248 beds, lost power from the grid for 47 hours following Hurricane Sandy. The project will assure that full power is supplied to these facilities in the event of an outage.

In addition, the overall community and surrounding areas would benefit from the services that the hospitals and other critical facilities could maintain during any disruptions to the main grid. For example, Mather Hospital serves more than 12,000 inpatients annually and more than 43,000 emergency room cases each year. It also provides more than 18,000 diagnostic breast health screenings each year, and employs over 2,500 people. St. Charles Hospital performs nearly 6,000 ambulatory procedures, has over 1,500 babies born, and has over 22,000 emergency visits, each year. St. Charles has over 1,700 employees, including a medical staff of 734.

Although these hospitals have back up, diesel-powered generators, the backup generators cannot provide power for diagnostic equipment, or provide cooling or chilled water, and fuel storage is limited to five days. (It is not economically feasible to convert the backup generators to use natural gas. Also, supplies of pipeline natural gas are limited.)

Suffolk County Water Authority (SCWA)

The microgrid would also improve reliability of the Suffolk County Water Supply Authority (SCWA) water supply and treatment facility located on Belle Terre Road, near Mather and St. Charles Hospitals. The facility is the primary water supply source for Mather and St. Charles Hospitals, and the Village of Port Jefferson.

The water supply system has three wells with a combined production capacity of 3,185 gallons per minute, and provides water quality monitoring and treatment. The facility produced and treated nearly 500 million gallons of water in 2011, and serves over 13,000 people. The facility has a peak electric load of 311 kW, and a load factor of about 24%. The facility intermittently utilizes pumps to fill its storage tank, which is then discharged. This intermittent pumping presents an opportunity to utilize batteries to reduce the peak demand charges, lower peak energy use in the load pocket, and reduce costs. The battery will also help provide stability for the microgrid during outages to the main grid. The project includes a 300 kW battery located at the SCWA facility.

SCWA is installing a new 500 kW back up diesel generator, but will only maintain two days of diesel fuel supply. Thus, connection of the SCWA facility to the microgrid will help assure that the water supply can be maintained for more than two days if diesel supplies are interrupted.

Transportation Hub

Port Jefferson, which is located about 60 miles east of New York City, is also the key transportation hub and evacuation route on the north shore of Long Island. Port Jefferson features a major ferry route to Bridgeport Connecticut, a Long Island Railroad terminus that connects to Penn Station in NYC, multiple bus lines, and an extensive network of roads.

The Bridgeport & Port Jefferson Ferry is one of two routes connecting Long Island to New England. The microgrid would provide backup power for the ferry terminal. (The other route is the Cross Sound Ferry at Orient Point; about 60 miles to the east, and no bridges or tunnels exist despite past proposals.) The Port Jefferson ferry can accommodate 85 vehicles per voyage, and has 16 departures each day.

The village additionally serves as the eastern terminus for the Long Island Railroad's Port Jefferson Branch, and connects with Pennsylvania Station in Manhattan or to Atlantic Terminal in Brooklyn.

Port Jefferson's Main Street forms a section of New York State Route 25A, a scenic and historic route through Long Island's North Shore that is locally known as North Country Road and continues westward to New York City. The microgrid will provide power for the northern stretch of Main Street. Also near the village is New York State Route 347, a larger highway that connects to Northern State Parkway.

Reduced Energy Costs

The project is expected to reduce energy costs for the hospitals and other facilities that purchase energy from the MESCO.

Use of the behind the meter CCHP system would allow St. Charles and Mather Hospitals to reduce or possibly eliminate PSEG-LI demand and delivery charges. The electric tariff demand charges are approximately $22 per kW from June through September, and delivery charges range from $0.0287-$0.0428 per kWh, depending on the time of day. The average PSEG-LI energy price in 2015 was $81.19 per MWH. The CCHP facilities would operate over 95% of the time. CCHP units would benefit a “high load factor” gas delivery rate, which would reduce the gas delivery charges for the CCHP system, in comparison to the existing gas tariff.

Taken together, the CCHP system would significantly reduce electric energy and delivery costs for the hospitals, and reduce if not eliminate peak demand charges. In addition, since the hospitals would utilize waste heat from the CCHP system, it would reduce fuel use and emissions. We estimate that the CCHP systems at St. Charles and Mather Hospitals would reduce gas use by approximately 135,000 MMBtu per year, and save approximately $1.1 million per year in fuel costs.

The project could also reduce energy costs for other critical facilities and commercial and residential establishments by supplying energy from the DERs, rather than energy supplied by PSEG-LI or other ESCOs. (Customers that do not have behind the meter DERs would still have to pay the PSEG-LI delivery and demand charges and other fixed charges.)

Natural Gas Supply

National Grid has indicated that it can provide an additional 15 MMBtu per hour of gas to St. Charles and Mather Hospitals, which could produce approximately 1,600kW of power at each hospital. This capacity will be needed to meet the peak hospital loads (after installing a new absorption chiller and thermal storage units). National Grid could supply this pipeline gas beginning in November 2019. National Grid will need to perform additional engineering studies to confirm locations where it could provide adequate gas supply for the electric only generation facility. However, it is likely that gas could be supplied at a site near the WWTP, which is near the existing Port Jefferson gas fueled power plants that are owned by National Grid.

Project Costs

It is expected that the DERs and energy efficiency measures will be funded by a third party investor and NYSERDA grants. This structure will eliminate the need for investment by the owners of critical facilities or the local community.

3.2.2 Benefits to the Utility

PSEG-LI would benefit in several ways. First, the project would reduce electric congestion in the Port Jefferson area that often occurs on hot summer days. For example, the NY Times reported on August 14, 2014 that there are often significant congestion issues in the Port Jefferson area during the summer. Please see the following link: http://www.nytimes.com/2014/08/15/business/energy-environment/traders-profit-as-power-grid-is-overworked.html?_r=0.

According to PSEG-LI, the hospitals are supplied from overhead feeders from a 13 kV distribution line from the Port Jefferson substation. The area was affected by flooding during Sandy. Therefore, additional distributed generation in Port Jefferson would help assure that power can be supplied due to limitations or disruptions in the existing generation or distribution systems, thus benefitting PSEG-LI's customers.

As a result of these benefits, PSEG-LI should be able to defer or avoid construction of new transmission or distribution capacity that would otherwise be needed to ensure reliable energy supply for this area.

The project will provide a more reliable and resilient microgrid that will help assure power for critical facilities when the main grid is out of service, and mitigate outages on the local distribution system.

3.2.3 Proposed Business Model

Subject to approval of project stakeholders, the Team anticipates that new DERs will be financed, owned and operated by a third party "Microgrid Energy Services Company" (MESCO). This arrangement would allow the critical facilities to focus on their core businesses, while reducing their energy costs and providing a more reliable and resilient grid.

The MESCO would sell energy from behind-the-meter DERs directly to the critical facility hosts. The MESCO would also supply other critical facilities and commercial and residential establishments with electric energy, either using excess energy from the behind the meter DERs, or from energy from the 2.0 MW electric-only generating facility. PSEG-LI would continue to own and operate the transmission and distribution systems.

This structure would allow critical facilities that host DERs to save money by reducing or possibly eliminating energy, delivery charges, and demand charges. This arrangement would also allow customers who do not host DERs to reduce their energy charges, but they would continue to pay standard charges for delivery and demand.

One issue that should be addressed is whether the MESCO's customers who do not host DERs should be obligated to continue paying demand charges and Transmission Service Charges (TSC) to PSEG-LI. Since the MESCO would be financing the additional generation capacity for the microgrid, and the microgrid would not utilize the transmission system, it would appear that these customers should not be obligated to pay demand or full TSC charges to PSEG-LI.

- Strengths
    - The project will provide more reliable and lower cost energy for the hospital and other customers
    - MESCO has expertise and resources to finance and manage the project

- The MESCO and/or investors can directly utilize Investment Tax Credits from the new solar PV system, whereas the schools are non-profits and could not directly utilize these incentives
- More efficient gas fired CCHP and electric generation would reduce emissions in comparison to more centralized and less efficient generation systems; in particular, PSEG-LI would be less reliant on generation from liquid fueled peaking plants in Holtsville (about 13 miles to the south), where there is a 450 MW kerosene-fueled peaking plant

- Weaknesses
  - The hospitals (and other stakeholders) would be more reliant on a third party to supply its energy than in the past; (this concern could be mitigated since the facilities would continue to be connected to the PSEG-LI grid, which could serve as source of backup power if needed.)
  - Customers would need to make a long-term commitment to purchase power from the MESCO in order to facilitate financing. (This concern would be mitigated by lower energy costs, and greater reliability)
  - The hospitals may be required to guarantee lease or other financing for the CCHP system, and may be reluctant to do so.
  - The MESCO may be subject to property taxes on the DERs, which would increase energy costs; (if the DERs were owned by a non-profit, they would be exempt from property taxes.)
- Opportunities
  - Management personnel at the hospitals can continue to focus on their core businesses, while benefiting from the CCHP system
  - PSEG-LI could focus its resources on other areas of concern, and avoid the need to invest in new generation or distribution in the Port Jefferson load pocket
- Threats
  - Project lenders and investors may be reluctant to finance the project due to concern over credit quality of the project participants, or concern over technical and operational issues with the microgrid; (these concerns could be mitigated by NYSERDA grants and innovative funding sources, such as the Green Bank, grants and tax incentives).
  - Existing PSEG-LI policy does not allow two feeders for facilities utilizing behind the meter CCHP; however, the hospitals require two feeders to assure redundancy. (Based on meeting with PSEG-LI, it appears we can address PSEG-LI's concern by designing the interconnect to include appropriate equipment and measures to prevent back-feeding.)

3.2.4 Unique Characteristics of Site or Technology

The project is unique and innovative in several ways, including:

- Electric Storage
- Thermal Storage
- Microgrid Controller

As explained further below, these technologies and strategies could also be used at other microgrid projects.

Energy Storage

The project will include a 250 kW battery at the Waste Water Treatment Plant and a 300 kW battery at the Water Authority. It is expected that the batteries will recharge at night when energy demand and charges are low, and discharge during the day when energy and demand charges are high. The batteries will have a discharge duration of four hours.

The batteries will help reduce peak loads due to pumping at the WWTP and the water supply facility. This will reduce the Village's peak energy demand, and reduce PSEG-LI's projected peak power deficit.

Thermal Storage

The project will also include 600 tons of thermal energy storage provided by Trane at Mather Hospital that will reduce peak demand at the hospital by 455 kW, or nearly 25%. The system will create ice at night that will be used for cooling during the day. This system will reduce both energy and peak demand charges for the hospital, and reduce peak demand on the main grid. The project cost will be approximately $2.6 million, and PSEG-LI will provide a grant for 70% of the project cost. Trane estimates that the payback period will be 2.4 years

Microgrid Controls

The Team is evaluating the current set of available commercial microgrid controllers. A best of breed selection will be made to obtain alignment with the microgrid site requirements. The controller will include monitoring and control functions to monitor voltage, frequency and line flows at multiple POIs and quickly issue commands to load and generation in the microgrid to initiate islanded mode.

3.2.5 Replicability and Scalability

All elements of the proposed project could be utilized at other microgrids that have a similar design basis. Some specific features that should be replicable at many locations are described below:

- The ESCO contract structure could be used at other microgrids to fully utilize output from DERs to reduce energy costs
- Batteries could be used to help provide stability and regulate frequency for microgrids in other locations; also, batteries could help reduce peak load and demand charges at facilities that have "spikey" load profiles.
- Thermal storage could be used to help reduce peak demand and costs at facilities with large summer cooling loads.
- Sale of excess energy, capacity and ancillary services from DERs to the NYISO could produce additional revenue sources that could make microgrids more economically viable.
- The proposed project financing business model involving third party ownership and non-recourse financing could be used for other microgrid projects. This structure would require that contracts and credit quality of all counterparties satisfy project lenders and investors.
- Across Long Island, there are many similar communities that were affected by recent major events. These communities share common system designs, load demographics, and usage patterns. This project allows the utility and stakeholders to identify and deploy designs, technologies, and operating rules that would allow enable replication in other communities.
- Outside of the current microgrid footprint, there are several other critical loads that were in the original proposal but were subsequently removed either due to infrastructure concerns or lack

of generation. A longer-term vision could scale the microgrid to serve more of the community, providing resiliency and energy surety to a wider base in Port Jefferson.

3.2.6 Purpose and Need for Project

PSEG-LI has identified Port Jefferson as one of eight areas on LI that should be considered for a microgrid.

Port Jefferson has experienced widespread and extended power outages as a result of extreme weather events, including hurricanes Sandy and Irene and other storms, and major bulk system outages such as the Northeastern Blackout in August 2003. These events resulted from disruptions to the main PSEG-LI grid, as well as from local distribution outages and resulted in significant economic loss, threats to life and safety, and disruptions to public and commercial services.

Port Jefferson has a number of critical facilities, and is a key transportation hub on the north shore of Long Island. Critical facilities that will be served by the microgrid include two large regional hospitals, a major water supply facility, a wastewater treatment plant, schools, government buildings and other facilities, as well as key parts of downtown Port Jefferson.

St. Charles Hospital, with 231 beds, lost power for 10 days following Hurricane Irene, and had to move 18 ventilator-dependent patients to another unit in the hospital in the middle of the night due to a failure of a back-up generator. Mather Hospital, which has 248 beds, lost power for 47 hours following Hurricane Sandy; although Mather has a back-up generator, the back-up system cannot power diagnostic equipment, or provide cooling or chilled water.

The microgrid will utilize a mix of DERs that will produce distributed energy, and reduce load. The electric power will be distributed using existing above ground feeders that will continue to be owned and operated by PSEG-LI. The feeders will be hardened in areas where there is a risk of exposure to vegetation/tree damage to ensure the functioning of the microgrid during and following storm events. Potential hardening measures include: stronger poles and cross-arms; compact construction; use of tree wire and spacer cable; more aggressive tree-trimming; removal of danger and hazard trees. These hardening measures will be coordinated with ongoing PSEG-LI storm hardening programs, initiated after recent storms.

During outages to the main grid, the existing back up diesel-powered generators would supply up to 85% of the hospitals peak load, and the new CCHP units would supply the remaining hospital load and the microgrid.

3.2.7 Overall Value Proposition to Customers and Stakeholders

Table 3-1 Project Value Proposition

Stakeholder	Value Proposition
Port Jefferson Hospital	• Reduce electric energy costs • Reduce or eliminate peak demand charges; currently at $22/kW from June-Sep; • Reduce fuel use for heating by combined total of 135,000 MMBtu per year, and reduce fuel cost, • Provide more reliable energy supply • No capital investment
Other critical and non-critical facilities	• Reduce electric energy charges • Possibly reduce or eliminate demand charges • Continued power supply during outages to the main grid will assure these facilities can maintain services for customers and the community • Commercial establishments will continue to earn revenue from their business operations during power outages to the main grid • During normal operating conditions, the batteries and thermal storage systems will reduce or eliminate peak demand charges for water supply and waste water treatment plants, and for Mather Hospital
Village of Port Jefferson	• Residents and customers will benefit from services provided by critical and non-critical facilities
PSEG-LI	• Project will help reduce need for peaking power and reduce congestion in the load pocket • Project will help assure power is maintained for PSEG-LI customers during outages to the main grid
National Grid	• CCHP system will provide two significant new customers for National Grid, with a high load factor demand profiles
Suffolk County Residents	• Residents will continue to benefit from services of St. Charles and Mather Hospitals during outages to the main grid
Long Island Residents	• Project will maintain the Port Jefferson as a key transportation hub during outages to the main grid
Environment	• Project will reduce air emissions by using more efficient CCHP technology to supply both electric and thermal energy.
NY State	• Project would represent an innovative and financially viable microgrid and business model that could be replicated in other areas
Project investors, developers and lenders	• Will receive positive returns on investment, commensurate with project risk • Private investors and lenders will gain experience with an advanced microgrid that could enable similar future investments
Vendors and contractors	• Will generate new business by providing equipment and services • Will gain valuable experience in cutting edge project that could be applied to future microgrid projects

3.2.8 Added Revenue Streams, Savings, and/or Costs

Table 3-2 Revenue Streams, Savings, and/or Costs

Purchaser	Revenue/savings
St. Charles and Mather Hospitals	• Reduction in electric energy costs • Reduction or elimination of peak demand charges • Reduction of fuel costs
Other microgrid customers	• Reduction in electric energy costs • Reduction or elimination of peak demand charges • Reduction of fuel costs
SCWA and Publicly Owned Treatment Works (POTW)	• These facilities would reduce peak demand charges by using batteries to shave peak loads; they would have to pay a service fee for use of the batteries that would be less than the peak demand charges

3.2.9 Project Promotion of State Policy Objectives

The project helps promote NY REV by providing distributed and renewable energy that will improve system reliability and resiliency and reduce costs and emissions. The project will also reduce peak energy demand by use of thermal storage and batteries. A summary of benefits relating to the NY REV goals is presented below:

Table 3-3 Project Support of NY REV/RPS

Metric	Result Supporting NY REV/RPS
Distributed generation	Project will provide 5,950 kW of new DERs, including 1,600 kW of CCHP each at Mather and St. Charles Hospitals, and 2,000 kW of electric only generation
Renewable generation	298 kW (4.9%) of generation will come from existing or new solar PV, including 200 kW of new solar PV at Port Jefferson High School
Peak demand	Reduction of 1,285 kW of peak demand from installation of absorption chiller, thermal storage, and batteries, or about 17% or peak microgrid load
GHG reduction	GHG resulting from CCHP and other DERs

3.2.10 Project Promotion of New Technology

The project involves use of several emerging technologies, including batteries, thermal storage and absorption chillers, that combined would reduce peak microgrid load by approximately 17%, or 1,285kW. These technologies would also substantially reduce peak demand charges. Successful implementation of these technologies will encourage their use at other locations.

The project will also include innovative control systems to assure that DERs maintain a balance between supply and demand is maintained in the island, and that the transition between connected and islanded modes is stable and secure. The project will also include a protection scheme that employs some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)

- Transfer Trip
- Anti-islanding

The microgrid control system could also offer a suite of ancillary and distribution grid support services, as well as the ability to interact with the NYISO market.

Subject to evolving NY REV framework, the NYISO market rules applicable to microgrids and distributed generation, and enabling technology (to allow back-feeding in the network), it is expected that the distributed generation within the Port Jefferson microgrid can sell energy into the larger grid though the Distribution System Platform (DSPP) model being developed within REV, but also participate in the NYISO energy, ancillary services, and capacity markets.

The details of qualifications for selling energy to the utility, and the requirements for NYISO participation are to be determined within the REV process and NYISO market design development. From a theoretical perspective, the on-site generation would sell energy at times when applicable Locational Marginal Price + Distribution Component (LMP + D) are higher than the marginal cost of on-site generation.

The ancillary services, including regulation up and down and spinning and non-spinning reserve can also be provided by the on-site generation subject to future market rules.

And finally, subject to qualification, on-site generation can participate in NYISO capacity auctions, and if they clear the market, they can be paid the applicable NYISO capacity prices.

3.3 Commercial Viability - Project Team

3.3.1 Securing Support from Local Partners

The project has received letters of support from the following groups:

- Mayor of Port Jefferson
- St. Charles Hospital
- Mather Hospital
- Port Jefferson Fire Department
- PSEG-LI
- National Grid

We have continued to update the Mayor, the hospitals and other key stakeholders on development activities. The mayor has expressed strong support for the project. We will need to obtain final formal approval for St. Charles and Mather hospitals prior to finalizing the CCHP plans; however, we expect to receive strong support in light of the benefits the project will provide to the hospitals.

3.3.2 Role of Each Team Member in Project Development

A summary of key roles and responsibilities is presented below:

Table 3-4 Summary of Key Team Member Roles

Team Member	Role
St. Charles and Mather Hospitals	Hosts of CCHP systems, and customers for purchase of electric and thermal energy; Mather also has an existing 50kW solar PV system; the hospitals also have existing diesel fueled backup generators that will be part of the microgrid.
PSEG-LI	Owner/operator of electric distribution system
National Grid	Supplier of pipeline gas for CCHP systems
SCWA, Port Jefferson High School, Spear Elementary School	Hosts of DERs and participants in the microgrid
Vendors and contractors	To be determined; will provide DER equipment and construct the project
GE Energy Consulting, Burns Engineering, D&B Engineers	Project engineering and design services
Project investor and lender	To be determined; will provide project financing
Global Common, LLC	Project developer, principal of Microgrid Energy Services Company (MESCO)

3.3.3 Public/Private Partnerships

We expect that the MESCO will have contracts with the Village of Port Jefferson relating to purchase and sale of energy produced by the DERs for village buildings, such as Village Hall and the DPW. In addition, the project will require NY Prize funding from NYSERDA. Based upon the exploratory work during the feasibility study, the Project Team recommends expects that both private and public funding will be needed to make this project economical, since project returns would not be adequate to attract private financing without adequate government subsidies.

3.3.4 Letter of Commitment from Utility

The project has letters of commitment from National Grid, the gas utility, and PSEG-LI. Also, National Grid has performed engineering analysis and provided written confirmation that it can supply 15 MMBtu per hour to St. Charles and Mather Hospitals for the CCHP systems by 2019. We have also met with PSEG-LI to explain the microgrid program and PSEG-LI's role. PSEG-LI has indicated that it will be necessary to design the CCHP systems in a way that ensures that there will be no risk of back-feeding onto the PSEG-LI grid as a result of operation of the CCHP systems. PSEG-LI and the PSC have previously designated Port Jefferson as one of only a few prospective areas on LI for a microgrid demonstration project.

3.3.5 Applicant Financial Strength

The project will be owned by private investors who will provide non-recourse financing for a Microgrid Energy Services Company (MESCO) that will manage and operate the project. The investors will have adequate financial resources or the MESCO will provide acceptable financial security to satisfy NYSERDA and project lenders and investors.

The project financing will be structured using traditional non-recourse project financing, with a capital structure that will include an appropriate level of equity, debt, and grant funding. Alternatively, the project may rely on lease financing. We have extensive experience financing energy projects with various structures. We have identified some potential investors, and will select the preferred investment partner during Stage 2. Subject to final approval from the Village of Port Jefferson, it is expected that Global Common, LLC will be the applicant for Stage 2 and Stage 3 NYSERDA funding.

3.3.6 Project Team Qualifications and Performance

A summary of qualifications is presented below, and detailed qualifications and performance records are presented in the appendices. As shown, the current project team has the capability to design and develop the microgrid and DERs, and arrange project financing. We will add other team members, including an EPC contractor, project investors and lenders, during Stage 2 design.

Table 3-5 Summary of Project Team Qualifications and Performance

Team Member	Qualifications
GE Energy Consulting	Extensive experience in design of microgrids, including distribution and microgrid control systems, and design of DERs; GE can also provide DER technologies, and advanced microgrid controllers.
Burns Engineering	Design and implementation of microgrids, including DERs.
D&B Engineers and Architects	Environmental/civil and electrical engineering
Global Common, LLC	Project development and financing, including negotiation of power purchase agreements (PPA's), fuel supply contracts, EPC contracts, environmental permitting, and financial analyses and project structuring to satisfy lenders and investors.
PSEG-LI	Management and operations of electric distribution systems
Vendors and contractors	To be determined
Project investor and lender	To be determined
DER Operator	To be determined

3.3.7 Contractors and Suppliers

Please see response to prior question. The existing and future contractors are and will be subcontractors to the applicant. The contractors, equipment suppliers and other vendors will be selected during Stage 2 based on competitive procurement or other appropriate procedures, subject to approval of project lenders, investors, and NYSERDA.

The MESCO will be formed prior to closing on project financing.

The MESCO will retain an experienced Engineering, Procurement and Construction (EPC) contractor experienced with significant energy projects, and the financial capacity to guarantee performance and satisfy the project lender, investor and NYDERDA. For example, we will consider firms such as Conti Construction, Burns & McDonnell, and Schneider Electric as possible EPC contractors.

3.3.8 Financiers or Investors

The project finance lenders and investors have not been identified and will be selected during Stage 2. We may engage an investment banker, such as Stern Brothers, to assist in securing financing, or may select lenders/investors without outside advisors based on our prior relationships and evaluation of proposed financing terms. The investors will have adequate financial resources to complete the project and provide needed working capital for operations, and have experience investing in energy projects. For example, we will consider financing from GE Capital as a project investor, and we may engage Stern Brothers to provide investment banking services. We may also consider strategic investors, such as our selected EPC contractor, or GE Capital. The specific financing strategy will be developed during Stage 2.

We will consider cost of capital, and experience with energy projects, among other criteria. The current team members may contribute professional services, but it is not expected that the current team members will contribute cash.

3.3.9 Legal and Regulatory Advisors

There are no legal advisors on the current project team at the present time. We will retain an experienced project finance attorney during later stages of Stage 2 to assure that project documentation satisfies lenders and investors, and to assist in closing on project financing. The project attorney will have extensive experience with project financing of energy projects. GC has worked extensively with Andrews Kurth on other energy projects, and may consider using their services on this project. Andrews Kurth is a nationally recognized firm in the energy project finance area. We will also engage Twomey Latham as local counsel to assist with local regulatory and environmental matters. Twomey Latham is based in Riverhead, and has extensive experience with energy and environmental issues on Long Island. It is expected that D&B Engineers will provide environmental consulting and permitting services. D&B is based in Melville, Long Island, and has extensive experience with environmental permitting on Long Island.

3.4 Commercial Viability - Creating and Delivering Value

3.4.1 Selection of Microgrid Technologies

The DERs were chosen based on a number of factors. We started overall system optimizations and initial asset selection, sizing, and configuration by using Lawrence Berkeley's Lab microgrid optimization tool, "DER-CAM". This tool takes a wide range of detailed inputs regarding DER assets, site loads, participant tariffs, site location weather, energy prices, and environmental parameters to optimize the selection and operation of DERs in the microgrid.

DER selections were further refined by considering the specific types of loads, available space, detailed asset performance characteristics and limitations given their intended function (e.g., base or peak generation) in the microgrid. Due to the significant electric and thermal base load of the hospitals, cogeneration was an appropriate technology to deliver electricity and hot water. Approximately 100 kW of existing solar PV will also be incorporated.

The CHP units will significantly reduce both electric and fuel costs. The batteries will help reduce peak demand for the water and waste water treatment facilities, and help stabilize the microgrid when the main grid is out of service. The solar PV systems will help reduce GHG emissions and help meet peak power demand.

We decided to use batteries because the water storage facility has a “spikey” load profile due to intermittent pumping operations. In addition, the batteries will help balance supply and demand when the microgrid operates in island mode.

We selected solar PV to help reduce the demand for peak energy.

In this stage, the control design focused more on functionalities and architecture than equipment or vendor specifications. Controller functionalities were chosen based on the technologies and needs of the project, and features of commercially available products from a range of vendors, including GE. These include the ability to monitor multiple POIs, fast load-shedding, and economic optimization. The ability to integrate BEMS into the control architecture and communicate with external utility systems is also highly valued.

3.4.2 Assets Owned By Applicant and/or Microgrid Owner

The project will include the following existing DERs

- 1,000 kW back up diesel at Mather Hospital
- 50kW solar PV at Mather Hospital
- 1,800 back up diesel at St. Charles
- 100 kW of back up diesel at the SCWA water supply facility
- 250 kW at the waste water treatment plant
- 48 kW of solar PV at Spear Elementary School

3.4.3 Generation/Load Balance

Once a utility outage is detected through voltage and frequency monitoring, the microgrid will island. The hospitals’ site emergency generators will come online to comply with code mandated starting times, with the microgrid paralleling to the site emergency distribution system. Upon formation of the microgrid, the emergency generators will ramp down and/or turn off based on demand.

The specific demands for power matching/frequency regulation will be determined through study during Stage 2. The microgrid controller will manage assets in response to changing conditions. In connected mode (parallel to the grid), microgrid generation resources would not be required to regulate frequency, and would likely have a small role if any in voltage regulation. These services are provided by the bulk power system. However, in islanded mode, microgrid resources will need to provide for power balance/frequency control and reactive power balance/voltage control.

For the Port Jefferson microgrid, some assets will provide base load power while other assets would switch to frequency control mode. There are a number of diesel generators at St. Charles Hospital, John T. Mather Hospital and elsewhere, which are excellent for black start and load-following applications. The CHP units at St. Charles and Mather Hospitals are the better suited to base load operation than frequency control. This means the majority of fast frequency regulation would come from one or more of the large diesel generators in isochronous mode, and the 550 KW of battery storage at the Waste Water Treatment Plant and the Water Authority. To augment frequency regulation, load may need to be controlled, particularly at the two Hospitals (the largest loads). The 455 kW of thermal storage at Mather presents a controllable to the system that can be leveraged for stable operation. Additionally, it may be necessary for solar production to be curtailed. This will also be managed by the controller.

3.4.4 Permits and/or Special Permissions

The project team expects to obtain typical construction permits as well as an air permit for the CCHP and electric only generation systems. It would also be necessary to obtain an interconnection agreement with PSEG-LI based on standard interconnection requirements. In addition, it will be necessary to get Site Plan approval from the Town and/or Village of Port Jefferson to install the DERs.

3.4.5 Approach for Developing, Constructing and Operating

Global Commons will be the project developer, and will engage investors, contractors and suppliers needed to execute the project during Stage 2. Global Commons will also establish a MESCO that will finance, build, own, operate and maintain the electric generating, batteries and solar PV facilities. PSEG-LI will continue to own and manage the distribution system. As explained in response to Question 3.3.7, we will retain a qualified EPC contractor to build the project and guarantee performance. The MESCO will secure service agreements with vendors who will operate and maintain DERs, and the MESCO will provide the business management functions relative to their individual DERs.

3.4.6 Benefits and Costs Passed To the Community

The benefits of the microgrid will redound to the community in a number of direct and indirect ways. Most directly, the new CCHP system will reduce energy costs for the hospitals. In addition, the long-term operational continuity of critical government, hospital, fire, and water facilities and services will be ensured. Also, the project will assure that all customers connected to the microgrid can maintain power during outages in the PSEG-LI grid. This reliability will benefit thousands of residents who rely on services in Southampton Village throughout the year. Potential revenues and savings from the microgrid operation will also help provide budget relief for the Village. The community would not incur any costs as a result of the project.

3.4.7 Requirements from Utility to Ensure Value

The existing PSEG-LI feeders will distribute energy from the DERs to the customers. PSEG-LI will be responsible for hardening the feeder lines; however, the project Team will provide input to PSEG-LI to help focus on key areas of concern. The project financing will include funding needed to harden the feeders.

The utility will continue to be responsible for operating and maintaining the T&D assets used by the microgrid during both blue and black sky days. The electrical interconnection of the facilities uses portions of four PSEG-LI feeders (8F706, 8F707, 8F7H7, and 8QR912)). During a large-scale grid outage, sections of the feeders will be disconnected from rest of the PSEG-LI system by switches and used to form the microgrid. Selected switches on PSEG-LI's system that define the boundaries of the microgrid will be automated to facilitate quick formation. This automation can only be accomplished in cooperation with PSEG-LI, and operation of the switches will be subject to hierarchical control from PSEG-LI's control center.

3.4.8 Demonstration of Microgrid Technologies

All of the technologies incorporated in the proposed microgrid are commercialized and proven. Combined heat and power generators, batteries, and solar PV are established technologies are well understood and proven solution to ensure long-term fuel availability and efficient power generation and usage.

The Microgrid Control design may incorporate GE's proven U90Plus Microgrid Cost Minimizer to dispatch the DERs, and the D400 RTU/Controller to implement various operational control strategies. GE is currently developing a DoE funded eMCS controller that expands upon the algorithms implemented in the U90Plus and incorporates many of the control functions that now reside in the D400. The eMCS will be tested at NREL in early 2016 and will be applied at a microgrid site on Potsdam, NY. The U90Plus algorithm is being incorporated into the D400 controller, and this solution will be deployed in mid-2016 on a Microgrid at the University of Ontario in Toronto.

Another proven solution that could be utilized is GE's proven C90Plus Fast Load Shed Controller. The C90Plus provides adaptive load shedding for loss of generation and/or a utility tie to trip non-critical load. The IEDs/relays communicate real-time load and generation values as well as status to the C90Plus via IEC 61850 GOOSE messaging. The C90Plus evaluates this information and will issue a fast trip GOOSE message to the IEDs/relays to trip non-critical loads to assure a generation-load balance. The tripping of the load breakers is initiated in less than 20ms from detection of the triggering event. This compares to 200ms to 400ms for conventional load shedding schemes. This solution was recently successfully deployed and demonstrated at the Portsmouth Naval Shipyard under a DoD Environmental Security Technology Certification Program (ESTCP) contract.

3.4.9 Operational Scheme

The operational scheme will be determined during Stage 2, based on input from the project team and project investor. It is currently expected to involve the following:

- Technical- During blue sky days, dispatchable DERs (including CCHP systems, electric only generation, and batteries) will deliver energy to the host and/or NYISO when market conditions are favorable; during grid outages, the microgrid will go into island mode, and the DERs will supply energy for the microgrid participants.
- Financial-The MESCO will arrange all project financing needed to close on the project, including construction costs, interest during construction, and soft costs. The MESCO will also secure an appropriate level of working capital needed to meet cash flow obligations, and performance security or letters of credit if required to meet counterparty requirements.
- Transactional-The project team will hire an experienced project finance attorney during Stage 2 to assure that all appropriate documentation needed to close on project financing is prepared to satisfy requirements of lenders and investors.
- Decision making- The decision making protocols will be documented in an Operating Agreement for the MESCO during Stage 2. It is expected that the Manager (to be determined) will be

responsible for day-to-day operations of the MESCO, and that certain major decisions requiring investor approval will be defined in the Operating Agreement.

3.4.10 Plan To Charge Purchasers of Electricity Services

We expect that the MESCO would enter into a Microgrid Energy Service Agreements (MESAs) with various customers. The MESCO would sell energy from the DERs contractually to customers within or possibly outside the microgrid; however, GC will explore PSEG-LI's interest in establishing a PPA for sale of energy and capacity during normal conditions. The MESA for the CCHP system will include an appropriate fuel adjustment mechanism to maintain consistent cash flow to assure long-term financial viability of the project.

The MESCO will also establish a MESA with PSEG-LI that will define terms for providing energy in the event of an outage on the PSEG-LI grid.

Revenue grade meters will record energy usage at individual sites.

3.4.11 Business/Commercialization and Replication Plans

The project's proposed P3 design build, own, operate and maintain (DBOOM) business and commercialization plans are appropriate for this project. Long-term power purchase and/or energy services agreements between private parties and governmental/ institutional/non-profit entities are a proven and widely used deal structure to implement large energy infrastructure projects. In addition to shifting upfront costs to the third party, this approach also shifts project technical and operational risk and responsibility. Lastly, governments and non-profit entities cannot take tax credits or accelerated depreciation tax benefits associated with certain technologies, while a private third party can.

3.4.12 Barriers to Market Entry

There are a number of significant barriers to market entry, including but not limited to the following:

- Lack of mechanism to place a market value on reliability and resiliency limits financial viability of many projects
- Complexity of design of an integrated system of DERs, distribution and controls to meet varying microgrid loads during blue-sky days and during grid outages.
- Lack of funding for design and development activities
- Limited experience with microgrids may deter lenders and investors
- Relatively small capital requirements will deter most large energy investors
- Ability to identify an EPC contractor that will provide performance guarantees for a highly complex microgrid system
- Ability to identify project lenders and investors that will provide project financing at acceptable cost of capital
- Availability of a microgrid control system that can manage multiple DERs and varying load conditions

3.4.13 Steps Required to Overcome Barriers

We will use the following strategies for addressing these barriers:

- **Lack of mechanism to place a market value on reliability and resiliency limits financial viability of many projects**
  - NYSERDA grants can help subsidize projects to indirectly recognize the value of reliability and resiliency
  - Policy makers should consider other means to place a value on reliability and resiliency
- **Complexity of design of an integrated system of DERs, distribution and controls to meet varying microgrid loads during blue sky days and during grid outages.**
  - The Project Team members have extensive experience in a full range of energy development and financing, including design and development of microgrids. GE previously performed the technical work in the 5-Site NYSERDA “Microgrids for Critical Facility Resiliency in New York State,” that formed the basis for the NY Prize program. GE is also working on several other NY Prize projects.
  - Burns Engineering has a comprehensive understanding of the use of P3 for energy projects and has participated in several as both owner's engineer and engineer of record. In particular, Burns has led the multi-year planning and implementation of a microgrid at the Philadelphia Navy Yard and developed a number of P3 project structures to fund the construction and facilitate the operation and ownership of distributed generation resources central to the microgrid.
  - Global Common has developed and arranged financing for a variety of conventional and renewable energy projects in NY and throughout the US, including a anaerobic digester/CHP project in Auburn, NY, that was partially funded by NYSERDA, and a 54 MW peaking plant in Greenport, NY. Global Common is also managing two other NY Prize projects.
- **Lack of funding for design and development activities**
  - Design and development will be partially funded by a NY Prize Stage 2 grant, supplemented by in-kind services from the Project Team and the Village of Port Jefferson.
- **Limited experience with microgrids may deter lenders and investors**
  - The team’s credibility and experience, project design, EPC performance guarantees, capital structure (including significant grant funding), credible revenue and cost model, and adequate financial returns should be sufficient to attract financing
- **Relatively small capital requirements will exclude most large energy investors**
  - Medium sized financial investors and/or strategic investors are likely to have interest in the project because they believe microgrids are a potentially significant growth opportunities
- **Ability to identify an EPC contractor that will provide performance guarantees for a highly complex microgrid system**
  - Medium sized EPC firms will have an interest in microgrid construction projects because of potential growth opportunities
- **Ability to identify project lenders and investors that will provide project financing at acceptable cost of capital**
  - Lenders and investors have an interest in participating in microgrids because of its potential for future growth, and because returns with other opportunities are relatively low

- **Availability of a microgrid control system that can manage multiple DERs and varying load conditions**
    - GE and others are developing sophisticated microgrid control systems, with funding assistance from US DOE.

The Project Team members have extensive experience in a full range of energy development and financing, including design and development of microgrids. GE previously performed the technical work in the 5-Site NYSERDA “Microgrids for Critical Facility Resiliency in New York State,” that formed the basis for the NY Prize program. GE is also working on several other NY Prize projects.

Burns Engineering has a comprehensive understanding of the use of P3 for energy projects and has participated in several as both owner's engineer and engineer of record. In particular, Burns has led the multi-year planning and implementation of a microgrid at the Philadelphia Navy Yard and developed a number of P3 project structures to fund the construction and facilitate the operation and ownership of distributed generation resources central to the microgrid.

Global Common has developed and arranged financing for a variety of conventional and renewable energy projects in NY and throughout the US, including a anaerobic digester/CHP project in Auburn, NY, that was partially funded by NYSERDA, and a 54 MW peaking plant in Greenport, NY. Global Common is also managing two other NY Prize projects

3.4.14 Market Identification and Characterization

The potential market for sale of electric and thermal energy would include all of the facilities included in the microgrid. In addition, it is possible that the MESCO may sell energy to some customers outside of the microgrid, if microgrid customers do not contract to purchase of the DER output. Also, the MESCO will explore if PSEG-LI would be interested in a PPA to purchase energy and capacity from the electric plant.

The project customers within the microgrid will include St. Charles and Mather hospitals, the Village of Port Jefferson, and other commercial and residential customers in and around the Village. The hospitals would purchase electric and thermal energy produced by the CCHP systems from the MESCO, and the electric only plant will sell energy to commercial and residential customers during normal conditions.

We expect that the hospitals, the Village and SCWA and other smaller users will all have interest in purchasing from the MESCO because the project would reduce costs and improve reliability.

Our review of PSEG-LI and NYISO prices indicates that revenue from sale of energy and capacity would produce returns that are adequate to attract private financing, assuming the project receives NY Prize Stage 3 funding. This new gas-fueled electric plant would be dispatched ahead of other less efficient, kerosene-fueled peaking power plants, such as the 450 MW kerosene-fueled peaking plant in Holtzville.

The market value of the energy produced by the DERs, and fuel and VOM costs, are reflected in the financial analyses in Section 3.5.

3.5 Financial Viability

3.5.1 Categories of Revenue Streams

A breakdown of annual revenue and income for different DERs is shown below.

Table 3-6 Revenue and EBITDA Breakdown

DER	Revenue	EBITDA
St. Charles CCHP	$1,918,090	$1,152,894
Mather CCHP	$2,133,122	$1,300,118
Electric generation	$1,074,278	$593,336
Solar	$40,366	$26,020
Battery	$163,713	$106,186
Total Revenue	**$5,329,569**	**$3,178,555**

3.5.2 Other Incentives Required or Preferred

Sources and uses of funds with and without funding from the NY Prize program and PSEG-LI CHP programs are shown below. It is expected that PSEG-LI will soon launch a new program to provide grant funding for CHP projects on LI. This program could supplement grants from NYSERDA and private sources. As shown, the project will require incentives from NYSERDA, as well as ITC credits. The capital costs for the distribution and control systems are estimated to be $220,000 and $489,060, respectively.

Table 3-7 Sources and Uses of Funds with NY Prize/PSEG-LI Subsidies

Uses	Amount	Sources	Amount
St. Charles CHP	$6,368,000	Equity	$7,725,060
Mather CHP	$6,368,000	Debt	$0
Electric generation	$4,000,000	NY Prize	$7,000,000
Solar	$600,000	PSEG LI CHP Grant	$4,500,000
Battery	$1,320,000	ITC	$180,000
Distribution and controls	$749,060		
Total	**$19,405,060**		**$19,405,060**

Table 3-8 Sources and Uses of Funds without without NY Prize/PSEG-LI Subsidies

Uses	Amount	Sources	Amount
St. Charles CHP	$6,368,000	Equity	$19,225,060
Mather CHP	$6,368,000	Debt	$0
Electric generation	$4,000,000	NY Prize	$0
Solar	$600,000	PSEG LI CHP Grant	$0
Battery	$1,320,000	ITC	$180,000
Distribution and controls	$749,060		
Total	**$19,405,060**		**$19,405,060**

3.5.3 Categories of Capital and Operating Costs

The tables below show the MESCO income statement, and a comparison of financial performance with and without NY Prize and PSEG-LI grant funding. As shown, the project would produce returns that would likely be able to attract private financing, assuming NY Prize and PSEG-LI funding are provided. However, it is not likely that the project could attract private financing without NY Prize and PSEG-LI funding. We do not believe it is likely the microgrid project could attract over $19 million in private financing based on a 10.1% IRR, given the nature of the project risk profile.

A full financial analysis is needed to determine investments needs, both public and private. It's anticipated this more detailed analysis will occur under a Stage 2 award. A more detailed analysis would need to be performed during Stage 2 to confirm these analyses.

Please note that VOM, FOM, and TOM refer to variable operations and maintenance, fixed operations and maintenance, and total operation and maintenance, respectively.

Table 3-8 Preliminary Consolidated MESCO Income statement

Revenue		**Amount ($/year)**
Energy sale to CHP host		$4,111,438
Demand payment from battery host		$0
NYISO energy sales		$338,475
Enery sale to microgrid customers		$493,772
CCHP host thermal revenue		$0
Capacity payments		$93,120
Frequency response		$83,225
Sub Total		$5,120,029
VOM		
Natural gas fuel		$1,417,328
VOM		$731,376
Capacity purchases from NYISO		$109,882
Ancillary services purchases from NYISO		$4,601
NTAC, RS1		$3,075
TSC		$10,300
Grid energy purchases		$36,846
Sub-total		**$2,313,407**
Gross profit		*$2,806,622*
Gross margin		*54.8%*
FOM		
Maintenance fee		$5,118
Site Lease		$0
Insurance	1.0%	$49,097
Management Fee	5.0%	$207,958
Utilities	1.0%	$49,097
Outside services	1.0%	$65,937
Property Taxes		$152,839
Sub-total		**$530,047**
TOM		**$2,843,454**
EBITDA		**$2,276,575**

Table 3-9 Comparison of Financial Performance

	With NY Prize/PSEG Funding	Without NY Prize/PSEGLI Funding
Private investment	$7,725,060	$19,225,060
EBITDA	$2,276,575	$2,276,575
Investor IRR	29.3%	10.1%

3.5.4 Business Model Profitability

The project risk will be mitigated using the following strategies:

- Capital structure will include adequate equity and grants to assure adequate cash flow and debt coverage. Please see tables above.
- The project company will have definitive energy and fuel supply contracts with key counterparties. The contracts will include traditional project finance terms satisfactory to project lenders, investors and NYSERDA.

3.5.5 Description of Financing Structure

Please see response to section 3.5.2.

Development funding, if awarded, would be provided primarily by the NYSERDA Stage 2 grant, as well as co-funding by the applicants. In addition, the project may qualify for new PSEG-LI grants for CCHP projects. The project investor will provide funding to cover the ITC, and the ITC will be recognized by the investor. The lenders and investors/owners will receive project cash flows to recover their loans, and provide a return of and on investment. It is unlikely that the project would proceed without Stage 2 and Stage 3 NY Prize funding.

3.6 Legal Viability

3.6.1 Proposed Project Ownership

Subject to approval of the Village of Port Jefferson and project stakeholders, the MESCO will own all of the new DERs, and GC and other qualified investors will own the MESCO. The specific ownership structure and participants will be determined during Stage 2. GC has relationships with a number of potential investors who may have an interest in investing in the project, assuming the project structure and returns meet their requirements. It is expected that GC will continue to manage the project and have an ownership stake in the electric generation and solar PV facilities.

3.6.2 Project Owner

The project owner/investor has not yet been identified. The project team has relationships with a number of qualified investors, one of which will be selected during Stage 2. For example, GC will explore the possibility of GE Capital providing part of the project financing. GC will arrange project financing and likely maintain an ownership interest in the project.

3.6.3 Site Ownership

The DERs will utilize land owned by project participants to accommodate the DER equipment. The participant off-takers would likely benefit from reduced energy costs in lieu of lease payments. The owner of the microgrid would be a private third party. GC will identify and secure space required for the DERs, and will negotiate a long-term power purchase and/or energy services agreement during Stage 2.

3.6.4 Protecting of Customer Privacy Rights

All terms involving customers would be protected with standard confidentiality agreements.

3.6.5 Regulatory Hurdles

We would need to confirm that NYISO requirements will allow certain the behind the meter DERs to sell energy to the grid when market conditions are favorable. We also need to confirm the ability of microgrid ownership entity to act as DR aggregator for wholesale markets, and determine valuation of locational benefit of microgrid DERs (LMP+D).

4 DEVELOP INFORMATION FOR BENEFIT COST ANALYSIS

The project Team prepared detailed questionnaires to obtain data needed for the IEC BCA analyses, and met with or called major energy users to obtain relevant data. The Team then compiled and analyzed the data, and completed the IEC questionnaires to provide all of the data requested in Task 4. The IEC report is presented later in this section, and the completed questionnaires are shown in the Appendices.

The sections below describe the procedures and key assumptions regarding the data for the BCA analyses. In addition, this section discusses the how exclusion of reductions in air emissions in the BCA model understates the project benefits.

Air Emissions Benefits

The BCA calculates the emissions impacts from the DERs. However, it does not account for the reduction of emissions from reducing dispatch of other liquid-fueled peaking plants in central Long Island.

There is an existing 645 MW kerosene-fueled peaking plant in Holtsville, which is about 11 miles south of Port Jefferson. This plant is inefficient, but is dispatched frequently during hot summer days to meet peak summer loads.

Since the new gas fueled electric and CCHP plants, as well as other DERs, would have lower variable operating costs than this facility, the project would reduce the need to dispatch these plants, thus significantly reducing air emissions. However, the BCA analysis does not recognize the benefits from these reductions in emissions at the Holstville plant. This omission is more significant in central Long Island than in most other areas of NYS, since the microgrid DERs in other areas would generally displace more efficient gas fueled power plants.

4.1 Facility and Customer Description

The Team consulted with Port Jefferson Village officials to identify the critical facilities and other establishments that should be included in the microgrid. We then worked closely with Village officials and stakeholders to obtain load data for these facilities. We obtained individual electric and fuel bills for large commercial and government establishments. PSEG-LI provided data on individual feeders that were used to estimate loads for smaller residential and commercial establishments. National Grid provided information on existing gas supply, and potential supply for new DERs. Based on a review of this information, the Team decided that the microgrid should include the selected critical facilities as well as numerous commercial establishments and residences in the downtown area of the Village of Port Jefferson.

4.2 Characterization of Distributed Energy Resources

The Team designed the DERs to meet peak microgrid loads during grid outages, and ensure an economically viable business model during normal conditions.

The CCHP system would reduce or possibly eliminate use of fuel oil at St. Charles and Mather Hospitals and reduce the cost of electricity.

The 2 MW electric generating plant would assure that most of downtown Port Jefferson has service has power during grid outages. During normal conditions, this plant would sell energy and capacity contractually to customers within and outside the microgrid service area. Since this plant would have lower fuel and operating costs than the kerosene fueled plant in Holtsville, and have lower operating cost than most gas fueled plants (with the exception of the Caithness plant), the new electric generating plant would be dispatched ahead of these plants, thus reducing their operating hours and significantly reducing air emissions.

The battery facility would shave peak loads due to pumping at the SWCA water supply facility, and help stabilize the microgrid during main grid outages. The new solar PV would further help reduce peak loads. Tables showing the requested microgrid data are provided in Appendix B.

4.3 Capacity Impacts and Ancillary Services

The project will provide 6.27 MW of peak load support, reducing the need for new peaking generation or transmission on the South Fork.

The project will also provide ancillary services and capacity. Finally, the project will significantly reduce emissions by reducing the need to dispatch existing diesel and kerosene fueled peaking plants, as discussed previously.

4.4 Project Costs

A breakdown of project costs is shown below:

Table 4-1 project Costs

Capital Component	Installed Cost ($)
Mather CHP	6,400,000
St Charles CHP	6,400,000
Switchgear	140,000
Existing Generation	120,000
Control & Communication	489,060
New Reciprocating Engine	4,000,000
Battery	1,320,000
Solar	533,400

In addition to the costs of the DERs, the cost of distribution and controls will be approximately $749,060. Thus, total project cost would be approximately $19 million.

4.5 Costs to Maintain Service during a Power Outage

Information addressing the points responding in this section is contained in Appendix B.

4.6 Services Supported by the Microgrid

The project will be able to meet peak loads for most of the downtown area of Port Jefferson Village during outages to the main grid. Specific responses to the points in this section are in Appendix B.

4.7 Summary of BCA Results

To assist with the completion of the project's NY Prize Stage 1 feasibility study, Industrial Economics, Inc. (IEc) conducted a screening-level analysis of its potential costs and benefits. IEc typically considers two scenarios for the benefit cost analysis. The first scenario assumes a 20-year operation periods with no major power outages (i.e., normal operating conditions only). The second scenario calculates the average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under the first scenario. In this case, a second scenario was not needed.

Results of IEc's analysis for Scenario 1A (included in Appendix A) suggest that if no major power outages occur over the microgrid's assumed 20-year operating life, the project's benefits would exceed its costs. The results are summarized in the table below. Figure 4-1 shows a breakdown of the benefits and costs.

Table 4-2 BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1A: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$8,720,000	Not Evaluated
Benefit-Cost Ratio	1.1	Not Evaluated
Internal Rate of Return	9.8%	Not Evaluated

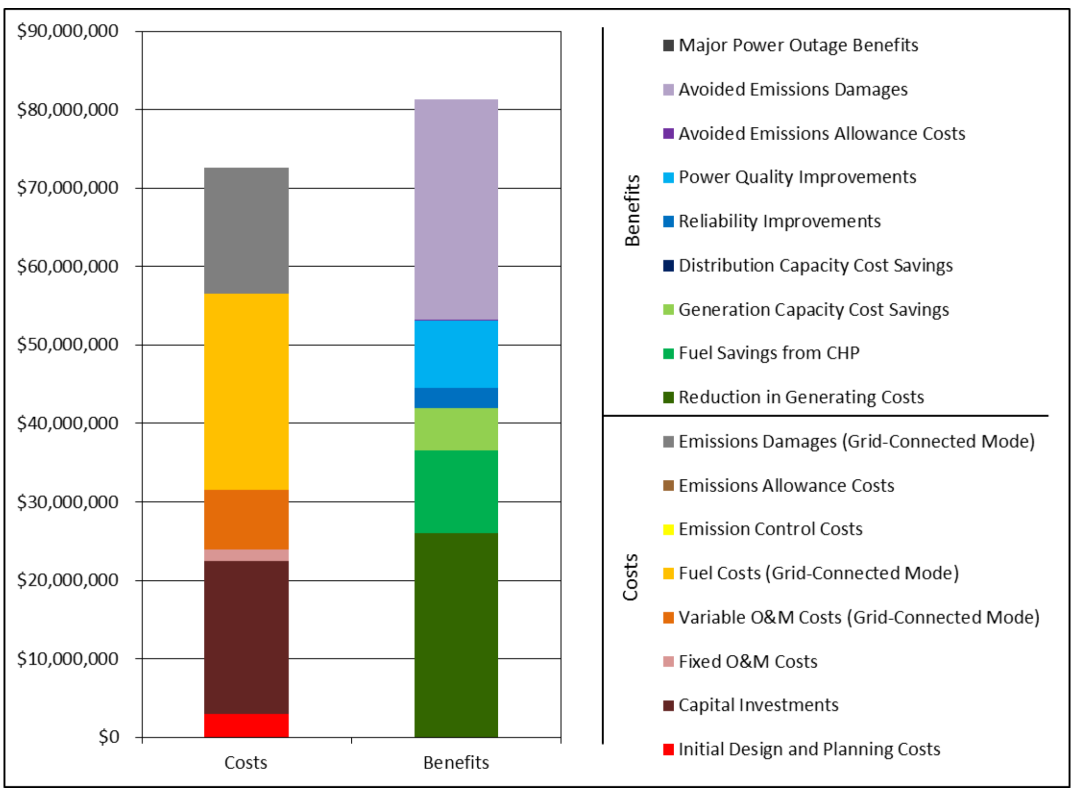


Figure 4-1 Present Value Results, Scenario 1 (No Major Power Outages; 7 % Discount Rate)

The major cost components are the DER fuel and the capital investment in the microgrid, particularly the CCHP units. The CCHP machines provide a return on investment during normal grid operations by providing thermal services to microgrid customers. This return is not included in IEc's societal-based evaluation. Emission Damages and Variable O&M costs of the microgrid generation resources during grid connected operations (due to the fuel consumption by the CCHP running during normal days) are also substantial cost components.

The major benefit components are the reduction in generating costs, attributable to the microgrid generation that displaces other conventional generation in the grid; and the avoided emission damages, attributable to clean natural gas and solar PV. The other significant benefit stream is the power quality improvements, particularly for the hospital.

The full IEc results including tables that detail the cost and benefits for both scenarios are included in Appendix A.

APPENDIX A - BENEFIT-COST ANALYSIS SUMMARY REPORT

Site 5 – Village of Port Jefferson

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Village of Port Jefferson has proposed development of a microgrid that would serve 1300 residential customers and 260 commercial customers in this Suffolk County community.[1] The critical service providers that would be served by the microgrid include two hospitals, a firehouse, a wastewater treatment plant, and public water supply facilities. In addition, the microgrid would serve approximately 250 small commercial establishments as well as three public schools, the department of public works, and the village hall.

Port Jefferson's microgrid would be powered by a new 2 MW natural gas generator, 200 kW of new solar photovoltaic arrays, and 98 kW of existing solar photovoltaic arrays. The microgrid would also include two new natural gas-fired combined cooling, heat, and power (CCHP) systems (3.2 MW combined) and 1 MW of energy storage. The solar arrays, cogeneration plants, and new natural gas generator would produce electricity for the grid during periods of normal operation. All resources would be available for peak load support and to support islanded operation during power outages. The system as designed would have sufficient generating capacity to meet average demand for electricity from all facilities on the microgrid during a major outage. The project's consultants also indicate that the system would be capable of providing frequency regulation, reactive power support, and black start support to the grid.

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

METHODOLOGY AND ASSUMPTIONS

In discussing the economic viability of microgrids, a common understanding of the basic concepts of benefit-cost analysis 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.

[1] The microgrid will be connected to a PSEG Long Island feeder line with approximately 1300 residential and 250 commercial customers. Since the project team is unable to provide detailed electricity usage information for each load group, this analysis applies PSEG Long Island's estimate of average annual residential electricity usage to the 1300 residential customers and assumes that the remaining load is split evenly among the 250 commercial customers.

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

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.[2] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for the following 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.[3]

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

[3] 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.

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that even if there were no major power outages over the 20-year period analyzed (Scenario 1); the project's benefits would exceed its costs by approximately 10 percent.

Since the results for Scenario 1 suggest a benefit-cost ratio greater than one, the report does not present a detailed analysis of the impact of major power outages under Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio. The discussion that follows provides additional detail on the findings from Scenario 1.

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1A: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$8,720,000	Not Evaluated
Benefit-Cost Ratio	1.1	Not Evaluated
Internal Rate of Return	9.8%	Not Evaluated

Scenario 1

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

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

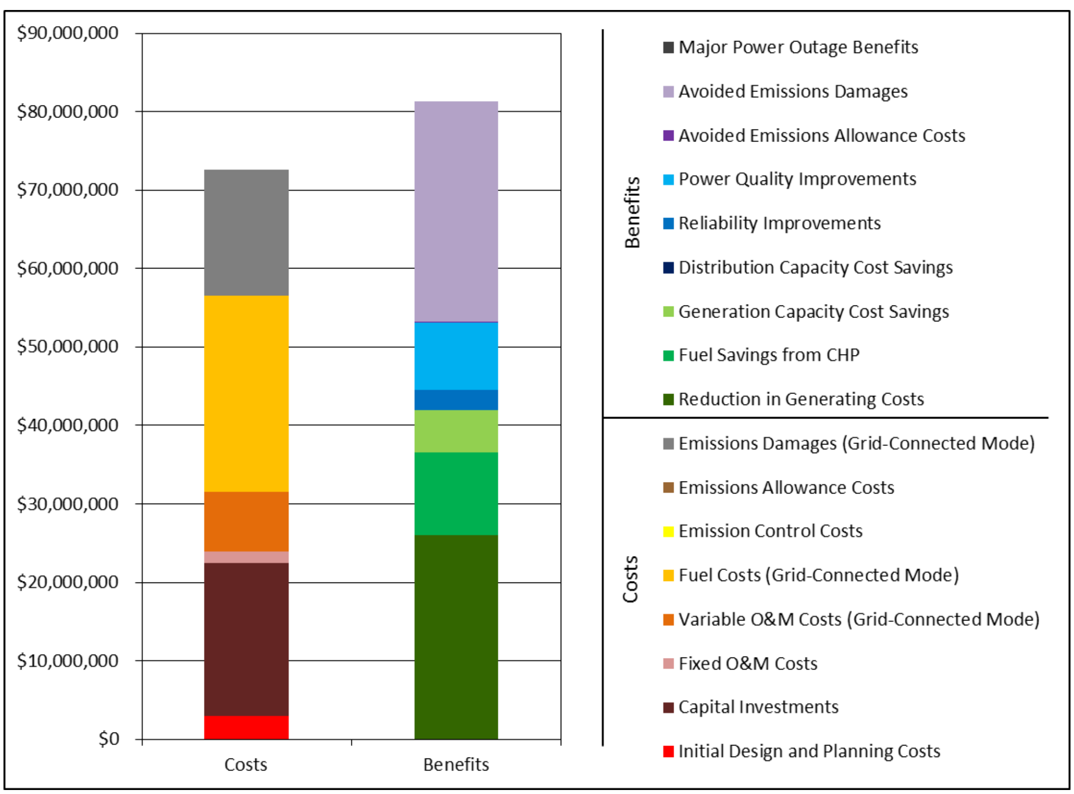


Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$2,910,000	$257,000
Capital Investments	$19,600,000	$1,660,000
Fixed O&M	$1,500,000	$132,000
Variable O&M (Grid-Connected Mode)	$7,530,000	$664,000
Fuel (Grid-Connected Mode)	$25,100,000	$2,210,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$16,100,000	$1,050,000
Total Costs	**$72,700,000**	
Benefits		
Reduction in Generating Costs	$26,000,000	$2,300,000
Fuel Savings from CCHP	$10,500,000	$923,000
Generation Capacity Cost Savings	$5,510,000	$486,000
Transmission/Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$2,540,000	$224,000
Power Quality Improvements	$8,610,000	$760,000
Avoided Emissions Allowance Costs	$13,100	$1,150
Avoided Emissions Damages	$28,200,000	$1,840,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$81,400,000**	
Net Benefits	**$8,720,000**	
Benefit/Cost Ratio	**1.1**	
Internal Rate of Return	**9.8%**	

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 $2.91 million. The present value of the project's capital costs is estimated at approximately $19.6 million, including the costs of the new CCHP plants ($6.4 million each), new natural gas generator ($4 million), new battery storage ($1.32 million), new solar array ($533,400), and $749,060 for microgrid switches and control equipment.

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 $1.5 million (approximately $132,000 annually). These costs include parts, preventative maintenance, and monitoring for all energy resources, as well as software licenses, permitting expenses, and legal and financing fees.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's new generator and CCHP plants. 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.[4] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $25.1 million.

The BCA also considers the project team's best estimate of the microgrid's variable O&M costs (i.e., O&M costs that vary with the amount of energy produced). These costs cover general operations and maintenance; their 20-year present value is estimated to be $7.53 million, or approximately $17.40 per MWh.

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 $1.05 million annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $16.1 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. In Port Jefferson's case, these cost savings would stem both from the production of electricity by distributed energy resources and by a reduction in annual electricity use associated with development of the new CCHP plants.[5] The BCA estimates the present value of these savings over a 20-year operating period to be approximately $26 million; this estimate assumes the microgrid provides base load power, which is consistent with the anticipated operating profile for all microgrid resources. The heightened fuel efficiency of the new CCHP systems would provide additional cost savings; the BCA estimates the present value of these savings over the 20-year operating period to be approximately $10.5 million. The reduction in demand for electricity from bulk energy suppliers and reduction in the use of fuel for heating and cooling purposes would also reduce emissions of CO_2, SO_2, NO_x, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $13,100 and avoided emissions damages with a present value of approximately $28.2 million.[6]

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[4] 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.

[5] The project team estimates that installation of the CCHP plants at St. Charles and John T. Mather Hospitals would enable the facilities to reduce their annual electricity use by 367 MWh.

[6] Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model values emissions of CO_2 using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency (EPA). [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.] Because emissions of SO_2 and NO_x from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity. Based on standard capacity factors for solar resources (20 percent of total generating capacity for photovoltaic solar), the project team estimates the capacity available for the provision of peak load support to be approximately 6.3 MW per year. In addition, the project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by 206 kW 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 $5.51 million over a 20-year operating period.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, in the form of frequency regulation, reactive power support, and black start support, to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the markets for ancillary services are highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing 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 $224,000 per year, with a present value of $2.54 million 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:[7]

- System Average Interruption Frequency Index (SAIFI) – 0.72 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 81.6 minutes.[8]

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[9]. 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. 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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[7] www.icecalculator.com.

[8] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for the regional electricity service provider, PSEG Long Island.

[9] Where data was not provided by the project team, this analysis used the ICE calculator's default values for NY State.

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. In Port Jefferson's case, the project team has indicated that development of a microgrid would enable its customers to avoid approximately three power quality events each year. Assuming that each customer in the proposed microgrid would experience these improvements in power quality, the model estimates the present value of this benefit to be approximately $8.61 million over a 20-year operating period.[10] In reality, some customers for whom power quality is important (e.g., medical facilities) may already have systems in place to protect against voltage sags, swells, and momentary outages. If this is the case in Port Jefferson, the BCA may overstate the power quality benefits the project would provide.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 1.1; i.e., the estimate of project benefits is greater than that of project costs. Accordingly, the analysis does not consider the potential of the microgrid to mitigate the impact of major power outages in Scenario 2. Consideration of such benefits would further increase the net benefits of the project's development.

[10] Importantly, the model relies on average costs per power quality event for customers across the United States, based on a meta-analysis of data collected through 28 studies of electric utility customers between 1989 and 2005. These values reflect the distribution of customers by economic sector in the areas studied, as well as other key characteristics of these customers, such as the percentage equipped with backup generators or power conditioning systems. The characteristics of these customers may not be representative of the characteristics of the customers that would be served by the proposed microgrid. This is likely to be the case for the Village of Port Jefferson. Based on information provided by the site team, Port Jefferson's proposed microgrid will serve few, if any, customers in the construction, manufacturing, and mining sectors, which typically incur the highest costs when power quality is poor. Instead, the proposed microgrid's customers are more likely to fall into the retail and public administration sectors. Power quality costs for facilities in these sectors are likely to be lower than the average values the model employs. [See: Sullivan, Michael J. *et al*. Estimated Value of Service Reliability for Electric Utility Customers in the United States. LBNL-2132E: June 2009.]

APPENDIX B - Facility Questionnaire and Microgrid Questionnaire

Facility Questionnaire

This questionnaire requests information needed to estimate the impact that a microgrid might have in protecting the facilities it serves from the effects of a major power outage (i.e., an outage lasting at least 24 hours). For each facility, we are interested in information on:

I. Current backup generation capabilities.

II. The costs that would be incurred to maintain service during a power outage, both when operating on its backup power system (if any) and when backup power is down or not available.

III. The types of services the facility provides.

I. Backup Generation Capabilities

1. Do any of the facilities that would be served by the microgrid currently have backup generation capabilities?
    a. ☐ No - proceed to Question 4
    b. ■ Yes - proceed to Question 2

2. For each facility that is equipped with a backup generator, please complete the table below, following the example provided. Please include the following information:
    a. **Facility name:** For example, "Main Street Apartments."
    b. **Identity of backup generator:** For example, "Unit 1."
    c. **Energy source:** Select the fuel/energy source used by each backup generator from the dropdown list. If you select "other," please type in the energy source used.
    d. **Nameplate capacity:** Specify the nameplate capacity (in MW) of each backup generator.
    e. **Standard operating capacity:** Specify the percentage of nameplate capacity at which the backup generator is likely to operate during an extended power outage.
    f. **Average electricity production per day in the event of a major power outage**: Estimate the average daily electricity production (MWh per day) for the

generator in the event of a major power outage. In developing the estimate, please consider the unit's capacity, the daily demand at the facility it serves, and the hours of service the facility requires.

g. **Fuel consumption per day:** Estimate the amount of fuel required per day (e.g., MMBtu per day) to generate the amount of electricity specified above. This question does not apply to renewable energy resources, such as wind and solar.

h. **One-time operating costs:** Please identify any one-time costs (e.g., labor or contract service costs) associated with connecting and starting the backup generator.

i. **Ongoing operating costs:** Estimate the costs ($/day) (e.g., maintenance costs) associated with operating the backup generator, excluding fuel costs.

Note that backup generators may also serve as distributed energy resources in the microgrid. Therefore, there may be some overlap between the information provided in the table below and the information provided for the distributed energy resource table (Question 2) in the general Microgrid Data Collection Questionnaire.

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/ Day)	Fuel Consumption per Hour		One-Time Operating Costs ($)	Ongoing Operating Costs ($/day)
						Quantity	Unit		
John T. Mather Hospital	*Unit 1*	*Diesel*	*0.500*	*80*	*9.6*	116.99	MMBtu/ day	200	211
John T. Mather Hospital	*Unit 2*	*Diesel*	*0.500*	*80*	*9.6*	116.99	MMBtu/ day	200	211
St. Charles Hospital	*Cummins Unit 1*	*Diesel*	*0.900*	*80*	*17.28*	210.58	MMBtu/ day	200	380
St. Charles Hospital	*Cummins Unit 2*	*Diesel*	*0.300*	*80*	*5.76*	70.19	MMBtu/ day	200	127
St. Charles Hospital	*Onan Unit*	*Diesel*	*0.250*	*80*	*4.8*	58.49	MMBtu/ day	200	105
St. Charles Hospital	*Martin Unit*	*Diesel*	*0.250*	*80*	*4.8*	58.49	MMBtu/ day	200	105
St. Charles Hospital	*Caterpillar Unit*	*Diesel*	*0.100*	*80*	*1.92*	26.21	MMBtu/ day	200	42
Suffolk County Water Authority Supply Well	*Unit 1*	*Diesel*	*0.100*	*80*	*1.92*	26.21	MMBtu/ day	200	42

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/ Day)	Fuel Consumption per Hour		One-Time Operating Costs ($)	Ongoing Operating Costs ($/day)
						Quantity	Unit		
Waste Water Treatment Plant	*Unit 1*	*Diesel*	*0.250*	*80*	*4.8*	58.49	MMBtu/ day	200	105

II. Costs of Emergency Measures Necessary to Maintain Service

We understand that facilities may have to take emergency measures during a power outage in order to maintain operations, preserve property, and/or protect the health and safety of workers, residents, or the general public. These measures may impose extraordinary costs, including both one-time expenditures (e.g., the cost of evacuating and relocating residents) and ongoing costs (e.g., the daily expense of renting a portable generator). The questions below address these costs. We begin by requesting information on the costs facilities would be likely to incur when operating on backup power. We then request information on the costs facilities would be likely to incur when backup power is not available.

A. Cost of Maintaining Service while Operating on Backup Power

3. Please provide information in the table below for each facility the microgrid would serve which is currently equipped with some form of backup power (e.g., an emergency generator). For each facility, please describe the costs of any emergency measures that would be necessary in the event of a widespread power outage (i.e., a total loss of power in the area surrounding the facility lasting at least 24 hours). In completing the table, please assume that the facility's backup power system is fully operational. In your response, please describe and estimate the costs for:

   a. One-time emergency measures (total costs)

   b. Ongoing emergency measures (costs per day)

   Note that these measures do not include the costs associated with running the facility's existing backup power system, as estimated in the previous question.

   In addition, for each emergency measure, please provide additional information related to when the measure would be required. For example, measures undertaken for heating purposes may only be required during winter months. As another example, some commercial facilities may undertake emergency measures during the work week only.

As a guide, see the examples the table provides.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
John T. Mather Hospital	*One-Time Measures*	Back power covers part of the load, and hence, some emergency measures need to be taken. Turn on and check backup power. Keep critical safety and security functions in operation. Notify personnel. Send non-essential staff home	10,000.	$	In the event of loss of power
St. Charles Hospital	*One-Time Measures*	Even though there is back power, some emergency measures need to be taken. Turn on and check backup power. Keep critical safety and security functions in operation. Notify personnel. Send non-essential staff home	10,000.	$	In the event of loss of power
Suffolk County Water Authority Supply Well	*One-Time Measures*	Backup power will enable partial operations. Emergency measures need to be taken. Turn on and check backup power. Keep critical safety and security functions in operation. Notify personnel. Send non-essential staff home	2,000.	$	In the event of loss of power
Waste Water Treatment Plant	*One-Time Measures*	Backup power will enable partial operations. Emergency measures need to be taken. Turn on and check backup power. Keep critical safety and security functions in operation. Notify personnel. Send non-essential staff home	2,000.	$	In the event of loss of power

B. Cost of Maintaining Service while Backup Power is Not Available

4. Please provide information in the table below for each facility the microgrid would serve. For each facility, please describe the costs of any emergency measures that would be necessary in the event of a widespread power outage (i.e., a total loss of power in the area surrounding the facility lasting at least 24 hours). In completing the table, please assume that service from any backup generators currently on-site is not available. In your response, please describe and estimate the costs for:

   a. One-time emergency measures (total costs)

   b. Ongoing emergency measures (costs per day)

   In addition, for each emergency measure, please provide additional information related to when the measure would be required. For example, measures undertaken for heating purposes may only be required during winter months. As another example, some commercial facilities may undertake emergency measures during the work week only.

   As a guide, see the examples the table provides.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
St. Charles Hospital	*One-Time Measures*	*Hooking up additional portable generator*	16000	$	Year Round
St. Charles Hospital	*Ongoing Measures*	*Renting additional portable generator*	21400	$/day	Year Round
John T. Mather Hospital	*One-Time Measures*	*Hooking up additional portable generator*	16000	$	Year Round
John T. Mather Hospital	*Ongoing Measures*	*Renting additional portable generator*	21400	$/day	Year Round
Department of Public Works	*One-Time Measures*	*Hooking up additional portable generator*	2300	$	Year Round, 5 days a week
Department of Public Works	*Ongoing Measures*	*Renting additional portable generator*	1200	$/day	Year Round, 5 days a week
Spear Elementary School	*One-Time Measures*	*Hooking up additional portable generator*	3600	$	5 days a week, September-June
Spear Elementary School	*Ongoing Measures*	*Renting additional portable generator*	2000	$/day	5 days a week, September-June
Waste Water Treatment Plant	*One-Time Measures*	*Hooking up additional portable generator*	7000	$	Year Round
Waste Water Treatment Plant	*Ongoing Measures*	*Renting additional portable generator*	7600	$/day	Year Round
Suffolk County Water Authority	*One-Time Measures*	*Hooking up additional portable generator*	4500	$	Year Round
Suffolk County Water Authority	*Ongoing Measures*	*Renting additional portable generator*	5400	$/day	Year Round
Port Jefferson Middle/High School	*One-Time Measures*	*Hooking up additional portable generator*	4000	$	5 days a week, September-June
Port Jefferson Middle/High School	*Ongoing Measures*	*Renting additional portable generator*	3200	$/day	5 days a week, September-June
Village Hall	*One-Time Measures*	*Hooking up additional portable generator*	2100	$	Year Round, 5 days a week

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Village Hall	*Ongoing Measures*	*Renting additional portable generator*	900	$/day	Year Round, 5 days a week
Port Jefferson Fire Department	*One-Time Measures*	*Hooking up additional portable generator*	2300	$	Year Round
Port Jefferson Fire Department	*Ongoing Measures*	*Renting additional portable generator*	12000	$/day	Year Round
Non-Critical Load (Approximately 250 commercial and 1300 residential customers, single family homes – cost estimates apply to commercial customers only)	*One-Time Measures*	*Hooking up additional portable generator*	525,000	$	Year Round
Non-Critical Load (Approximately 250 commercial and 1300 residential customers, single family homes – cost estimates apply to commercial customers only)	*Ongoing Measures*	*Renting additional portable generator*	225,000	$/day	Year Round

III. Services Provided

We are interested in the types of services provided by the facilities the microgrid would serve, as well as the potential impact of a major power outage on these services. As specified below, the information of interest includes some general information on all facilities, as well as more detailed information on residential facilities and critical service providers (i.e., facilities that provide fire, police, hospital, water, wastewater treatment, or emergency medical services (EMS)).

*A. Questions for: **All Facilities***

5. During a power outage, is each facility able to provide the same level of service when using backup generation as under normal operations? If not, please estimate the percent loss in the services for each facility (e.g., 20% loss in services provided during outage while on backup power). As a guide, see the example the table provides.

Facility Name	Percent Loss in Services When Using Backup Gen.
John T. Mather Hospital	50%
St. Charles Hospital	20%
Suffolk County Water Authority Supply Well	64%

Facility Name	Percent Loss in Services When Using Backup Gen.
Suffolk Sewer Department	67%

6. During a power outage, if backup generation is not available, is each facility able to provide the same level of service as under normal operations? If not, please estimate the percent loss in the services for each facility (e.g., 40% loss in services provided during outage when backup power is not available). As a guide, see the example the table provides.

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
Department of Public Works	100%
St. Charles Hospital	100%
Spear Elementary School	100%
John T. Mather Hospital	100%
Suffolk County Water Authority Supply Well	100%
Suffolk Sewer Department	100%
Port Jefferson Middle/High School	100%
Village Hall	100%
Port Jefferson Fire Department	40%
Non-Critical Loads	100%

B. Questions for facilities that provide: Fire Services

7. What is the total population served by the facility?

8000

8. Please estimate the percent increase in average response time for this facility during a power outage:

100% assuming loss of backup power; 0% if backup power is available

9. What is the distance (in miles) to the nearest backup fire station or alternative fire service provider?

1.6

C. Questions for facilities that provide: Emergency Medical Services (EMS)

10. What is the total population served by the facility?

700,000

11. Is the area served by the facility primarily:

☐ Urban

■ Suburban

☐ Rural

☐ Wilderness

12. Please estimate the <u>percent increase</u> in average response time for this facility during a power outage:

100% assuming loss of backup power; 0% if backup power is available

13. What is the distance (in miles) to the next nearest alternative EMS provider?

2

D. Questions for facilities that provide: Hospital Services

14. What is the total population served by the facility?

700,000

15. What is the distance (in miles) to the nearest alternative hospital?

6 MI

16. What is the population served by the nearest alternative hospital?

700,000

E. Questions for facilities that provide: Police Services

17. What is the total population served by the facility?

Click here to enter text.

18. Is the facility located in a:

☐ Metropolitan Statistical Area

☐ Non-Metropolitan City

☐ Non-Metropolitan County

19. Please estimate:

a. The <u>number</u> of police officers working at the station under normal operations.

Click here to enter text.

b. The <u>number</u> of police officers working at the station during a power outage.

Click here to enter text.

c. The <u>percent reduction</u> in service effectiveness during an outage.

Click here to enter text.

*F. Questions for facilities that provide: **Wastewater Services***

20. What is the total population served by the facility?

8000

21. Does the facility support:

☐ Residential customers

☐ Businesses

■ Both

*G. Questions for facilities that provide: **Water Services***

22. What is the total population served by the facility?

13,000

23. Does the facility support:

☐ Residential customers

☐ Businesses

■ Both

H. Questions for: Residential Facilities

24. What types of housing does the facility provide (e.g., group housing, apartments, nursing homes, assisted living facilities, etc.)?

Single family homes

25. Please estimate the number of residents that would be left without power during a complete loss of power (i.e., when backup generators fail or are otherwise not available).

1000

Microgrid Questionnaire

This questionnaire solicits information on the community microgrid you are proposing for the NY Prize competition. The information in this questionnaire will be used to develop a preliminary benefit-cost analysis of the proposed microgrid. Please provide as much detail as possible. The questionnaire is organized into the following sections:

A. Project Overview, Energy Production, and Fuel Use

B. Capacity Impacts

C. Project Costs

D. Environmental Impacts

E. Ancillary Services

F. Power Quality and Reliability

G. Other Information

If you have any questions regarding the information requested, please contact Industrial Economics, Incorporated, either by email (NYPrize@indecon.com) or phone (929-445-7641).

Microgrid site: 5. Village of Port Jefferson

Point of contact for this questionnaire:

Name: Bob Foxen

Address: 95 Brook Street
Garden City, New York 11530

Telephone: 516-528-8396

Email: bob_foxen@globalcommon.com

A. Project Overview, Energy Production, and Fuel Use

1. The table below is designed to gather background information on the facilities your microgrid would serve. It includes two examples: one for Main Street Apartments, a residential facility with multiple utility customers; and another for Main Street Grocery, a commercial facility. Please follow these examples in providing the information specified for each facility. Additional guidance is provided below.

   - **Facility name:** Please enter the name of each facility the microgrid would serve. Note that a single **facility** may include multiple **customers** (e.g., individually-metered apartments within a multi-family apartment building). When this is the case, you do not need to list each customer individually; simply identify the facility as a whole (see Table 1, "Main Street Apartments," for an example).

- **Rate class:** Select the appropriate rate class for the facility from the dropdown list. Rate class options are residential, small commercial/industrial (defined as a facility using less than 50 MWh of electricity per year), or large commercial/industrial (defined as a facility using 50 or more MWh of electricity per year).
- **Facility/customer description:** Provide a brief description of the facility, including the number of individual customers at the facility if it includes more than one (e.g., individually-metered apartments within a multi-family apartment building). For commercial and industrial facilities, please describe the type of commercial/industrial activity conducted at the facility.
- **Economic sector:** Select the appropriate economic sector for the facility from the dropdown list.
- **Average annual usage:** Specify the average annual electricity usage (in MWh) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from average annual usage for the facility as a whole.
- **Peak demand:** Specify the peak electricity demand (in MW) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from peak demand for the facility as a whole.
- **Percent of average usage the microgrid could support in the event of a major power outage:** Specify the percent of each facility's typical usage that the microgrid would be designed to support in the event of a major power outage (i.e., an outage lasting at least 24 hours that necessitates that the microgrid operate in islanded mode). In many cases, this will be 100%. In some cases, however, the microgrid may be designed to provide only enough energy to support critical services (e.g., elevators but not lighting). In these cases, the value you report should be less than 100%.
- **Hours of electricity supply required per day in the event of a major power outage:** Please indicate the number of hours per day that service to each facility would be maintained by the microgrid in the event of a major outage. Note that this value may be less than 24 hours for some facilities; for example, some commercial facilities may only require electricity during business hours.

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Department of Public Works	Large Commercial/Industrial	All Other Industries	*All other industries*	96.960	0.045	100%	8
St. Charles Hospital	Large Commercial/Industrial	Hospital	*All other industries*	10,721.628	1.932	100%	24
Spear Elementary School	Large Commercial/Industrial	School	*All other industries*	418.560	0.130	100%	8
John T. Mather Hospital	Large Commercial/Industrial	Hospital	*All other industries*	11,923.603	1.959	100%	24
Suffolk County Water Authority	Large Commercial/Industrial	Water Supply	*All other industries*	16.038	0.007	100%	24
Suffolk Sewer Department	Large Commercial/Industrial	Waste water treatment	*All other industries*	1,612.080	0.659	100%	24
Port Jefferson Middle/High School	Large Commercial/Industrial	School	*All other industries*	783.763	0.223	100%	8
Village Hall	Large Commercial/Industrial	Community Center	*All other industries*	71.100	0.024	100%	8
SCWA (Water Supply & treatment)	Large Commercial/Industrial	Water Supply & Treatment	*All other industries*	656.800	0.311	100%	24
Port Jefferson Fire Department	Large Commercial/Industrial	Fire Department	*All other industries*	158.000	0.050	100%	24

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Non-Critical Load (Approximately 200 commercial and 1000 residential customers, single family homes – cost estimates apply to commercial customers only)	Mix Residential + Commercial/Industrial	Approximately 250 commercial and 1300 residential customers, single family homes	*All other industries*	17,747.770	3.576	100%	24
Waste Water treatment plant - Battery	Large Commercial/Industrial	Waste water treatment	*All other industries*	520.843	0.550	100%	24
LOAD REDUCTION MEASURES					**Load Reduction (MW)**		
St. Charles Hospital – Absorption Chillers	Large Commercial/Industrial	Hospital	*All other industries*	366.549	0.626	100%	24
Mather Hospital – Thermal Storage	Large Commercial/Industrial	Hospital	*All other industries*	7,567.390	0.469	100%	24

2. In the table below, please provide information on the distributed energy resources the microgrid will incorporate. Use the two examples included in the table as a guide.

- **Distributed energy resource name:** Please identify each distributed energy resource with a brief description. In the event that a single facility has multiple distributed energy resources of the same type (e.g., two diesel generators), please use numbers to uniquely identify each (e.g., "Diesel generator 1" and "Diesel generator 2").
- **Facility name:** Please specify the facility at which each distributed energy resource is or would be based.
- **Energy source:** Select the fuel/energy source used by each distributed energy resource from the dropdown list. If you select "other," please type in the energy source used.
- **Nameplate capacity:** Specify the total nameplate capacity (in MW) of each distributed energy resource included in the microgrid.
- **Average annual production:** Please estimate the amount of electricity (in MWh) that each distributed energy resource is likely to produce each year, on average, **under normal operating conditions.** The benefit-cost analysis will separately estimate production in islanded mode in the event of an extended power outage. **If the distributed energy resource will operate only in the event of an outage, please enter zero.**
- **Average daily production in the event of a major power outage:** Please estimate the amount of electricity (in MWh per day) that each distributed energy resource is likely to produce, on average, **in the event of a major power outage.** In developing your estimate for each distributed energy resource, you should consider the electricity requirements of the facilities the microgrid would serve, as specified in your response to Question 1.
- **Fuel consumption per MWh:** For each distributed energy resource, please estimate the amount of fuel required to generate one MWh of energy. This question does not apply to renewable energy resources, such as wind and solar.

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
Solar (existing)	John T. Mather Hospital	Solar	0.050	131.044	0.359	N/A	Choose an item.
Solar (existing)	Spear Elementary School	Solar	0.048	125.802	0.345	N/A	Choose an item.
Mather CCHP (new)	John T. Mather Hospital	Natural Gas	1.600	14,004.611	38.400	8.530	MMBtu/MWh
St Charles CCHP (new)	St. Charles Hospital	Natural Gas	1.600	14,012.455	38.400	8.530	MMBtu/MWh
New Reciprocating Engine (new)	TBD	Natural Gas	2.000	9.898.800	48.000	8.530	MMBtu/MWh
PV (new)	Port Jefferson Middle/ High School	Solar	0.200	256.846	0.704	N/A	Choose an item.
Mather Generator 1 (existing)	John T. Mather Hospital	Diesel	0.500	0	9.600	12.186	MMBtu/MWh
Mather Generator 2 (existing)	John T. Mather Hospital	Diesel	0.500	0	9.600	12.186	MMBtu/MWh
St Charles Generator 1 (existing)	St. Charles Hospital	Diesel	0.900	0	6.876	12.186	MMBtu/MWh
St Charles Generator 2 (existing)	St. Charles Hospital	Diesel	0.300	0	2.292	12.186	MMBtu/MWh
St Charles Generator 3 (existing)	St. Charles Hospital	Diesel	0.250	0	1.910	12.186	MMBtu/MWh

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
St Charles Generator 4 (existing)	St. Charles Hospital	Diesel	0.250	0	1.910	12.186	MMBtu/MWh
St Charles Generator 5 (existing)	St. Charles Hospital	Diesel	0.100	0	0.764	12.186	MMBtu/MWh
WA Generator 1 (existing)	Suffolk County Water Authority Supply Well	Diesel	0.100	0	0.764	12.186	MMBtu/MWh
WWTP Generator 1 (existing)	Waste Water Treatment Plant	Diesel	0.250	0	1.910	12.186	MMBtu/MWh
WWTP Battery (new)	Waste Water Treatment Plant	Electric	0.250	236.747	0.689	N/A	N/A
WA Battery (new)	Water Authority	Electric	0.300	284.096	0.827	N/A	N/A
Thermal Storage (new)	John T. Mather Hospital	Electric	0.469	851.251	4.101	1.100	MWh (Input)/MWh (Output)

Notes:

Some of the existing backup generation is not needed during microgrid islanded operation, due to the sufficiency of additional new generation and load curtailment.

206 kW of Load Curtailment during emergency will be based on 97 kW from St. Charles Hospital, 98 kW from John T. Mather Hospital, and 11 kW from Port Jefferson Middle/High School. Same resources will also provide demand response during normal days (please see Table 5).

The two Combined Cool & Heat & Power (CCHP) unit will be equipped with a 313 kW equivalent absorption chillers each.

Absorption Chillers save 366.55 MWh of electricity, if same cooling load was provided by a central chiller, i.e., the 366.55 MWh is the Electric Cooling Load Offset by absorption chiller which is powered by the recovered heat from the two CCHPs.

There is also a Thermal Cool Storage to be installed at John T. Matter hospital with a 469 kW equivalent capacity.

B. *Capacity Impacts*

3. Is development of the microgrid expected to reduce the need for bulk energy suppliers to expand generating capacity, either by directly providing peak load support or by enabling the microgrid's customers to participate in a demand response program?

☐ No – proceed to Question 6

☒ Yes, both by providing peak load support and by enabling participation in a demand response program – proceed to Question 4

☐ Yes, by providing peak load support only – proceed to Question 4

☐ Yes, by enabling participation in a demand response program only – proceed to Question 5

Provision of Peak Load Support

4. Please provide the following information for all distributed energy resources that would be available to provide peak load support:

- **Available capacity:** Please indicate the capacity of each distributed energy resource that would be available to provide peak load support (in MW/year).
- **Current provision of peak load support, if any:** Please indicate whether the distributed energy resource currently provides peak load support.

Please use the same distributed energy resource and facility names from Question 2.

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does distributed energy resource currently provide peak load support?
Solar	John T. Mather Hospital	0.039	☐ Yes
Solar	Spear Elementary School	0.037	☐ Yes
Mather CCHP	John T Mather Hospital	1.600	☐ Yes
St Charles CCHP	St Charles Hospital	1.600	☐ Yes
New Reciprocating Engine	Waste water treatment plant site	2.000	
PV	Port Jefferson Middle/High School	0.156	☐ Yes
Mather Generator 1	John T. Mather Hospital	0.500	
Mather Generator 2	John T. Mather Hospital	0.500	
St Charles Generator 1	St. Charles Hospital	0.900	
St Charles Generator 2	St. Charles Hospital	0.300	
St Charles Generator 3	St. Charles Hospital	0.250	
St Charles Generator 4	St. Charles Hospital	0.250	
St Charles Generator 5	St. Charles Hospital	0.100	
WA Generator 1	Suffolk County Water Authority Supply Well	0.100	
WWTP Generator 1	Waste Water Treatment Plant	0.250	
WWTP Battery	Waste Water Treatment Plant	0.250	☐ Yes
WA Battery	Water Authority	0.300	

Thermal Cool Storage	John T Mather Hospital	0.469	
Absorption Chillers (Cooling Load Offset)	John T Mather Hospital	0.313	
Absorption Chillers (Cooling Load Offset)	St. Charles Hospital	0.313	

If development of the microgrid is also expected to enable the microgrid's customers to participate in a demand response program, please proceed to Question 5. Otherwise, please proceed to Question 6.

Participation in a Demand Response Program

5. Please provide the following information for each facility that is likely to participate in a demand response program following development of the microgrid:

   - **Available capacity:** Please estimate the capacity that would be available to participate in a demand response program (in MW/year) following development of the microgrid.
   - **Capacity currently participating in a demand response program, if any:** Please indicate the capacity (in MW/year), if any, that currently participates in a demand response program.

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently
Mather Hospital	0.098	0
St. Charles Hospital	0.097	0
Port Jefferson Middle/High School	0.011	0

6. Is development of the microgrid expected to enable utilities to avoid or defer expansion of their transmission or distribution networks?

   ☐ Yes – proceed to Question 7

   ☒ No – proceed to Section C

7. Please estimate the impact of the microgrid on utilities' **transmission** capacity requirements. The following question will ask about the impact on distribution capacity.

Impact of Microgrid on Utility Transmission Capacity	Unit
0	MW/year

8. Please estimate the impact of the microgrid on utilities' **distribution** capacity requirements.

Impact of Microgrid on Utility Distribution Capacity	Unit
0	MW/year

C. Project Costs

We are interested in developing a year-by-year profile of project costs over a 20-year operating period. The following questions ask for information on specific categories of costs.

Capital Costs

9. In the table below, please estimate the fully installed cost and lifespan of all equipment associated with the microgrid, including equipment or infrastructure associated with power generation (including combined heat and power systems), energy storage, energy distribution, and interconnection with the local utility.

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
Mather CCHP	6,400,000	20	CCHP
St Charles CCHP	6,400,000	20	CCHP
Switchgear	140,000	30	Microgrid Switchgear installation and upgrades
Existing Generation	120,000	20	Switchgear, protection, step up transformers needed to operate in grid connected mode
Control & Communication	489,060	20	Microgrid controls and communication upgrades
New Reciprocating Engine	4,000,000	30	Generator at or near waste water treatment plant site
Battery	1,320,000	20	Battery installation
Solar	533,400	18	Port Jefferson Middle/High School Solar

Initial Planning and Design Costs

10. Please estimate initial planning and design costs. These costs should include costs associated with project design, building and development permits, efforts to secure financing, marketing the project, and negotiating contracts. Include only upfront costs. Do not include costs associated with operation of the microgrid.

Initial Planning and Design Costs ($)	What cost components are included in this figure?
2,910,369	Engineering, permitting, legal, financing fees, development expenses and fees

Fixed O&M Costs

11. Fixed O&M costs are costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces each year (e.g., software licenses, technical support). Will there be any year-to-year variation in these costs for other reasons (e.g., due to maintenance cycles)?

☒ No – proceed to Question 12

☐ Yes – proceed to Question 13

12. Please estimate any costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces each year.

Fixed O&M Costs ($/year)	What cost components are included in this figure?
132,000	Software upgrades and annual testing

Please proceed to Question 14.

13. For each year over an assumed 20-year operating life, please estimate any costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces.

Year	Fixed O&M Cost ($)	What cost components are included in this figure?
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Variable O&M Costs (Excluding Fuel Costs)

14. Please estimate any costs associated with operating and maintaining the microgrid (excluding fuel costs) that are likely to vary with the amount of energy the system produces each year. Please estimate these costs per unit of energy produced (e.g., $/MWh).

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
17	$/MWh	CCHP at Mather
17	$.MWh	CCHP at St Charles
19	$/MWh	New Reciprocating Engine
22	$/MWh	All Existing Diesel Engines
0	$/MWh	Solar PVs and Storage Systems

Fuel Costs

15. In the table below, please provide information on the fuel use for each distributed energy resource the microgrid will incorporate. Please use the same distributed energy resource and facility names from Question 2.

- **Duration of design event:** For each distributed energy resource, please indicate the maximum period of time in days that the distributed energy resource would be able to operate in islanded mode without replenishing its fuel supply (i.e., the duration of the maximum power outage event for which the system is designed). **For renewable energy resources, your answer may be "indefinitely."**
- **Fuel consumption:** For each distributed energy resource that requires fuel, please specify the quantity of fuel the resource would consume if operated in islanded mode for the assumed duration of the design event.

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
Solar	John T. Mather Hospital	Indefinite	N/A	N/A
Solar	Spear Elementary School	Indefinite	N/A	N/A
Mather CCHP	John T Mather Hospital	7	2,293	MMBtu
St Charles CCHP	St Charles Hospital	7	2,293	MMBtu
New Reciprocating Engine	Waste water treatment plant site	7	2,866	MMBtu
Mather Generator 1	Mather Generator 1	7	818.914	MMBtu

Mather Generator 2	Mather Generator 2	7	818.914	MMBtu
St Charles Generator 1	St Charles Generator 1	7	586.542	MMBtu
St Charles Generator 2	St Charles Generator 2	7	195.514	MMBtu
St Charles Generator 3	St Charles Generator 3	7	162.928	MMBtu
St Charles Generator 4	St Charles Generator 4	7	162.928	MMBtu
St Charles Generator 5	St Charles Generator 5	7	65.171	MMBtu
WA Generator 1	WA Generator 1	7	65.171	MMBtu
WWTP Generator 1	WWTP Generator 1	7	162.928	MMBtu
PV	Port Jefferson Middle/ High School	Indefinite	N/A	N/A

16. Will the project include development of a combined heat and power (CHP) system?

☒ Yes – proceed to Question 17

☐ No – proceed to Question 18

17. If the microgrid will include development of a CHP system, please indicate the type of fuel that will be offset by use of the new CHP system and the annual energy savings (relative to the current heating system) that the new system is expected to provide.

Type of Fuel Offset by New CHP System	Annual Energy Savings Relative to Current Heating System	Unit
Natural gas	135,032	MMBtu
Electricity (by CCHP Absorption Chillers)	366.55	MWh

The two Combined Cool & Heat & Power (CCHP) units will be equipped with a 323 kW equivalent absorption chillers each.

Absorption Chiller saves 366.55 MWh of electricity, if same cooling load was provided by a central chiller, i.e., the 366.55 MWh is the Electric Cooling Load Offset by the absorption chillers which are powered by the recovered heat from the two CCHPs.

Thermal Cool Storage does not offset use of any energy, so it was not included in the above table.

Emissions Control Costs

18. We anticipate that the costs of installing and operating emissions control equipment will be incorporated into the capital and O&M cost estimates you provided in response to the questions above. If this is not the case, please estimate these costs,

noting what cost components are included in these estimates. For capital costs, please also estimate the engineering lifespan of each component.

Cost Category	Costs ($)	Description of Component(s)	Component Lifespan(s) (round to nearest year)
Capital Costs ($)	0		
Annual O&M Costs ($/MWh)	0		
Other Annual Costs ($/Year)	0		

19. Will environmental regulations mandate the purchase of emissions allowances for the microgrid (for example, due to system size thresholds)?

☐ Yes

☒ No

D. Environmental Impacts

20. For each pollutant listed below, what is the estimated emissions rate (e.g., tons/MWh) for the microgrid?

Emissions Type	Emissions /MWh	Unit
CO_2	0.476	Short tons/MWh
SO_2	0.00000649	Short tons/MWh
NO_x	0	Short tons/MWh
PM	0	Short tons/MWh

E. Ancillary Services

21. Will the microgrid be designed to provide any of the following ancillary services? If so, we may contact you for additional information.

Ancillary Service	Yes	No
Frequency or Real Power Support	☒	☐
Voltage or Reactive Power Support	☒	☐
Black Start or System Restoration Support	☒	☐

F. Power Quality and Reliability

22. Will the microgrid improve power quality for the facilities it serves?

☒ Yes – proceed to Question 23

☐ No – proceed to Question 24

23. If the microgrid will result in power quality improvements, how many power quality events (e.g., voltage sags, swells, momentary outages) will the microgrid avoid each year, on average? Please also indicate which facilities will experience these improvements.

Number of Power Quality Events Avoided Each Year	Which facilities will experience these improvements?
3	All facilities on microgrid

24. The benefit-cost analysis model will characterize the potential reliability benefits of a microgrid based, in part, on standard estimates of the frequency and duration of power outages for the local utility. In the table below, please estimate your local utility's average **outage frequency per customer** (system average interruption frequency index, or SAIFI, in events per customer per year) and average **outage duration per customer** (customer average interruption duration index, or CAIDI, in hours per event per customer).

For reference, the values cited in the Department of Public Service's 2014 Electric Reliability Performance Report are provided on the following page. If your project would be located in an area served by one of the utilities listed, please use the values given for that utility. If your project would be located in an area served by a utility that is not listed, please provide your best estimate of SAIFI and CAIDI values for the utility that serves your area. In developing your estimate, please *exclude* outages caused by major storms (a major storm is defined as any storm which causes service interruptions of at least 10 percent of customers in an operating area, and/or interruptions with duration of 24 hours or more). This will ensure that your estimates are consistent with those provided for the utilities listed on the following page.[1]

Estimated SAIFI	Estimated CAIDI
0.76	1.42

[1] The DPS service interruption 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 Con Edison's underground network system). SAIFI and CAIDI 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. The BCA model treats the benefits of averting lengthy outages caused by major storms as a separate category; therefore, the analysis of reliability benefits focuses on the effect of a microgrid on SAIFI and CAIDI values that exclude outages caused by major storms.

SAIFI and CAIDI Values for 2014, as reported by DPS

Utility	SAIFI (events per year per customer)	CAIDI (hours per event per customer)
Central Hudson Gas & Electric	1.62	3.74
Con Edison	0.11	3.09
PSEG Long Island	0.76	1.42
National Grid	1.17	2.87
New York State Electric & Gas	1.34	2.97
Orange & Rockland	1.19	2.4
Rochester Gas & Electric	0.85	2.32
Statewide	*0.68*	*2.7*
Source: New York State Department of Public Service, Electric Distribution Systems Office of Electric, Gas, and Water. June 2015. 2014 Electric Reliability Performance Report, accessed at: http://www3.dps.ny.gov/W/PSCWeb.nsf/All/D82A200687D96D3985257687006F39CA?OpenDocument.		

G. Other Information

25. If you would like to include any other information on the proposed microgrid, please provide it here.

Port Jefferson has a population of approximately 7,700, and is located on the north shore of Long Island, about 60 miles east of midtown Manhattan. Port Jefferson is the key transportation hub and evacuation route on the north shore of Long Island. Port Jefferson features a major ferry route, a Long Island Railroad terminus, multiple bus lines, and an extensive network of roads.

The Bridgeport & Port Jefferson Ferry is one of two routes connecting Long Island to New England. The other route is the Cross Sound Ferry at Orient Point; about 60 miles to the east, and no bridges or tunnels exist despite past proposals. The ferry can accommodate 85 vehicles per voyage, and has 16 departures each day.

The village additionally serves as the eastern terminus for the Long Island Railroad's Port Jefferson Branch, and connects with Pennsylvania Station in Manhattan or to Atlantic Terminal in Brooklyn.

Port Jefferson's main street forms a section of New York State Route 25A, a scenic and historic route through Long Island's North Shore that is locally known as North Country Road and continues westward to New York City. Also near the village is New York State Route 347, a larger highway that connects to the Northern State Parkway. Port Jefferson has a number of facilities that are critical both to Port Jefferson and central Suffolk County, including Mather and St. Charles hospitals that have a total of over 550 beds. The village experienced major power outages and flooding following Hurricane Sandy, and other storms. In addition, PSEG-LI and the PSC have identified Port Jefferson as a possible area for a microgrid project.