75 - City of Oswego

Notice

City of Oswego Feasibility Assessment Report for **NY Prize Community Grid Competition**

Oswego Microgrid

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Stage 1: Feasibility Assessment *NYSERDA RFP 3044*

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Section 1 – Project Summary and Description

This first section of the report provides background information about the proposed microgrid and the process undertaken to assess technical and economic feasibility. Section 2 provides detailed information about the preliminary technical design costs and configuration.

Project Summary

The microgrid being considered for Oswego would provide power resilience to one of the snowiest towns in the United States. The average annual snowfall in Oswego is 92.0 inches with some winters totaling over 300 inches - substantially higher than New York State's average of 55.3 inches. In 2007, Oswego received national attention when approximately 130" (nearly 11 feet) of snow fell within a two-week period, breaking a previous record set in 1966. As a result of this storm, the school district closed all facilities for a week and the county opened an Emergency Operations Center for 13 days. Oswego County was declared a State Disaster Area on February 8, 2007 and New York State's Transportation Infrastructure Group was recruited to help with snow removal. A Presidential Declaration for a Snow Emergency resulted in an award of $783,341 in public assistance for the County, its municipalities, and public agencies. According to records from the NYS Office of Emergency Management and the Federal Emergency Management Agency, Oswego County experienced six weather-related Presidential Disaster Declarations between 1954 and 2010 including an ice storm, flooding, Hurricane Eloise in 1975, severe storms, high winds and wave action and Tropical Storm Agnes. In addition, five Emergency Declarations were issued between 1974 and 2010 in the County, including lake effect storms, Hurricane Katrina evacuation, and a power outage.

The microgrid would, as presently conceptualized, provide power to four critical facilities that all play a critical role in the community and region. SUNY Oswego enrolls approximately 8,000 students, some 7,000 of them full-time undergraduates. SUNY Oswego's Laker Hall also serves as a State of New York planned emergency response center with the ability to accommodate up to approximately 1,200 residents. The next available SUNY emergency response center location is 45 miles south in Syracuse, NY. It is expected that the Proposed Oswego Microgrid will improve overall system efficiency at SUNY Oswego and may also allow for an increase in the capacity of the emergency response center by up to 300% (roughly 3600 people) by supplying uninterrupted heat and power to several additional campus buildings.

The City of Oswego Water Department is responsible for providing potable water to the City of Oswego and the Town of Scriba. The Water Treatment Plant has a capacity of over 20 million gallons per day ("MGD") with a combined storage capacity of 11 million gallons. The Water Treatment Plant serves a population of 29,400 (18,000+ in Oswego and 7,300 in the Town of Scriba) comprised of residential, commercial, and industrial customers and also serves the fire protection needs of the community.

From an intake shared with the City of Oswego Water Treatment Plant, the Metropolitan Water Board also pumps "raw" water to its nearby water treatment plant where it is filtered, purified and tested prior to the transmission of "finished" water. The Raw Water Pumping Station has a design capacity of 72 MGD and supplies between 20 and 54 MGD depending upon customer demands. This pumping station serves a population of 500,000 in the following five counties: Onondaga, Oneida, Oswego, Madison and Cayuga.

The west side sewer and wastewater management system serves approximately 10,000 people on the west side of Oswego including the entire SUNY Oswego campus as well as small portions of the Town of Minetto and accommodates combined sanitary and storm water sewers and related overflows during storm events. A failure of in the wastewater system can result in environmental and property damage caused by raw sewage entering watersheds or backing up into homes and businesses.

It is proposed that NRG, through a wholly-owned special purpose entity, will own the microgrid, and the above noted public entities will be the off-takers of the power and microgrid services.

1.1 Minimum Required Capabilities

The proposed microgrid concept includes representation of all the critical facilities located on separate properties within a pre-defined microgrid area. As additional visibility is gained into electrical demand, infrastructure challenges, and isolation challenges for islanded operation, the final determination of what facilities can be practically served will be made. The facilities of the proposed microgrid are shown in the following table and further shown in Figure 1-1.

	RISK AREA	*CRITICAL FACILITY**	*COMMUNITY VALUE*	*SOCIALLY VULNERABLE POPULATION*
SUNY OSWEGO CAMPUS	High	No, locally significant	High	Yes
WATER TREATMENT PLANT	High	No, locally significant	High	Yes
WASTEWATER PLANT	High	No, locally significant	High	Yes
RAW WATER PUMPING STATION	High	No, locally significant	High	No

*"Critical Facility" designation is as defined by FEMA in terms of scale and magnitude of the potential loss of life that would likely result.

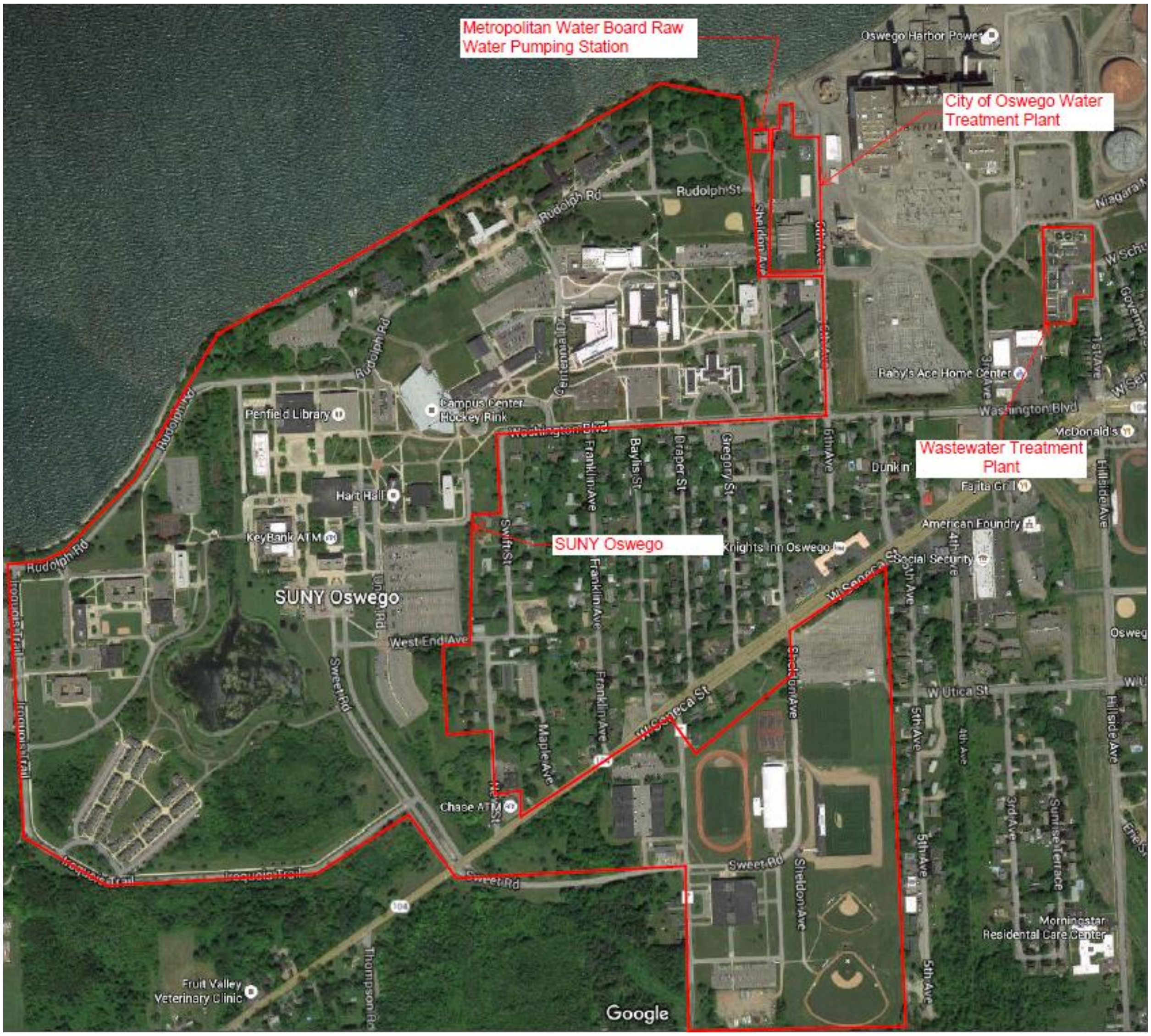
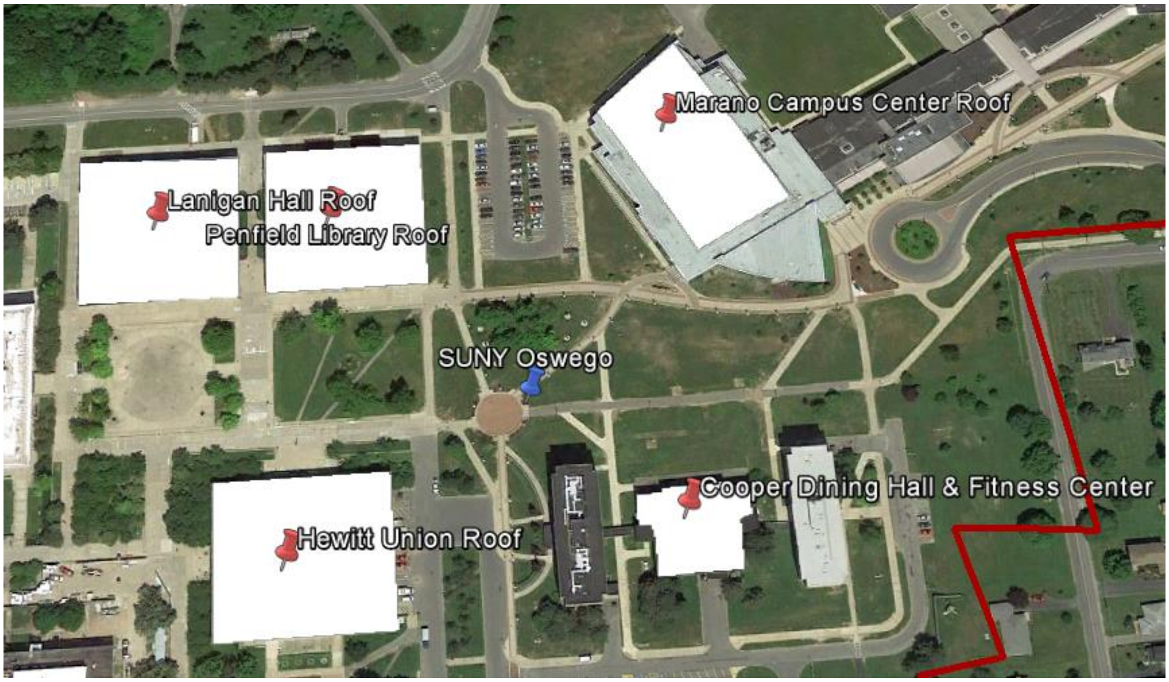


Figure 1-1: Overview of the Proposed Microgrid Location and the Facilities Served

In microgrid applications depending on the types of loads, natural gas engines are typically preferable to diesel engines provided that there is an existing natural gas distribution network. In addition, natural gas supply has proven to be highly reliable, with limited or no interruptions even during severe weather events.

In most cases, existing diesel storage systems are sized to enable diesel engine operations for a day or two during short-term grid outages. So, one of the factors against selection of diesel engines is the availability of adequate storage to ensure uninterrupted operation of the microgrid for a period of at least two weeks.



A variety of distributed energy resources are being evaluated at a conceptual level to provide diverse, integrated and resilient power to the Oswego Microgrid. Presented below are initial DER considerations and applications:

Combined Heat and Power (CHP) or Cogeneration

For maximum economic performance, CHP requires a consistent thermal/heat sink. The four primary facilities, SUNY Oswego, the Water Treatment Plant (WTP), wastewater treatment plant (WWTP) and the MWB raw water pumping station (WPS), have varying thermal loads, with only SUNY requiring thermal energy all year. SUNY, by virtue of its size and function, has a significant thermal requirement during the winter. This load decreases during the non-heating season, but there remains a minimum thermal requirement for domestic hot water during the warmer months. The remaining three have very limited to no hot water requirements during the summer.

Solar PV

The estimated combined rooftop and ground-mounted capacity of the microgrid facilities is estimated to exceed 1 MW. This estimated range is based on nameplate capacity with peak output occurring on a few hours during peak sunny days in summer. Questions related to roof load bearing capacity, local wind regimes, and mechanically attached vs ballasting are beyond the scope of this assessment and remain to be assessed. Based on the potential for high winds off of Lake Ontario, adequate wind resistance is a critical factor. Similarly, due to the “lake-effect”, snowfall amounts can be significant. This impacts the viability of PV during the winter months and the resilience value of this generation source even when coupled to energy storage.

Battery Storage
Battery storage mitigates electric load variability and ensures higher levels of power quality and microgrid stability.

Fuel Cells
Fuel cells need to operate at a consistent output level, i.e., base-loaded, as they are not well suited to starting up quickly or following electric loads.

Wind Power
Small-scale wind power, both ground and building mounted, would benefit from what is a relatively high wind resource due to the lakeshore location. However, issues related to permitting, noise, aesthetics, and concerns for birdlife can limit this option.

Backup Generators
The installed capacity of backup generation within the proposed microgrid exceeds 4.3 MW:

SITE/FACILITY	CAPACITY (kW)	FUEL	# of Units
SUNY OSWEGO Natural Gas	1,270	Nat Gas	21
SUNY OSWEGO Diesel	2,634	Diesel	13
SUNY OSWEGO Total:	3,904	Mix	34
Raw Water Pumping Station	0	N/A	
Wastewater Treatment Plant	450	Nat Gas	1
Water Treatment Plant	0	N/A	
TOTAL BACKUP-All Facilities	**4,354**		**35**

Most of the 13 residence halls at SUNY Oswego are equipped with backup generators, as is the Shineman Science Building and the Central Heating Plant (both diesel). Two critical facilities, the Raw Water Pumping Station and the Water Treatment Plant are not backed up. Also, there is no storage option.

Depending on the nature and duration of the events or circumstances causing the prolonged islanded condition, it is expected that in most instances the already installed backup generation would serve to provide both incremental output to the microgrid facilities during peak demand periods and redundancy in the event of a major failure of primary distributed energy resources.

Microgrid Control System

Along with the advanced microgrid controller being developed in a DOE project by GE, NREL and others, a set of commercial platforms are also available as candidate solutions. The available commercial microgrid control platforms vary in functionality, and 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 to the microgrid, as well as the utility enterprise systems (EMS/DMS/OMS) and the ISO control center.

Microgrid Islanding

This is the situation where distributed generation or a microgrid continues energization of 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 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 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 microgrid to seamlessly and quickly transition to islanded mode, and also incorporate the appropriate communications and controls technologies (also discussed above) that would allow the microgrid to remain electrically viable and persist for the duration of the emergency, subject to fuel availability. Many utilities have been historically resistant to intentional islanding, however, with the correct IEEE 1547 settings in the protective relays, and the potential to incorporate utility direct transfer tripping, this obstacle is expected to be overcome.

The 2013 New York State Department of Public Service (“DPS”) data also clearly shows that the total customer hours of interruption due to major storms has increased substantially over the last two decades, particularly since 2010. With this in mind, the project team will develop a resilient design that incorporates hardening strategies commonly practiced by systems engineers in areas exposed to storms and outage events. This includes flood avoidance and flood control measures applied to generators, transformers, and switchgear, fault-tolerant and self-healing network designs, redundant supply or reconfigurable supply where it makes sense, remote monitoring and diagnostic equipment, robust construction, undergrounding where possible, and a host of other time-tested measures.

In general, history has shown that while “blue sky” outage events are stochastic, they can be clustered during times of high demand when the system is stressed. Also, major storm-related events (hurricanes, ice, snow, tornadoes, etc.) are more likely during certain seasons or months of the year than others.

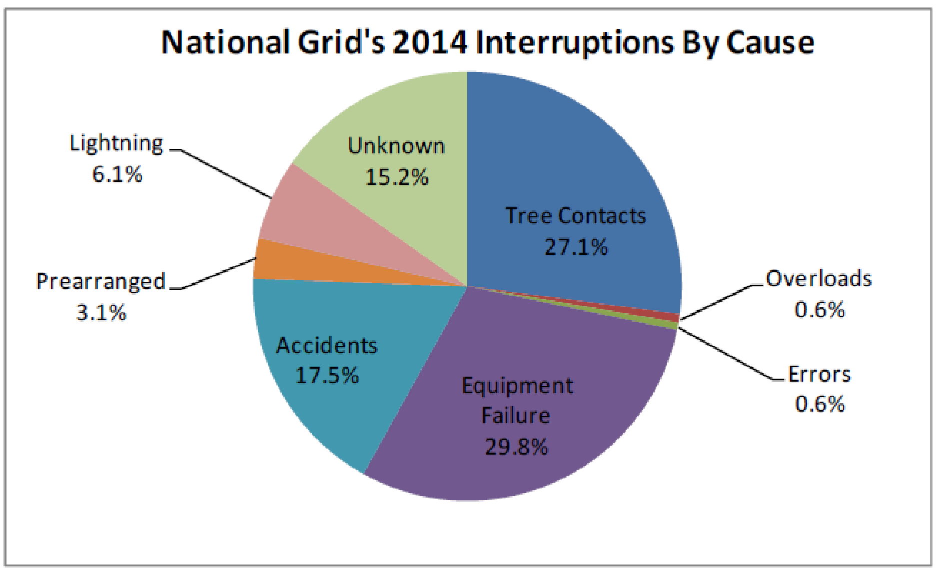
Oswego History of Extreme Weather and Major Outage

Oswego is considered one of the snowiest towns in the United States due to the lake effect. The average annual snowfall in Oswego is 92.0 inches with some winters totaling over 300 inches - substantially higher than New York State’s average of 55.3 inches. In 2007, Oswego received national attention when approximately 130” (nearly 11 feet) of snow fell within a two-week period, breaking a previous record set in 1966. As a result of this storm, the school district closed all facilities for a week and the county opened an Emergency Operations Center for 13 days. Oswego County was declared a State Disaster Area on February 8, 2007 and New York State's Transportation Infrastructure Group was recruited to help with snow removal. A Presidential Declaration for a Snow Emergency resulted in an award of $783,341 in public assistance for the County, its municipalities, and public agencies. According to records from the NYS Office of Emergency Management and the Federal Emergency Management Agency, Oswego County experienced six weather-related Presidential Disaster Declarations between 1954 and 2010 including an ice storm, flooding, Hurricane Eloise in 1975, severe storms, high winds and wave action and Tropical Storm Agnes. In addition, five Emergency Declarations were issued between 1974 and 2010 in the County, including lake effect storms, Hurricane Katrina evacuation, and a power outage. The following table reflects National Grid's Reliability system-wide.

National Grid Reliability Information

Performance Metric	2010	2011	2012	2013	2014	Current RPM Target	5-Year Average
Frequency (SAIFI)	0.80	0.98	0.90	0.99	0.96	1.13	0.92
Duration (CAIDI)	1.98	1.95	2.04	1.96	1.94	2.05	1.97

As is common to most utilities, a majority of faults and loss of power were the direct consequence of natural events, but also a large percentage of equipment failures.



Microgrid Design Considerations

The microgrid's functional design considers both the sufficiency and control and communication capability for generation to maintain voltage and frequency while in islanded mode. The study also explores the economics of energy storage both as a resource for capturing variable renewable energy, if any, to ensure reliability of meeting load during emergency or engage in energy arbitrage with the grid, and for providing ancillary services to the grid.

As part of evaluating the load / generation mix, several classifications of load were 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 was 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 is required 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.

Though islanded operation of the microgrid was the primary driver for determining the load / generation mix, size and operating modes and import / export in grid-connected mode was also evaluated. The import / export of power to and from the microgrid were determined from the Load & Supply Analysis 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).

The project teamconsidered design options for two-way communication and control between the community microgrid owner/operator and the local distribution utility through automated and seamless integration, including processes to secure control/communication systems from cyber-intrusions/ disruptions and protect the privacy of sensitive data.

The project team will evaluate 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 trade-off 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 project team considered at a preliminary level 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. Based on the preliminary feasibility scope of this project, no final determination was made as to the appropriateness and cost-benefit of these cyber security measures.

Critical Facilities

The four facilities that comprise the Proposed Oswego Microgrid all play a critical role in the community and region:

Education and Emergency Response Services: SUNY Oswego enrolls approximately 8,000 students, some 7,000 of them full-time undergraduates. Overall, Oswego's lakeside campus stretches for almost 700 acres and includes 58 buildings. Around 4,400 students live on campus among the college's 13 residence halls and communities. SUNY Oswego’s Laker Hall also serves as a State of New York planned emergency response center with the ability to accommodate up to approximately 1,200 residents. The next available SUNY emergency response center location is 45 miles south in Syracuse, NY. Since emergency events typically take place during winter months as a result of record snow falls in Oswego, it is important to ensure that emergency shelters at SUNY Oswego have reliable sources of power and heat. It is expected that the Proposed Oswego Microgrid will improve overall system efficiency at SUNY Oswego and may also allow for an increase in the capacity of the emergency response center by up to 300% by supplying uninterrupted heat and power to several additional campus buildings.

Potable Water Supply: The Water Department is responsible for providing potable water to Oswego and the Town of Scriba. The Water Treatment Plant has a capacity of over 20 million gallons per day (“MGD”) with a combined storage capacity of 11 million gallons. The Water Treatment Plant serves a population of 29,400 (18,000+ in Oswego and 7,300 in the Town of Scriba) comprised of residential, commercial, and industrial customers and also serves the fire protection needs of the community. Sithe Independence Power Station (“Independence Station”), a 1,108 MW combined cycle gas turbine power generating facility, also relies on a substantial portion of the City’s water production to supply the cooling water necessary for its operation. Without this water, the plant would be forced to shut down. The Water Treatment Plant currently uses two aging boilers for building heat and receives power from two grid connections which share a common 34.5kV transformer. If grid power to those connections goes down, the Water Treatment Plant will be without power and not be able to operate. From an intake shared with the City of Oswego Water Treatment Plant, the Metropolitan Water Board also pumps "raw" water to its nearby water treatment plant where it is filtered, purified and tested prior to the transmission of "finished" water. The Raw Water Pumping Station has a design capacity of 72 MGD and supplies between 20 and 54 MGD depending upon customer demands. This pumping station serves a population of 500,000 in the following five counties, including: Onondaga, Oneida, Oswego, Madison and Cayuga. There is no back-up power at this site; however, procurement of a diesel generator is being considered for the Raw Water Pumping Station through the Metropolitan Water Board's energy performance-based project that would involve its Raw Water Pumping Station. The implementation of a microgrid could negate the need to procure this backup generator.

Wastewater Management: The west side sewer system serves approximately 10,000 people on the west side of Oswego including the entire SUNY Oswego campus as well as small portions of the Town of Minetto and accommodates combined sanitary and storm water sewers and related overflows during storm events. The west side sewer system includes over 90 miles of sanitary sewer and storm water pipe and the West Side Wastewater Treatment Plant, a 4 MGD (12 MGD wet weather capacity) activated sludge facility. The West Side plant also operates an Excess Flow Management Facility. A failure of in the wastewater system can result in environmental and property damage caused by raw sewage entering watersheds or backing up into homes and businesses. Currently, a 450 kW backup generator is in place and able to meet the load of the plant.

Uninterruptable Fuel Supply

The natural gas fired plants are supplied by pipeline. Renewable resources would be constrained by the extent of storage deployed in the microgrid and the intermittency of the renewable source.

Resilience to Extreme Weather

The microgrid design takes into account GE-EC's findings from its NJ Storm Hardening Project performed for the NJ Board of Public Utilities. On-site power generation mitigates the risk of excess load on underground wires. The project team considered the utilization underground distribution as much as possible in order to mitigate the risk of power cuts due to high winds, flooding and icing.

The project team expects that natural gas powered generation should be able to run for days without an operator being on-site; however, the project team will work with City authorities and stakeholders to ensure that clearing of snow or dirt and debris from solar panels and providing access to microgrid assets has a high priority.

Black Start Capability

The proposed microgrid will be designed to provide black start capability. It will be designed to be automatic based on a specified time frame of sustained utility outage and/or 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.

1.2 Preferable Microgrid Capabilities

The proposed microgrid is a microcosm of the modern electric power system, and to that extent, the application of advanced automation and control technologies was explored to enable enhanced visualization, monitoring, control and interaction.

Reliability-oriented Smart Grid-Distribution Automation (SG-DA), including automated field devices (switches, sensors, and reclosers) and decentralized or centralized control, improve reliability by accelerating the detection and isolation of faults and reconfiguring the delivery system to restore service more quickly to more customers (wherever feasible). The project team explored the application of SG-DA solutions to the community microgrid to ensure reliability in both connected and islanded mode and to enable rapid, seamless transfer when the grid is down. Final determination of SG-DA solutions to the proposed microgrid will occur as part of a potential Stage 2 engineering and design effort.

The project team evaluated at a preliminary level the current set of available commercial microgrid controllers. As part of a potential Stage 2, a best of breed selection will be made to obtain alignment with the microgrid site's requirements. From recent microgrid studies, the project team is 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.

The project team considered opportunities to incorporate renewable resources into the generation mix for the Oswego microgrid. The project's preliminary design is based on the generation resource mix (as determined by the availability and potential costs-benefits) and desired environmental requirements.

Energy efficiency options were considered at a high level. Ultimately, the energy efficiency of the system will be based on the final choice of new equipment and devices that in turn will be determined as part of a detailed design. Also part of the final design will be demand response functionalities for scheduling and control of the demand response resources included in the microgrid.

At this stage, the study considered the potential of demand response at Oswego based on experience and best engineering estimates, and determined that 10% of load could be curtailed.Electric and thermal loads were classified as critical, discretionary, and curtailable. Curtailable loads, as the name implies, are loads that can immediately be dropped. Discretionary load is more akin to more recent demand response programs. However, the main signal to activate the demand response's action is the microgrid's own assessment of availability of supply instead of utility's price or event signal.

As part of Stage 2, specific demand response options will be determined 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.

Microgrid Interface and Interconnection with Macro Grid

The project team conferred with National Grid 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 preliminary design of the microgrid accounts for the current utility distribution network and equipment with due consideration of relative costs and benefits. The project team assessed the requirements for the interconnection or interconnections between the microgrid and the larger grid, in terms of installation, operations, maintenance, and communications. Section 2 describes the requirements in the functional design of the microgrid and its point or points of contact with the larger grid.

Alignment with REV

The project team considered market opportunities to establish public-private partnerships and develop efficient and resilient microgrids, and evaluated at a high level the demand for enhanced reliability/resiliency services. The proposed microgrid promotes clean distributed generation, and creates quantifiable value steams that may be replicated and used to engage additional customers.

Cost Benefit Analysis

The project 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. On the cost side, the project 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, and (c) costs of the control and communications infrastructure. On the benefit side, the project 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 included estimation of avoided costs of power interruptions for different facilities within the microgrid.

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

In addition, the BCA includes societal net benefits/costs. The project team drew on learnings from the original NYSERDA-DPS-DHSES 5-site study (Microgrids for Critical Facility Resiliency in New York State, NYSERDA Report Number 14-36), which included consideration of various financial benefit and cost streams and was supplemented by accounting for other non-tangible benefits and costs, including environmental benefits and avoided interruption costs. This last item (avoided interruption costs), which is more difficult to quantify, can be 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.

Another benefit of the proposed microgrid has to do with the leveraging of private capital and third-party operational and energy asset ownership experience. NRG, for example, may consider development and construction of the microgrid using its own capital, thereby minimizing public sector capital outlays and overall project risk exposure.

The project will positively impact thousands of Oswego residents as it will enhance both the grid's reliability and resilience in response to extreme weather events and other grid emergencies, provide for operational continuity and, reduce local emissions from the use of renewable resources including solar and ultra-low emitting fuel cells.

The project team considered 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 Reforming of Energy Vision (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 project 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 project team understands that actionable information will enable 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. Such actionable information would function and be used mostly in the background in automated microgrid systems, although it may be accessible to customers when requested or queried.

Section 2 – Preliminary Technical Design Costs and Configuration

Executive Summary

The Oswego microgrid will connect the SUNY Oswego Campus (SUNY), City of Oswego Water Department (WTP), Onondaga County Metropolitan Water Board – Raw Water Pumping Station (MWB), and City of Oswego Wastewater Department (WWD).

These facilities are critical to maintaining municipal services to the businesses and residents of the area, and present a unique educational opportunity for the University and residents of the area.

The proposed Oswego microgrid includes 1,270kW of existing natural gas generators, 2,634kW of existing diesel generators, two (2) 2,000kW fuel cells, and one (1) 1,000kW CHP generator all located at SUNY Oswego. At the City of Oswego Waste Water Plant (WWTP), the planned microgrid will incorporate an existing 450kW dual-fuel natural gas generator. The Water Treatment Plant (WTP) will incorporate a new 100kW solar/storage system.

The microgrid control system (or energy management system) is responsible for monitoring the microgrid resources in grid connected mode and controlling the voltage and frequency in islanded mode. This is accomplished via a hierarchy of controller devices that communicate through a new dedicated wireless or fiber-optic network. Besides dispatching optimal levels of generation and managing load in the microgrid facilities, the main task of the control system will be to coordinate the switching devices at the interconnection points with the surrounding distribution network.

2.1 Proposed Microgrid Infrastructure and Operations

2.1.1 Provide a simplified equipment layout diagram and a simplified one-line diagram of the proposed microgrid, include location of the distributed energy resources (DER) and utility interconnection points. Identify new and existing infrastructure that will a part of the microgrid

Figure 2-1 shows a simplified layout of the Oswego microgrid showing electrical interconnection of microgrid facilities. The microgrid benefits from the close proximity of the MWB Raw Water Pumping Station, and SUNY, and WTP's substations. The microgrid design will feature a new lineup of paralleling switchgear with advanced controls to isolate and island from National Grid as necessary. The existing 34.5 kV feeder connection to each of these facilities will remain "as is" and the microgrid will operate in parallel with OSWEGO-VARICK 207, CITY PUMP NO. 26, and PALOMA FEEDER NO. 25453.

The microgrid assets will be tied together via directional boring or ductbanks to connect to the microgrid paralleling bus, which will be responsible for controlling the various assets and maintaining the necessary electrical protection interface with National Grid.

Figure 2-1 Simplified layout of Oswego microgrid showing routing of electrical connections and select facilities

Figure 2-2 below shows a simplified one-line diagram with the location of the distributed energy resources (DER) and the utility interconnection points. The major additions include 1 MW of CHP at the SUNY Oswego steam plant, and 4 MW of fuel cells tied into the medium voltage distribution system.

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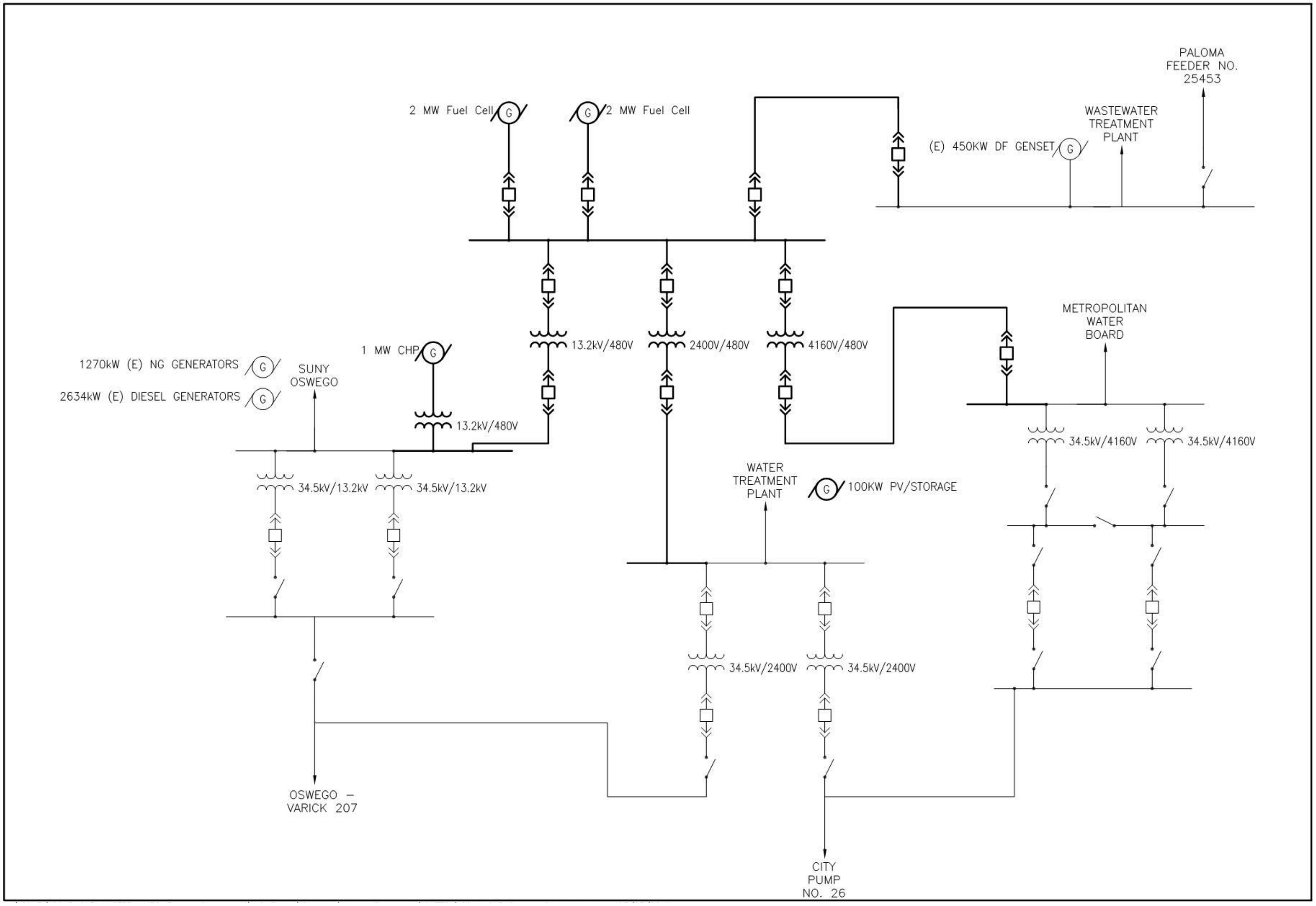

Figure 2-2 Oswego microgrid one-line diagram showing generation sources and major equipment

2.1.2 Provide a brief narrative describing how the proposed microgrid will operate under normal and emergency conditions. Include description of normal and emergency operations.

Normal Conditions

Under normal conditions, the facilities that will be part of the microgrid are fed by the 34.5 kV sub-transmission system stepped down to 13.2 kV for SUNY Oswego, 2.4 kV for the water treatment plant, and 4.16 kV for the Metropolitan Water Board. The fuel cell generation is stepped up (with appropriate transformers) to feed into the buses for each of these loads. The CHP generation will feed into the local SUNY Oswego 13.2 kV distribution system and be connected through existing duct bank connection from the SUNY substation and campus. The additional generation installed for microgrid will continue to operate during normal conditions, reducing the peak demand of the system and possibly reducing the energy cost.

Emergency Conditions

Under emergency conditions, the three facilities will be isolated from the 34.5 kV system via IEEE 1547 compliant breakers and relay upgrades. The fuel cells will feed the water treatment plant through a direct 2.4 kV connection, the SUNY Oswego campus through a direct 13.2 kV connection and the pumping station through a direct 4.16 kV connection at the Substation. The CHP unit at SUNY can also be able to be black-started if necessary through the usage of the existing natural gas generators.

The microgrid controller which is monitoring the points of facility interconnection (POIs) with the main grid and the switchgears that form boundary of microgrid will sense loss of voltage or frequency, and the CHP and other inverter based generations (PV, battery, fuel cells) will go off-line (in accordance with anti-islanding protection procedures). Existing backup generation at SUNY Oswego and the wastewater treatment plant will start up to supply critical loads in those facilities. Once the facilities are isolated from the utility system and each other, the Fuel Cell units and CHP will restart and synchronize with the online backup generation (5-10 minutes). When the generation is stabilized, the breakers are closed in and the microgrid is formed with the load at all facilities being served by fuel cells, CHP and backup generators (which may be ramped down if not 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. Loads on some breakers could be shed and some backup 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 to microgrid mode is possible. In this scenario inverter-based generation would remain online during the transition, and the microgrid controller would shed load quickly or bring backup generation online to maintain balance in the island.

2.2 Load Characterization

2.2.1 Fully describe the electrical and thermal loads served by the microgrid when operating in islanded and parallel modes: Peak KW, Average KW, annual/monthly/weekly KWh, annual/monthly/weekly BTU(consumed and recovered) and identify the location of the electrical loads on the simplified equipment layout and one-line diagrams.

In parallel mode, each facility will be on its own and either be fed by its onsite facility or purchase power from the grid. The fuel cell and CHP units will be running at close to full capacity in most days during on-peak periods subject to their ramp up and ramp down constraints. Power will be imported from the grid to make up any shortfall over the load cycle.

In islanded mode the identified facility electrical loads will be met by the microgrid generation. The fuel cells and CHP will serve as base load generation and online reciprocating engines will modulate output to match the electrical demand of the island. Whenever demand exceeds CHP generation capacity, curtailable load will be shed and/or backup generation will be brought online to fill the gap. The existing generators located at SUNY are fueled with natural gas, and hence able to draw from firm supplies.

During an emergency, a portion of the microgrid load equivalent to about 5% of peak load of the facilities (about 400 kW) will be curtailed. These demand-side resources will also be available during normal blue sky days for participation in the utility or NYISO demand response programs.

The only thermal load included in the microgrid is the heating load of the SUNY Oswego. The recovered thermal energy from the 1,000 kW CHP, to be installed in the SUNY Oswego amounts to 3.4 mmbtus/hour, will provide a small portion of the annual thermal needs of the SUNY (with the rest to be met by the existing thermal system in SUNY). This sizing was based on summer thermal demand; sizing the system larger would waste heat, lower overall system efficiency and reduce the economic benefit of the CHP system. The facility annual electrical and thermal energy and peak demand are provided in the following tables.

	Energy (kWh)	Peak (kW)
January	4,180,349	6,385
February	3,993,349	6,731
March	4,420,087	6,637
April	3,940,038	6,304
May	4,571,566	7,086
June	3,870,341	6,287
July	4,963,062	7,754
August	5,391,821	8,844
September	5,725,855	9,247
October	4,261,810	6,731
November	3,984,942	6,463
December	4,151,084	6,277
Annual	53,454,303	9,247

Table 2-1: Monthly Microgrid Electrical Load

	Energy (kWh)	Peak (kW)
January	9,422,209	21,489
February	12,030,621	30,850
March	12,609,620	28,072
April	10,474,141	26,049
May	7,269,355	17,137
June	3,957,096	9,321
July	2,099,704	5,113
August	2,242,630	5,402
September	2,422,562	5,662
October	2,844,161	6,643
November	4,568,618	10,676
December	7,814,395	17,570
Annual	77,755,111	30,850

Table 2-2: Monthly Microgrid Thermal Load

2.2.2 Provide hourly load profile of the loads included in the microgrid and identify the source of the data. If hourly loads are not available, best alternative information shall be provided.

The sources of data are both the hourly load data and also the electric and fuel billing statements. The monthly energy information was used and applied to various 12 x 24 load profiles from the DER-CAM model for appropriate facility types in order to develop the individual 12 x 24 facility load profiles, and then aggregated into the total microgrid load.

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

Table 2-3: Microgrid 12x24 Electrical Load

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
week	January	5175	4843	4693	4711	4757	4915	5273	5673	5922	5976	6181	6201	6279	6303	6359	6284	6166	6385	6293	6196	6162	5845	5587	5232
week	February	5505	5350	5156	5123	5107	5168	5566	5849	6000	6229	6345	6557	6658	6616	6731	6605	6534	6695	6615	6644	6483	6246	6014	5669
week	March	5705	5482	5232	5091	5069	5198	5601	5711	6002	6237	6366	6388	6576	6616	6637	6547	6504	6539	6625	6481	6468	6360	6136	5792
week	April	5259	4882	4741	4684	4604	4750	5085	5153	5682	5878	6035	6099	6194	6304	6250	6220	6219	6038	5893	5818	5966	5967	5737	5429
week	May	5650	5508	5411	5380	5325	5503	5853	6243	6547	6873	6874	6923	7086	6986	6960	6821	6752	6823	6724	6787	6859	6669	6479	6083
week	June	5020	5021	4919	4766	4810	4910	5275	5651	5871	6087	6165	6172	6287	6129	5828	5909	5768	5744	5673	5532	5521	5447	5036	4893
week	July	6259	6063	5639	5537	5563	5722	6178	6617	6907	6832	7251	7702	7603	7748	7754	7611	7377	7416	7297	7238	7233	7032	6700	6485
week	August	6565	6578	6414	6419	6457	6481	6735	7246	7842	8287	8515	8754	8793	8844	8303	8237	7986	7882	7718	7667	7785	7975	7641	6963
week	September	7464	7294	7056	6897	6819	6904	7573	7915	8341	8710	8836	9066	9225	9146	9247	9176	9143	9070	9043	9003	9029	8583	8355	7812
week	October	5336	5076	4857	4837	4746	4877	5335	5541	5812	6066	6232	6578	6731	6697	6731	6651	6631	6449	6477	6402	6341	6038	5925	5512
week	November	5154	5053	4817	4792	4744	4849	5261	5393	5642	5736	6114	6326	6463	6280	6140	6284	6234	6280	6258	6026	5964	5837	5646	5249
week	December	5184	4887	4635	4609	4599	4630	5179	5632	5790	5837	6140	6202	6249	6170	6219	6179	6241	6277	6197	6169	6092	5953	5761	5431
weekend	January	5004	4799	4667	4683	4636	4711	4901	4933	5095	5236	5597	5688	5684	5863	5814	5831	5866	5878	5891	5928	5728	5585	5500	5073
weekend	February	5344	5139	5015	4984	4974	4920	5128	5280	5415	5499	5661	5845	5913	5988	6019	6077	5976	6211	6119	6163	6104	6118	6003	5615
weekend	March	5399	5273	5192	5054	5025	4996	5163	5148	5414	5488	5725	5820	5925	5978	5881	5875	6073	5940	6170	6272	6059	6094	6005	5822
weekend	April	4934	4818	4709	4602	4483	4515	4522	4592	4783	4874	5111	5313	5462	5393	5446	5391	5373	5342	5331	5251	5453	5383	5352	5136
weekend	May	5037	4914	4745	4747	4741	4812	4864	5047	5378	5619	5949	6084	6236	6251	6278	6205	6200	6100	6059	6000	6020	5679	5436	5264
weekend	June	4743	4592	4602	4610	4624	4621	4796	4945	5040	5078	5061	5087	5156	5187	5178	5269	5156	5293	5210	5176	5141	5082	5018	4938
weekend	July	6031	6002	5860	5833	5905	5928	6002	6339	6485	6603	6783	6442	6424	6441	6474	6326	6425	6399	6260	6295	6417	6602	6476	6387
weekend	August	5784	5739	5646	5577	5453	5492	5701	5793	5987	6271	6456	6742	6862	7077	7070	7068	7174	7188	7137	6984	7132	6847	6613	6198
weekend	September	6385	6300	6077	6068	6005	5971	6106	6353	6653	6867	7092	7359	7724	7696	7647	7733	7560	7559	7556	7345	7548	7118	7036	6775
weekend	October	5076	4918	4770	4669	4595	4696	4722	4793	4873	5030	5232	5405	5553	5522	5603	5595	5670	5662	5930	5895	5779	5795	5670	5270
weekend	November	4783	4750	4501	4465	4423	4453	4559	4648	4823	4911	5119	5307	5383	5436	5411	5478	5633	5800	5708	5616	5477	5514	5382	5057
weekend	December	5023	4828	4744	4633	4590	4646	4850	5059	5146	5139	5254	5419	5605	5630	5663	5686	5870	6080	5947	5911	5854	5649	5557	5364

Table 2-4: Microgrid 12x24 Thermal Load

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
week	January	15429	15475	15669	15865	15725	21489	17088	15165	13753	12607	11779	11118	10673	10477	10157	10085	10367	10600	11038	11226	12386	12736	13459	14151
week	February	21041	21178	21639	21984	21458	30850	23924	20986	19419	18436	17425	16477	15981	15581	15285	15284	15460	16098	17076	17691	19779	20529	22340	23147
week	March	20784	21207	21654	21370	28072	26232	21704	19703	18533	17446	16584	15892	15465	14961	14491	14377	14440	14977	15678	17326	18574	19497	20244	20868
week	April	17651	17873	18067	17448	26049	19871	17521	16346	15651	14895	14390	13885	13604	13221	12808	12598	12722	12909	13559	15331	15748	16599	16910	17239
week	May	12513	12690	12813	12335	17137	12943	11408	10669	10154	9786	9542	9260	9040	8731	8530	8360	8319	8664	9183	10650	11035	11673	11962	12173
week	June	7312	7435	7524	7255	9321	7105	6318	5864	5458	5250	4987	4769	4522	4274	4048	3936	3867	4248	4670	5924	6264	6789	7009	7177
week	July	3906	3991	4066	3954	5113	3869	3453	3207	2979	2828	2655	2489	2348	2177	2017	1941	1858	2015	2179	2823	3032	3365	3559	3731
week	August	4097	4174	4238	4124	5402	4161	3691	3435	3188	3023	2850	2704	2580	2420	2288	2214	2195	2355	2586	3130	3280	3565	3704	3853
week	September	4297	4350	4410	4267	5662	4418	3949	3676	3454	3333	3241	3138	3041	2930	2870	2860	2893	3064	3205	3675	3772	3999	4093	4183
week	October	4675	4732	4766	4600	6643	5083	4575	4269	4071	3873	3716	3607	3531	3421	3419	3409	3496	3602	3686	4134	4211	4442	4534	4610
week	November	7629	7810	7945	7965	8068	10676	8358	7458	6970	6661	6377	6163	5993	5864	5705	5701	5888	5963	5929	6122	6693	6873	7193	7351
week	December	12035	12320	12658	12807	12304	17570	13781	12090	11202	10633	9953	9463	9165	9019	8899	8943	9148	9188	9417	9695	10746	11173	11868	12220
weekend	January	14996	14826	14485	14327	14187	14153	13011	13144	10936	9401	8840	8377	8053	7722	7700	7446	8448	9048	10197	10281	11392	11977	12171	13196
weekend	February	17165	17774	17925	18610	19376	19133	17204	17777	15384	13055	11890	11227	10744	10397	10171	9001	9283	9947	11163	11546	12484	12849	13366	13685
weekend	March	14120	14402	14744	14886	15139	14531	14203	14201	13047	12151	11684	11339	11110	10894	10026	9336	9544	10472	11067	11854	12447	12886	13235	13563
weekend	April	11634	11886	12090	12023	12102	10459	12371	11511	10749	10357	10005	9855	9627	9388	8087	7968	8260	9315	9941	11097	11356	11830	12094	12302
weekend	May	8347	8479	8592	8460	8504	7119	8103	7517	6993	6733	6550	6420	6283	6029	5337	5333	5441	6192	6577	7527	7740	8129	8327	8472
weekend	June	5074	5152	5205	5120	5125	4241	4669	4384	4172	4108	4056	3997	3929	3805	3354	3308	3395	3816	3984	4647	4841	5098	5216	5290
weekend	July	2677	2762	2819	2783	2803	2333	2490	2305	2127	2054	1997	1911	1834	1747	1483	1465	1512	1782	1919	2283	2410	2591	2674	2743
weekend	August	2647	2715	2763	2738	2765	2320	2536	2361	2182	2105	2036	1964	1879	1846	1648	1626	1718	1997	2147	2480	2570	2717	2808	2880
weekend	September	2836	2853	2880	2828	2847	2429	2778	2565	2382	2261	2164	2098	2055	1978	1761	1755	1829	2163	2295	2603	2679	2819	2881	2936
weekend	October	3208	3253	3303	3277	3311	2900	3390	3120	2872	2738	2636	2550	2499	2414	2125	2155	2281	2588	2676	2958	3017	3147	3205	3251
weekend	November	4873	4962	5054	5097	5098	5006	4834	5439	4983	4639	4456	4287	4175	4080	3923	3583	3721	3923	4225	4412	4757	4957	5140	5223
weekend	December	9492	9875	10083	11005	11363	11100	9999	11060	9871	8775	8098	7731	7444	7385	7270	6568	6906	7247	8084	8661	9312	9612	9974	10401

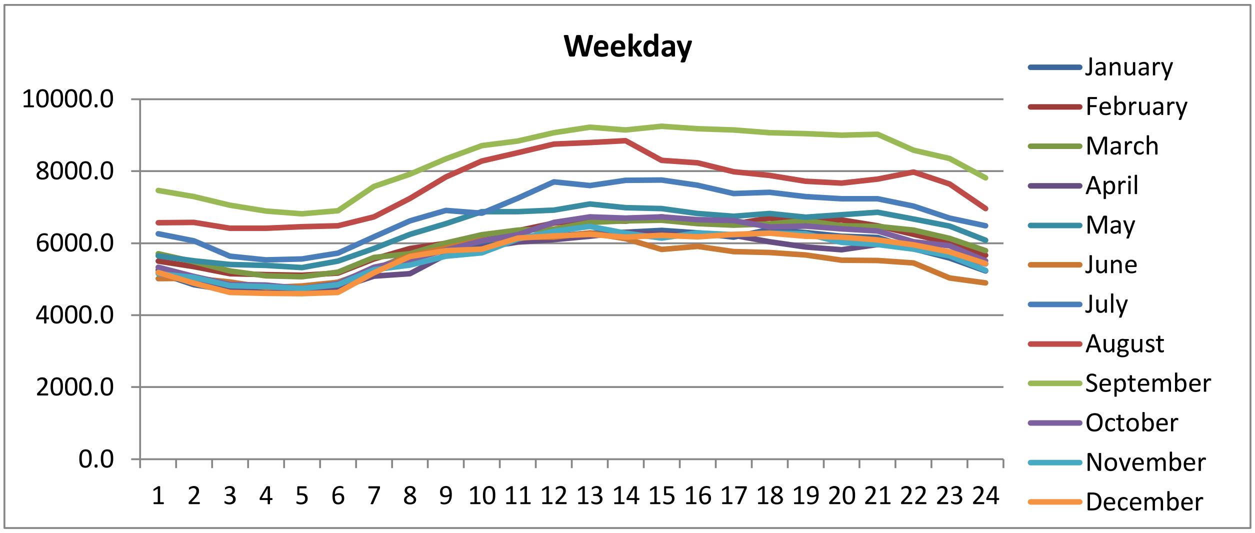

Figure 2-3: Microgrid Weekday Electrical Load

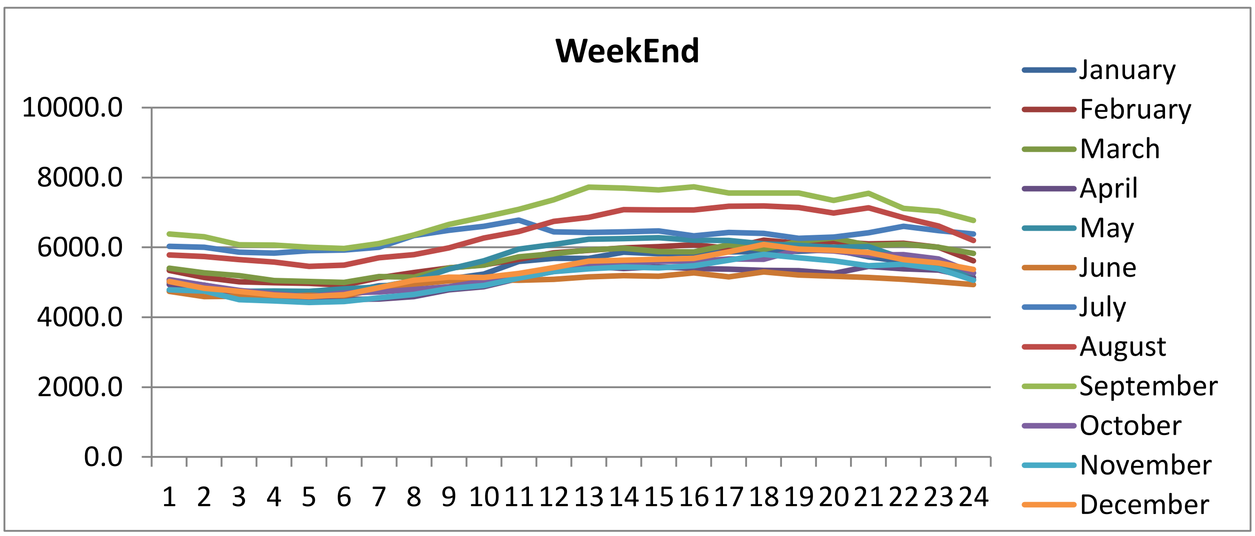

Figure 2-4: Microgrid Weekend Electrical Load

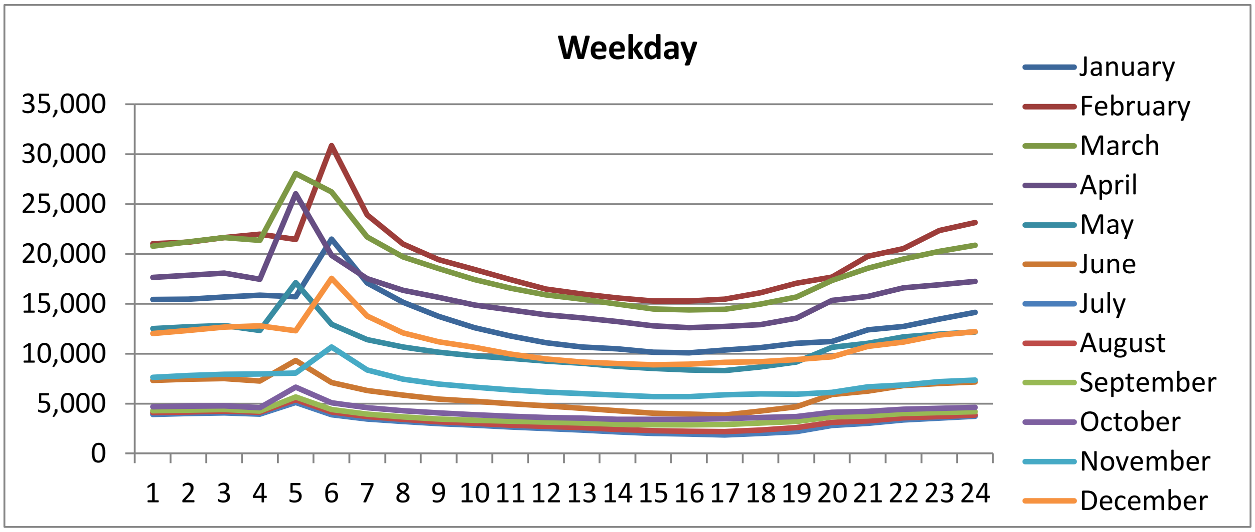

Figure 2-5: Microgrid Weekday Thermal Load

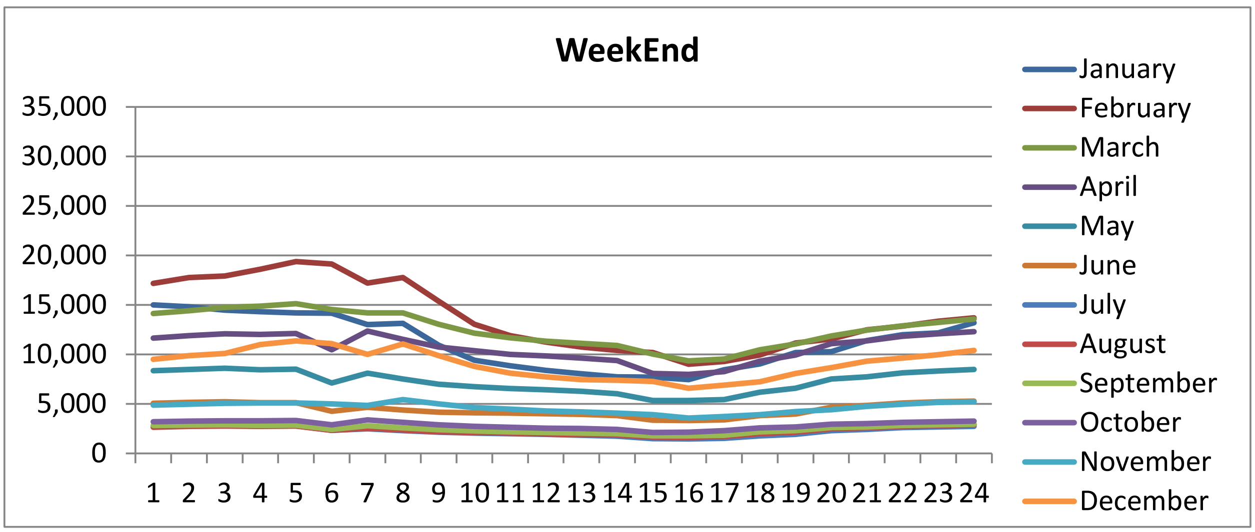

Figure 2-6: Microgrid Weekend Thermal Load

2.2.3 Provide a written description of the sizing of the loads to be served by the microgrid including a description of any redundancy opportunities (ex: n-1) to account for equipment downtime.

The microgrid total load is based on the loads of the individual facilities to be served by the microgrid, as listed in Table 2-5 below. The load sizes are based on 12 consecutive months of the electrical and fuel billing statements.

As can be seen, the microgrid load includes the extra feeder load, which was estimated based on the available information on the utility feeders serving the critical facilities.

The only thermal load included in the microgrid is the thermal load of SUNY Oswego, and only a small part of it will be met by the 1,000 kW CHP.

The total system peak load occurs in September and is 9,247 kW; however, this load includes the entire SUNY Oswego Campus. The overall microgrid will interface directly with the SUNY Oswego substation to ensure load can be curtailed down to 6 MW of total microgrid load.

Initial microgrid generation, only those on the network, include 1,270 kW Existing SUNY NG, 450 kW Existing WWTP NG, 2,000 kW New SUNY Fuel Cell 1 Dual + 2,000 kW New SUNY Fuel Cell 2 + 1,000 kW New SUNY CHP = 6,720 kW.

At the time of peak load (hour 15) solar generation is 54 kW (from 100 kW nameplate capacity).

This results in a surplus of 258 kW (+ 6,720 + 2,634 + 54 – 9,247) (If emergency happens to be in September)

There is also 100 kW of battery storage– but to be on the conservative side, it is assumed that in actual operations it will be difficult to align the time of storage dispatch to time of peak load.

There is an additional 2,634 kW of backup generation (both natural gas and diesel based) that is in the microgrid territory – but not planned to be "integrated" into the microgrid control system.

Hence, the total available nameplate capacity in the system is about 9,408 kW Table 2-5 below indicates that the sum of the non-coincident peak loads of the microgrid facilities is 9,360 kW.

		Electrical Load			**Thermal Load**		
ID	**Facility**	**Usage (kWh/year)**	**Peak Demand (kW)**	**LF (%)**	**Usage (kWh/year)**	**Peak Demand (kW)**	**LF (%)**
1	SUNY Oswego Campus A	38,740,534	6,957.00	63.57%	77,755,111	30,850.41	28.77%
2	City of Oswego Water Department	6,751,632	989.00	77.93%			
3	Onondaga County Metropolitan Water Board - Raw Water Pumping Station	6,606,088	1,217.00	61.97%			
4	City of Oswego Wastewater Department	1,356,049	197.00	78.58%			
	Total	53,454,303	9,360	65.19%	77,755,111	30,850	28.77%

Table 2-5: Microgrid Electrical and Thermal Load Sources

2.3 Distributed Energy Resources Characterization

2.3.1 Provide ... information regarding Distributed Energy Resources (DER) and thermal generation resources that are a part of the microgrid:

DER Type	Facility Name	Energy Source	Name plate Capacity (MW)	Avg. Annual Production Normal (MWh)	Avg. Daily Production Emergency (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
1000kW CHP Generator	SUNY Oswego	*Natural Gas*	1.0	8,048.7	24	13.036	MMBtu/MWh
100kW PV cell	Water Treatment Plant	*Solar*	.100	165.564	0.4536	0	N/A
100kWh Battery Storage	Water Treatment Plant	*Solar*	.100	15.1548	0.04152	0	N/A
Existing 1270kW of NG Generators	SUNY Oswego	*Natural Gas*	1.270	823.44	30.48	14.6	MMBtu/MWh
Existing 2634kW of Diesel Generators	SUNY Oswego	*Diesel*	2.634	0	63.216	11.1	MMBtu/MWh
Existing 450kW Generator	Wastewater Treatment Plant	*Natural Gas*	.450	1,238.664	10.8	9.59	MMBtu/MWh

Table 2-6: Microgrid Generation Resources

2.3.2 If new DER or other thermal generation resources are a part of the microgrid, provide a written description of the approximate location and space available. Identify the DERs on the simplified equipment layout and one-line diagrams. Differentiate between new and existing resources.

New generation resources and their locations are listed in bold font in the following table:

DER Type	Facility Name	Energy Source	Name plate Capacity (MW)	Avg. Annual Production Normal (MWh)	Avg. Daily Production Emergency (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
1000kW CHP Generator	SUNY Oswego	*Natural Gas*	1.0	8,048.7	24	13.036	MMBtu/MWh
100kW PV cell	Water Treatment Plant	*Solar*	.100	165.564	0.4536	0	N/A
100kWh Battery Storage	Water Treatment Plant	*Solar*	.100	15.1548	0.04152	0	N/A
Existing 1270kW of NG Generators	SUNY Oswego	*Natural Gas*	1.270	823.44	30.48	14.6	MMBtu/MWh
Existing 2634kW of Diesel Generators	SUNY Oswego	*Diesel*	2.634	0	63.216	11.1	MMBtu/MWh
Existing 450kW Generator	Wastewater Treatment Plant	*Natural Gas*	.450	1,238.664	10.8	9.59	MMBtu/MWh

Table 2-6: Microgrid Generation Resources

DER Type	Facility Name	Energy Source	Name plate Capacity (MW)	Avg. Annual Production Normal (MWh)	Avg. Daily Production Emergency (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
1000kW CHP Generator	SUNY Oswego	*Natural Gas*	1.0	8,048.7	24	13.036	MMBtu/MWh
100kW PV cell	Water Treatment Plant	*Solar*	.100	165.564	0.4536	0	N/A
100kWh Battery Storage	Water Treatment Plant	*Solar*	.100	15.1548	0.04152	0	N/A
Existing 1270kW of NG Generators	SUNY Oswego	*Natural Gas*	1.270	823.44	30.48	14.6	MMBtu/MWh
Existing 2634kW of Diesel Generators	SUNY Oswego	*Diesel*	2.634	0	63.216	11.1	MMBtu/MWh
Existing 450kW Generator	Wastewater Treatment Plant	*Natural Gas*	.450	1,238.664	10.8	9.59	MMBtu/MWh

Table 2-6.

1 MW of CHP and 4 MW of fuel cells are being proposed at the SUNY Oswego campus. Additionally 100 kW of storage and 100 kW of PV are being proposed at the Water Treatment Plant.

The new CHP unit, located at SUNY Oswego, will meet a portion of the SUNY Oswego thermal needs. The rest of the thermal needs will be met by the existing thermal systems at SUNY Oswego.

2.3.3 Provide a written description of the adequacy of the DERs and thermal generation resources to continuously meet electrical and thermal demand in the microgrid.

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

Figure 2-5 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).

The project team is working with Lawrence Berkeley National Laboratory (LBNL), the provider of the DER-CAM model to improve the operation of the Fuel Cell by providing the option of "must run" operation. The dispatch profile shown is based on purely economic considerations.

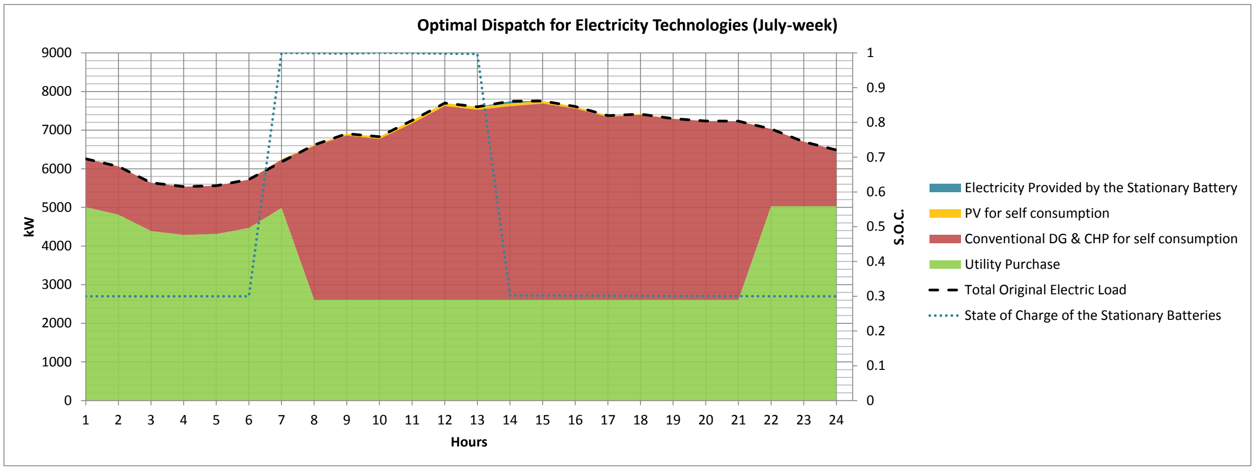

Figure 2-5: Microgrid Optimal Dispatch to Meet Electrical Load – July Normal Weekday

Figure 2-6 shows the microgrid operation during an emergency weekday in July. As can be observed, there is no utility purchase, and all microgrid load is met by on-site generation, including solar, battery, and also load curtailment.

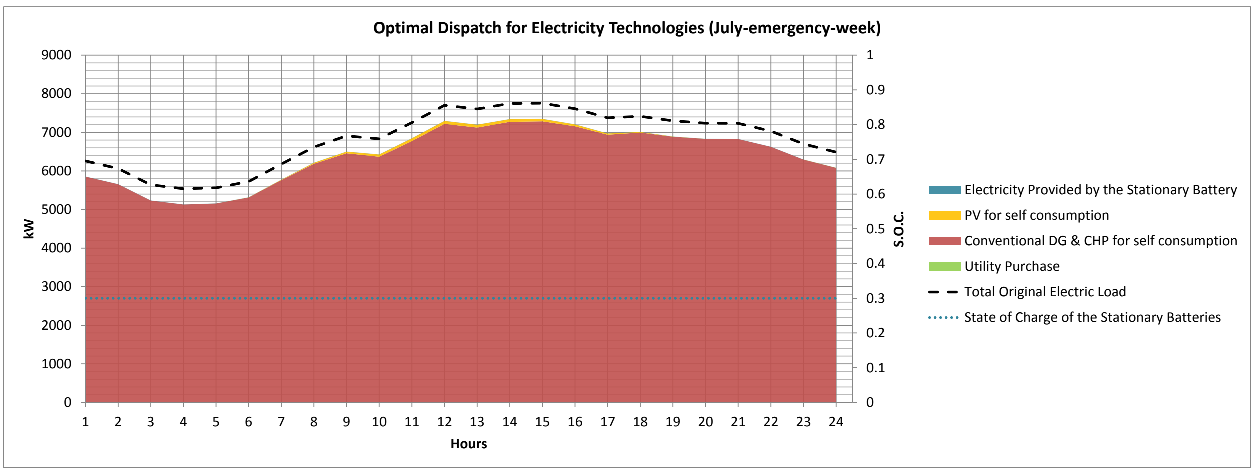

Figure 2-6: Microgrid Optimal Dispatch to Meet Electrical Load – July Emergency Weekday

A normal weekday thermal dispatch in July is shown in Figure 2-7.

It appears that the CHP unit is only running during on-peak hours and hence, the thermal load is met by CHP only during the on-peak hours. The additional thermal load during off-peak hours is met by thermal energy from the conventional boilers.

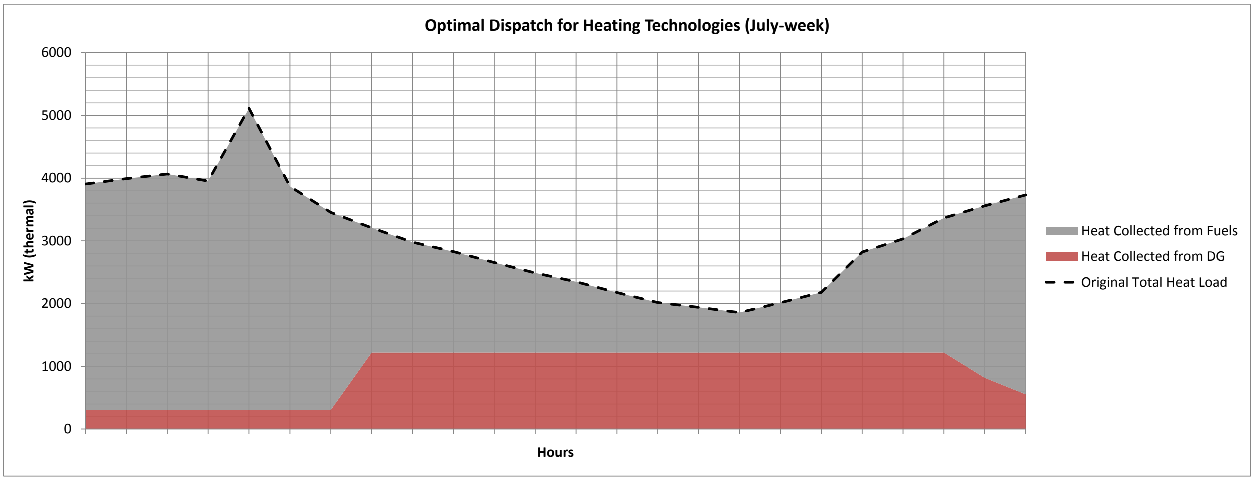

Figure 2-7: Microgrid Optimal Dispatch to Meet Thermal Load – July Normal Weekday

However, during emergency weekday, more of the thermal load is met by the CHP, since CHP and other generation resources are in operation all day in the absence of power availability from the larger grid.

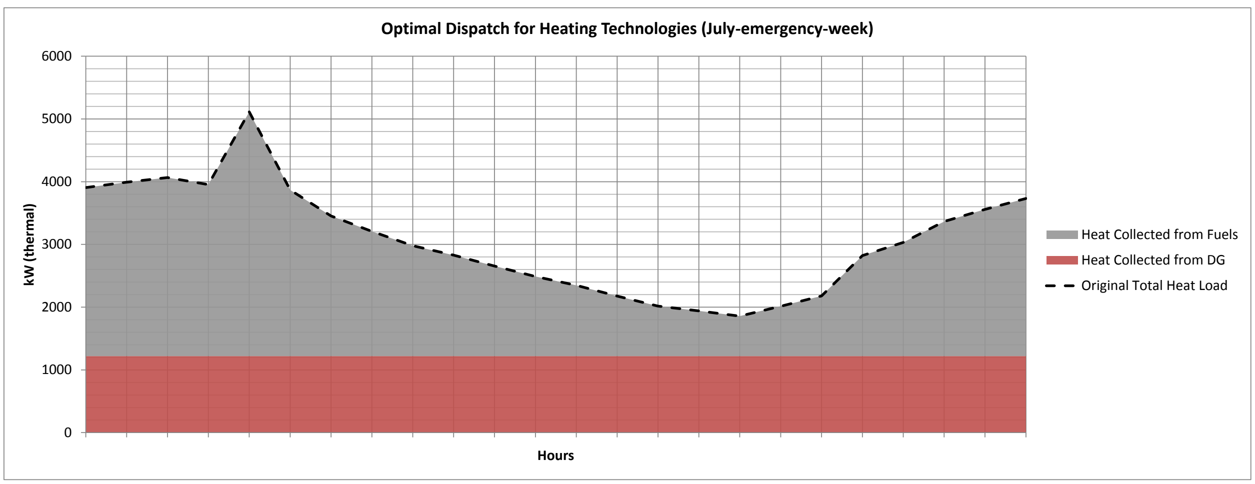

Figure 2-8: Microgrid Optimal Dispatch to Meet Thermal Load – July Emergency Weekday

2.3.4 Describe how resilient the DERs and thermal generation resources will be to the forces of nature (severe weather) that are typical to and pose the highest risk to their operation(example, reduced or zero output due to snow cover over PV panels, potential flooding of low lying areas, etc.)?

Oswego is located in an area that is subject to major ice storms, snowstorms, high winds, and other extreme weather events. Although the area's power grid has been fairly reliable in recent years, the microgrid facilities are fed from an overhead power line which is not hardened to ice and snow load. Hence, the fuel cells and CHP systems which are providing the majority of electrical load during extreme events will be designed with appropriate heaters to keep certain components from freezing.

The roof-top solar PV panels are at some risk of being partially or completely covered with snow cover during parts of the year. However, the actual 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 microgrid controller should be able to recognize when solar PV panels are under-producing relative to normal operation, and can generate an inspection/maintenance signal. The battery storage system can be scheduled to be charged early during off peak hours to carry enough storage to compensate for the loss of solar PV energy due to inclement weather and snow cover.

2.3.5 Provide a description of the fuel sources for DER. Describe how many days of continuous operation of the microgrid can be achieved with current fuel storage capability? If additional fuel storage is required, provide a written description of needs required for this.

In this project natural gas is the primary fuel sources for generation. 4 MW of proposed fuel cell generation and 1 MW of proposed CHP will use natural gas as fuel. Additionally, most of the existing backup generation (1.135 MW) is fueled by natural gas. In total, 6.135 MW of microgrid generation will be fueled by natural gas. Natural gas supply has proven to be highly reliable, with limited or no interruptions even during severe weather events.

In addition to the natural gas fueled generation, 100 kW of solar PV is planned. This PV will be located at the Water Treatment Plant. Annual PV production for the microgrid is estimated at 165 MW/year. There is also some diesel-powered backup generation at SUNY that is not integrated into the microgrid.

2.3.6 Provide a written description of the capability of DERs including, but not limited to the following capabilities; black start, load-following, part-load operation, maintain voltage, maintain frequency, capability to ride-through voltage and frequency events in islanded mode, capability to meet interconnection standards in grid-connected mode.

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 National Grid 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.

The backup natural gas generators located at SUNY Oswego and the Wastewater Treatment Plant are capable of operating without the presence of the distribution system which makes them ideal for blackstart application. As such, these generators 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.

Additionally, the proposed Oswego microgrid contains 100 kW of storage. This storage adds a lot of flexibility to the microgrid by smoothing variations caused by PV and providing a synchronization source for the fuel cells in blackstart scenarios.

Some types of generators are more capable of providing frequency control than others. For the Oswego microgrid, some assets will provide baseload power while other assets would switch to frequency control mode. Both the CHP and the fuel cell units tend to be better suited to baseload operation than frequency control. That means the majority of fast frequency regulation must come from the backup generation. To augment this fast frequency regulation, load may need to be controlled. Additionally, it may be necessary for solar production to be curtailed. 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 Oswego microgrid, some combination of these modes will be employed depending on the asset type. For example, the fuel cells will likely be in voltage control mode to provide fast voltage regulation/reactive power balance and to support voltage during a fault to allow the protection system to operate correctly. The CHP units may be used in VAr control mode to supply a reactive power base, and the PV 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 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. However, the storage should ensure PV generation can be used efficiently.

2.4 Electrical and Thermal Infrastructure Characterization

2.4.1 Provide a high-level written description of the electrical infrastructure (feeders, lines, relays, breakers, switches, current and potential transformers (CTs and PTs) and thermal infrastructure (steam, hot water, cold water pipes) that are a part of the microgrid. Identify the electrical and thermal infrastructure on the simplified equipment layout (with approximate routing) and one-line diagrams (electrical only). Differentiate between new, updated and existing infrastructure.

The project will make use of existing infrastructure to distribute power to SUNY Oswego and the deliver power from the CHP unit to the microgrid (if needed); however, the majority of the microgrid will be new construction. As seen in Figure 2-2, the fuel cells will be connected to the secondary of the 34.5 kV transformers for the connected facilities. To accomplish this, three transformers, associated switch gear, monitoring equipment and protection equipment will be added. Since the electrical connections to all 3 facilities are located within close geographical proximity to each other (see Figure 2-1) the need for lines or cables is estimated to be minimal. The proposed CHP plant is adjacent to the campus central steam plant, and the thermal distribution line to connect to the steam plant is estimated to be approximately 200 ft. The line will be buried to ensure reliability, resilience and minimal thermal losses.

2.4.2 Describe how resilient the electrical and thermal infrastructure will be to the forces of nature that are typical to and pose the highest risk to the location/facilities. Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time. Discuss the impact of severe weather on the electrical and thermal infrastructure.

The small footprint of the core microgrid sources and loads will help minimize the impact of severe weather. As seen in Figure 2-1, the fuel cells and much of the distribution transformers, switchgear and loads will be located in the same area.

While the CHP and much of the distribution within the SUNY Oswego campus will be some distance from the core of the microgrid, much of the distribution within the SUNY Oswego campus is underground. Where it is overhead, the lines are relatively free of foliage or other obstructions. However, as part of a more detailed design, hardening or burying cable will be evaluated to ensure reliability is maintained under severe weather conditions. The proposed CHP plan is adjacent to the campus central steam plant, and the thermal distribution line will be approximately 200 ft. To ensure reliability and resilience, and to minimize thermal losses, the distribution line will be buried below the frost line.

2.4.3 Provide a written description of how the microgrid will be interconnected to the grid. Will there be multiple points of interconnection with the grid. What additional investments in utility infrastructure may be required to allow the proposed microgrid to separate and isolate from the utility grid. Provide a written description of the basic protection mechanism within the microgrid boundary.

Figure 2-2 shows the points of interconnection with the larger system. When in islanded mode, the microgrid will be fed normally through the 34.5 kV system. When entering islanded mode, the microgrid will isolate from the 34.5 kV system and be fed through a medium voltage distribution system ranging from 2.4 kV to 13.2 kV.

Because the microgrid sources are largely inverter based, traditional protection schemes based on high fault currents will likely be avoided. Furthermore, the protection system must be flexible enough to protect the system in both islanded and grid-connected mode. To ensure proper operation over a range of operating conditions with inverter based DER, the microgrid will rely heavily on advanced microprocessor based relays with flexible set points and distributed intelligence. The protection scheme will also rely heavily on the microgrid controller to detect abnormal conditions.

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

2.5 Microgrid and Building Controls Characterization

2.5.1 Provide a high-level written description of the microgrid control architecture and how it interacts with DER controls and Building Energy Management Systems (BEMS), if applicable. Identify the locations of microgrid and building controls on the simplified equipment layout diagram. Differentiate between new and existing controls.

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.

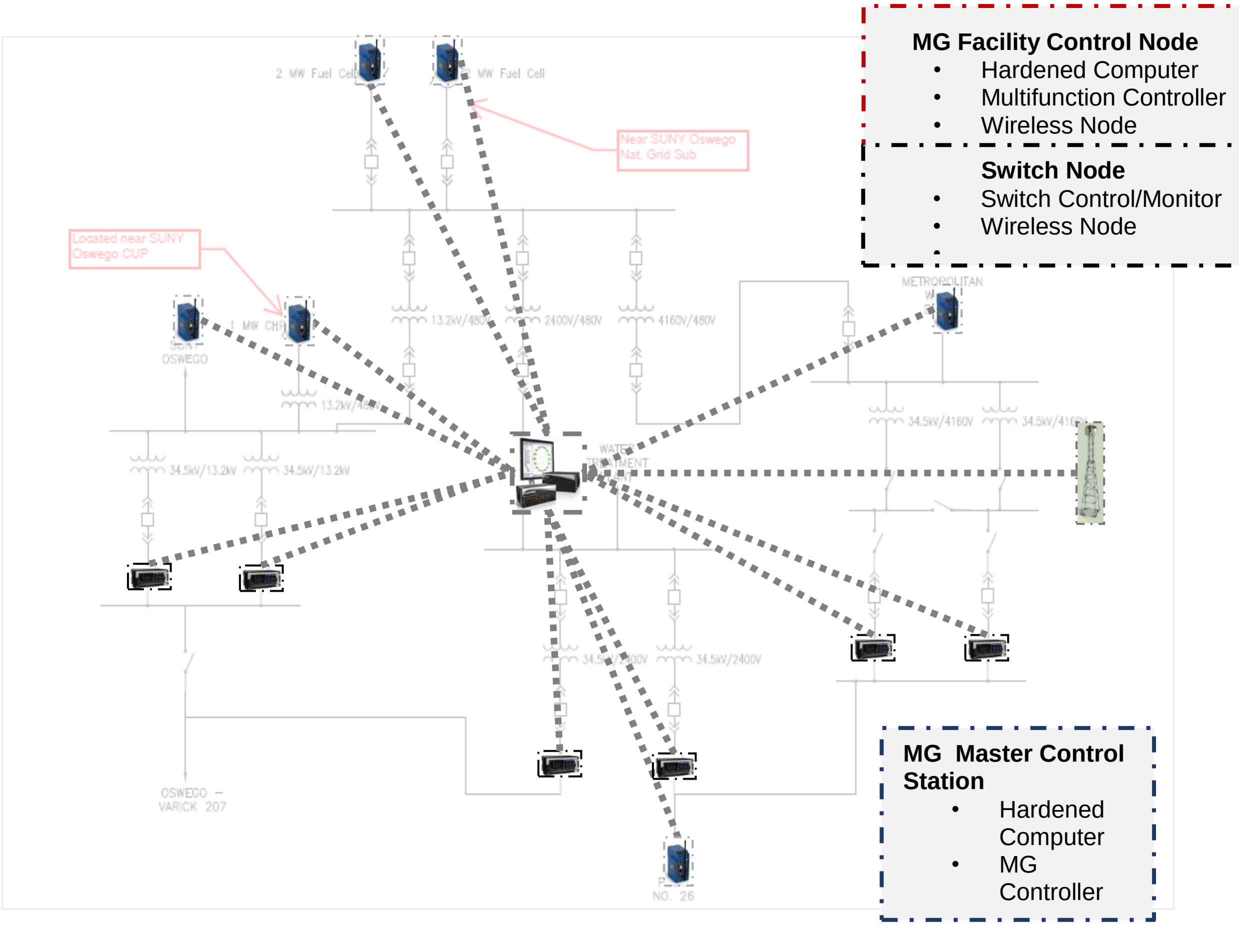

Figure 2-9: Oswego Microgrid Electrical One-Line Diagram with Control and Communications Overlay

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 CHP gas engines, the fuel cells, the solar PV 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. The 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 external 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. The diagram in Figure 2-9 assumes that the SUNY Oswego and County Metropolitan Water energy management systems will be included in microgrid optimization. Thus, 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.

The Microgrid Control design will 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

2.5.2 Provide a brief written description of the 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. 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 grid. The microgrid will isolate from the 34.5 kV system as shown in Figure 2-2. The configuration may be a combination of manual an automated steps. The microgrid will then form in the manner described above.

Automatic connection: The microgrid will also be capable of automatically reconnecting to the grid if desired. However, since the microgrid will be reconnecting into a network, the microgrid may be required to power down before reconnection. 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 at the utility interconnection point. Using either active or passive synchronization, the microgrid controller may close the breaker that ties the microgrid to the utility 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.

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.

Any of the standby generators located at SUNY Oswego or the Water Treatment Plant are good candidates for black-start. 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 storage located at the Water Treatment Plant may be used for blackstart. Once blackstart power is provided via the standby generators, the fuel cells and CHP can come online and provide power to the larger microgrid.

Performing economic dispatch and load following

The Oswego microgrid will provide load following during emergency periods utilizing its currently existing backup generation at Wastewater Treatment Plant and at SUNY Oswego. Based on usage data and developed load profiles, CHP and fuel cells will operate in base load mode.

The economic dispatch of the microgrid plants 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 microgrid economic dispatch will be based on the relative economic costs of on-site generation versus purchase from the utility or even sales to the larger grid or NYISO, subject to applicable future REV framework. The on-site generation versus utility purchase is demonstrated in the DER-CAM modeling. Although simplified compared to actual operations, the DER-CAM model illustrates the timing and amount of utility purchases that vary with time and highly dependent on not only the relative energy costs of on-site generation versus utility purchases, but also on the applicable utility monthly and also daily on-peak demand charges.

Demand response

The same load resources that are available for load shedding, are also available for demand response. The initial plan is to have at least 10% of the microgrid peak load to be curtailable during long-term emergency when the microgrid goes into islanded mode. However, the end use control elements will be available to use same load resources as demand response resourced during normal/blue sky days. 10% of peak load of the facilities is about 816 kW, and also be available as demand response during normal days. These 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 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 microgrid design incorporates 100 kW of storage located at the water treatment plant. In addition to smoothing the available power from solar generation, energy storage operation can be optimized to add value by shifting the energy availability from low price hours to high price hours, or from low load periods to high load periods. If seamless transition from grid-connected mode is a critical requirement, then storage is a good option.

Maintaining frequency and voltage

When in grid-connected mode, the primary focus of the microgrid control systems will be to maintain system voltage within the acceptable range. This range is generally specified in ANSI C84.1 but may also be coordinated with utility conservation voltage reduction schemes.

For the Oswego microgrid, a large portion of the generation will be fuel cell (4 MW). This generation along with the 1 MW of CHP generation will act as base-load generation and reserve margin. The faster acting generators such as the natural standby units located at SUNY Oswego and the Wastewater Treatment Plant as well as the storage will 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.

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 2-9. The total nameplate capacity of PV installations is roughly 100 kW, less than 5% of peak 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 project team may consider another layer of protection that predicated on transfer trip signals from the controller.

Because the microgrid sources are primarily inverter based, traditional protection schemes based on high fault currents will likely not be appropriate when in islanded mode. Microprocessor based protection equipment with multiple modes or set-points will be needed to ensure adequate protection during islanded and grid-connected mode.

Selling energy and ancillary services

Subject to evolving NY REV framework, and also NYISO market rules applicable to microgrids and distributed generation, it is expected the distributed generation within the Oswego microgrid can sell energy into the larger grid though the Distribution System Platform (DSP) as 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 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 How resilient are the microgrid and building controls? Discuss the impact of severe weather on the 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 Information Technology (IT)/Telecommunications Infrastructure Characterization

2.6.1 Provide a high-level written description of the IT/Telecommunications Infrastructure (wide area networks, access point, ethernet switch, cables etc.) and protocols. Identify the IT and telecommunications infrastructure on the simplified equipment layout diagram. Differentiate between new and existing infrastructure.

Due to the lack of existing dedicated communication infrastructure, for the microgrid communications backbone we are proposing a wireless field network as shown in Figure 2-9. 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. At least the control node at the SUNY Oswego will integrate with the existing building management systems. 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, OPC or IEC61850 depending on MG deployed devices (e.g. IED's, PLC, switchgear, relay, sensors, meters, etc.).

2.6.2 Provide a written brief description of communications within the microgrid and between the microgrid and the utility. Can the microgrid operate when there is a loss in communications with the utility? How resilient are the IT and telecommunications infrastructure?

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 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.

Section 3 – Commercial Viability of the Oswego Microgrid

3.1 Commercial Viability – Customers

3.1.1 Identify the number of individuals affected by/associated with critical loads should these loads go unserved (e.g. in a storm event with no microgrid)?

The City of Oswego population is approximately 30,000. In addition the Raw Water Pumping Station has a design capacity of 72 MGD and supplies between 20 and 54 MGD depending upon customer demands. This pumping station serves a population of 500,000 in the following five counties: Onondaga, Oneida, Oswego, Madison and Cayuga.

3.1.2 Identify any direct/paid services generated by microgrid operation, such as ancillary services, or indirect benefits, such as improved operation, to the utility or NYISO? If yes, what are they?

The project team believes there is potential to leverage planned DER for demand response participation in NYISO's voluntary response (EDRP) or mandatory response (ICAP-SCR) program. The Oswego microgrid includes approximately 5 MW of capacity that would be available. NYISO's SCR Program involves a 100 kW minimum reduction in aggregate, mandatory response during reliability events for a minimum of four hours, and payments for capacity (monthly based on sales made through ICAP auctions or bilateral contracts) and energy (based on performance in capability tests & reliability events).

Current rules for NYISO demand response limit the capacity value of resources to the demand located at the same retail electric meter where the generation is connected. The aggregation and combined treatment of microgrid DER and loads will require a change in NYISO rules. NRG believes such a rule change is warranted and achievable, to support the implementation of microgrids and other DER, consistent with NY State policies, and to support the use of the full capability of these resources in NYISO planning and operations.

3.1.3 Identify each of the microgrid's customers expected to purchase services from the microgrid?

SUNY Oswego, the Town of Oswego, the Water Department, the Raw Water Pumping Station, and the Wastewater Department would all be customers of the microgrid.

3.1.4 Identify other microgrid stakeholders; what customers will be indirectly affected (positively or negatively) by the microgrid?

The benefits of the microgrid will redound to community stakeholders in a number of direct and indirect ways. By ensuring the long-term operational continuity of the City of Oswego's water purification and treatment related facilities in the face of a severe, protracted grid failure, the microgrid will provide significant benefits to the more than 30,000 people who rely on these facilities and services daily. The microgrid will provide continuity of source water supply to a population of 500,000 people in five counties through the Metropolitan Water Board Raw Water Pumping Station. In addition, the microgrid will help protect the roughly 8,000 students, faculty and staff who attend, teach or work at SUNY Oswego, and provide a base of operations for emergency personnel and first responders. Potential revenues and savings from the microgrid operation will also provide much needed budget relief for the City of Oswego and help keep taxes from rising.

3.1.5 Describe the relationship between the microgrid owner and the purchaser of the power?

Financing of the microgrid assets can generally be accomplished by either purchase of the assets by the facility owners or third-party ownership of the assets. It is proposed that NRG, through a wholly-owned special purpose entity, will own the microgrid, and the above noted public entities will be the off-takers of the power and microgrid services. Upon establishing the technical and economic feasibility of the Oswego microgrid, the parties will commence discussion of commercial terms for further phases of work on the project.

3.1.6 Indicate which parties/customers will purchase electricity during normal operation? During islanded operation? If these entities are different, describe why.

All of the participants in the microgrid will purchase power during both normal and islanded operation.

3.1.7 What are the planned or executed contractual agreements with critical and non-critical load purchasers?

It is anticipated that long-term Power Purchase Agreements (PPAs) or Energy Services Agreements (ESAs) will be entered into between microgrid customer participants and the microgrid owner (i.e. NRG under the proposed commercial structure). Additional information on the ESA follows:

- Governs sales of electricity, heating, cooling, and related services, such as provision of back-up power, securing supply and delivery of power from the local utility and/or competitive suppliers, purchasing natural gas and other fuel, and the billing and/or metering mechanism
- Establishes appropriate standards and benchmarks for operations and maintenance, including performance and up-time guarantees
- May authorize or require the payment of management fees, resiliency fees, and/or customer subscription fees
- May be separate Fuel Cell and/or Solar PPAs between the system owner and off-takers.

NRG, as the expected project sponsor and operator, would assume responsibility for project guarantees or plant operational guarantees. NRG would also obtain appropriate capital project guarantees from equipment suppliers and contractors. NRG would provide any operational availability, output, and/or heat rate guarantees to the customer participants as negotiated and required under the ESA.

There are no executed contractual agreements with critical and non-critical load purchasers currently in place. In addition to ESA/PPA described above, planned contracts may include Engineering, Procurement and Construction Agreements, Site Lease/Ownership Agreements, and Site Improvement Agreements.

Specific terms, conditions, roles, and responsibilities will be negotiated by the parties as the project progresses through the detailed design and structuring phases. Although NRG is proposed to serve as both the owner and operator, another option could be ownership by the customer participants (most likely the City of Oswego) with a long-term contract with NRG for dispatch/operational control of the DER assets and on-going O&M services.

3.1.8 How does the applicant plan to solicit and register customers (i.e. purchasers of electricity) to be part of their project?

NRG has the capabilities to finance, build, own, operate and maintain the microgrid and would be responsible for soliciting and registering the microgrid participants/customers in the proposed commercial structure.

3.1.9 Are there any other energy commodities (such as steam, hot water, chilled water) that the microgrid will provide to customers?

The microgrid will provide steam to the SUNY Oswego campus.

3.2 Commercial Viability - Value Proposition

3.2.1 What benefits and costs will the community realize by the construction and operation of this project?

The community, to include residents, students, businesses, and fire and police services personnel, will benefit from the enhanced resilience and ensured operational continuity of the microgrid facilities which include critical water, wastewater treatment services, as well as an evacuation/crisis command center. The upfront costs of the project will be absorbed by NRG as developer, owner and operator, and incorporated into the cost of power and thermal energy delivered by the microgrid. The CHP system is expected to create savings that will help offset the costs of the remaining microgrid infrastructure and distributed energy resource. Though the thermal demand in summer is low, the CHP unit might still operate to shave peaks and participate in energy and ancillary services markets, thus providing revenue that can be shared between the stakeholders and NRG.

3.2.2 How would installing this microgrid benefit the utility? (E.g. reduce congestion or defer upgrades)? What costs would the utility incur as a result of this project?

For the Oswego Microgrid, no utility feeders will be used as part of the microgrid operating in either island or grid-connected mode. Costs related to any reverse power relaying or any direct transfer trip requirements would be incurred by the customers. National Grid stands to benefit from reduced stress and losses on its distribution system due to the local DER present in the Oswego microgrid. In the case of emergencies or an overloaded grid, capacity from the microgrid’s generation assets, as well as demand-side curtailment, can offset peak load and improve the stability of the macrogrid through participation in demand response.

3.2.3 Describe the proposed business model for this project. Include an analysis of strengths, weaknesses, opportunities and threats (SWOT) for the proposed business model

The Oswego microgrid participants are ideal candidates to host and serve as off-takers to the proposed microgrid. As public-sector entities with high energy demands and critical operational requirements, they represent attractive low-risk partners to private entities developing microgrids. NRG is a recognized and respected energy service provider that designs, builds, owns and operates distributed energy resources. The design-build-own-operate-maintain (DBOOM) business model is core to their go-to-market strategy and daily business operations.

The microgrid participants have expressed interest in a public-private-partnership or “P3” DBOOM structure that shifts construction, technical, financial and operational risk to a qualified, financially strong entity with a proven track record. They recognize that the project would not be viable if it was upon them to band together and attract vendors, contractors and a team of engineering firms to design, develop, finance, construct, operate and own the microgrid. An added benefit of the P3 approach is that it allows the private entities to monetize the tax related benefits associated with the deployment of certain distributed generation technologies including PV, fuel cells, and cogeneration.

SWOT ANALYSIS – P3 DESIGN, BUILD, OWN, OPERATE & MAINTAIN BUSINESS MODEL

Internal

Strengths

- No upfront capital required
- Large public entities with long-term financial stability, high energy loads and critical operating requirements are attractive microgrid hosts/off-takers
- Immediate savings can accrue to hosts/off-takers
- Procurement can be expedited because no funds need to be budgeted, dispersed
- Scalable for host if it has other sites
- Leverage underutilized resources/assets (roofs, land)
- Financial and technical risk is limited

Weaknesses

- Microgrid hosts/off-takers trade some benefits including lower costs for reduced risk
- Some risk remains related to fuel costs and technology performance
- Contracts can be hard to negotiate due to long-term nature and technical complexity
- Microgrid hosts/off-takers may lack technical and legal experts to protect their interests
- Shortage of interested/capable P3 partners may limit ability to negotiate best deal
- Limited transparency

External

Opportunities

- Leverage external expertise, resources and capital
- For good projects, may be possible to attract multiple interested private partners and increase competitiveness of procurement
- Ensure operational continuity and resilience in face of extreme weather and other disruptions to the power grid
- Provide critical health, life and safety services to community, staff and broader public
- Private partners assume most of operating and technical risk

Threats

- Hosts/off-takes could forego savings if energy prices fall and they are locked into long=term PPA contract
- If technology advances, may not have option to swap out/upgrade system
- Shifting responsibility for critical resilience infrastructure and systems to P3 partner whose long-term business prospects are uncertain

3.2.4 Are there any characteristics of the site or technology (including, but not limited to, generation, storage, controls, information technology (IT), automated metering infrastructure (AMI), other) that make this project unique?

This site includes a water treatment plant, a water pumping station and a university campus, all of which provide critical services and refuge for students, local residents and the larger region. Technology and distributed energy resources include low and no emissions generation such as solar PV, fuel cells, and cogeneration, all of which will contribute to a more reliable and resilient energy supply system in the event of a prolonged power grid interruption.

3.2.5 What makes this project replicable? Scalable?

The proposed P3 business model will expedite and simplify the commercial procurement process. The primary generation is supplied by a combination of cogeneration, fuel cells, solar PV, and battery storage, all technologies that are scalable and applicable to a variety of setting and facility types.

3.2.6 What is the purpose and need for this project? Why is reliability/ resiliency particularly important for this location? What types of disruptive phenomenon (weather, other) will the microgrid be designed for? Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time.

The purpose of this project is to ensure that these critical facilities remain operational during an extreme and highly protracted power grid failure. Thousands of local residents depend on these facilities daily to provide safe drinking water and treat wastewater, and approximately 8,000 students are dependent on SUNY Oswego for shelter. An additional 500,000 people or more in Onondaga County as well as portions of some adjacent counties, depend on the Raw Water Pumping station to supply potable water.

The microgrid is designed to operate at full load indefinitely as long as natural gas supply is not disrupted. All electrical infrastructure will be underground, and the generating assets, including fuel cells, solar PV, dual fuel emergency backup generators and battery storage are designed to withstand extreme weather.

3.2.7 Describe the project's overall value proposition to each of its identified customers and stakeholders (including, but not limited, the electricity purchaser, the community, the utility, the suppliers and partners, and NY State).

The microgrid project's value proposition is based in the ability to provide operational continuity during an extreme and highly protracted power grid failure. Energy savings and long-term supplies of power at fixed costs through a power or energy services purchase agreement (PPA and ESA) provide a hedge against electric cost increases without an upfront investment by the Town.

A microgrid with behind the meter distributed generation has the direct benefit of reducing transmission and distribution system losses, including line losses and transformer losses. These system losses are often greatest during periods of peak demand, electric system congestion and high ambient temperatures – three contributing factors that often coincide, further compounding the problem in a sort of "perfect storm" manner. While average losses are in the 6%-7% range, losses during "perfect storm" circumstances can exceed 10%. Potential revenue from future power market participation represents, at a fundamental level, the value of broader transmission and distribution system efficiency. In these ways, the Oswego Microgrid value proposition directly benefits the utility and advances the goals of REV, goals that call for, among other things, the creative and targeted deployment of distributed energy resources to improve the efficiency and resilience of the electric grid.

3.2.8 What added revenue streams, savings, and/or costs will this microgrid create for the purchaser of its power?

The cogeneration system will provide energy savings for SUNY Oswego. In general, with the potential enactment of new policies to allow "behind the meter net generation" or "BTM:NG" by the end of 2016, it is hoped that the microgrid will be better able to sell ancillary services to the grid and receive new ongoing revenue as a result. The magnitude of these potential revenues is difficult to predict at this stage given the emerging nature of these grid services and markets.

3.2.9 How does the proposed project promote state policy objectives (e.g. NY REV, RPS)?

The proposed project will enable the efficient and optimized generation and storage of power at a local level in a resilient, low carbon manner. By working closely with the local utility and utilizing its distribution infrastructure, the local utility stands to benefit from a "smart load center" that can respond to the needs of the macrogrid during times of congestion, instability and/or high cost periods. In this manner, the utility serves as a distribution system operator or DSO, enabling and being compensated for the generation and distribution of power from a variety of distributed resources.

3.2.10 How would this project promote new technology (including, but not limited to, generation, storage, controls, IT, AMI, other)? What are they?

Technologies included in the proposed microgrid include cogeneration, dual-fuel generators, microgrid control and IT. In addition to showcasing these advanced energy technologies individually, the project will demonstrate the potential of microgrids to provide a platform for integrating and optimizing diverse systems to lower energy costs, increase resilience and reduce carbon emissions.

3.3 Commercial Viability - Project Team

3.3.1 Describe the current status and approach to securing support from local partners such as municipal government? Community groups? Residents?

Project Developer/Implementer and Microgrid Design Firms: NRG is a Fortune 200 company, the largest competitive power producer in the U.S., and one of the nation's largest developers and owners of renewable generation. NRG is a competitive energy solutions provider with a proven track record of developing and implementing microgrids incorporating multiple generation and storage technologies under an integrated control and optimization platform at locations such as Necker Island and the University Medical Center of Princeton at Plainsboro. Burns Engineering and GE Energy Consulting have been engaged to provide technical engineering and analysis services.

Local Distribution Companies: National Grid is the local electric and gas distribution company serving millions of customers in upstate New York.

Local Government, Customer Participant, and DER Host Sites: The City of Oswego is located on the shore of Lake Ontario and it operates the Water Treatment Plant and the Wastewater Treatment Plant, both participating sites in the proposed microgrid.

Local Government, Customer Participant, and DER Host Sites: The Metropolitan Water Board pumps raw" water to its nearby water treatment plant where it is filtered, purified and tested prior to the transmission of "finished" water to the Terminal Reservoir in the Town of Clay. The Raw Water Pumping Station has a capacity of between 20 and 35 MGD depending upon customer demands and serves a population of 500,000 in Onondaga County as well as portions of some adjacent counties

Customer Participant and DER Host Site: SUNY Oswego occupies approximately 700 acres along Lake Ontario, and has an enrollment of roughly 8,000 students.

3.3.2 What role will each team member (including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners) play in the development of the project? Construction? Operation?

NRG, on behalf of the Town of Oswego, will be the project applicant. NRG's role will be to oversee the further assessment and follow-on engineering and design of the microgrid as part of Phase 2. Burns Engineering and GE Energy Consulting will continue to provide technical engineering and analysis services. Looking forward to Phase 3, NRG is interested to provide a design-build-own-operate solution that includes project funding.

3.3.3 Are public/private partnerships used in this project? If yes, describe this relationship and why it will benefit the project.

A public-private-partnership (P3) to implement a DBOOM solution is central to this projects commercial viability. This P3 approach will overcome two issues that would otherwise present insurmountable hurdles going forward: project financing and microgrid design, construction, operation and maintenance. It is proposed that NRG would develop, finance, design, build, own, operate and maintain. In turn, the Town of Oswego and SUNY Oswego would both sign long-term energy or power purchase agreements with NRG, thus providing a means for NRG to recover its investment over 15-20 years.

3.3.4 Describe the financial strength of the applicant. If the applicant is not the eventual owner or project lead, describe the financial strength of those entities.

NRG, a Fortune 200 company, is expected to be the eventual owner and project lead. With $693 million of unrestricted cash and $2.1 billion in liquidity at the NRG Corporate level as of December 31, 2015, as well as $14.7 billion in annual operating revenues in 2015, NRG has sufficient liquidity to fund and deliver the proposed microgrid development and construction project on balance sheet. Sources of NRG equity would include its current cash balances as well as future cash flows generated by its existing operations.

NRG would strive to finance the energy system in the most optimal, cost-effective manner, which could involve a combination of NRG and third-party funds. NRG would also take steps to increase the attractiveness of the project to sources of potential financing, as well as other project participants, such as EPC contractors. This would include efforts to structure a financeable, long-term power purchase or energy services agreement with customer participants. NRG has ample balance sheet liquidity, NRG Yield (NYSE: NYLD) as a potential financing vehicle and long-term owner upon commercial operation, deep relationships with third-party capital providers, including lenders, tax equity investors and institutional investors, and experience with government grants and incentive funds, including for innovative renewable energy projects.

NRG has successfully raised financing for construction projects in the last several years that range in size from large and small utility scale to distributed and residential scale. NRG has financed 3,700+ net MW of development projects on a non-recourse basis, resulting in over $7 billion of project debt financing at competitive terms. NRG has experience structuring and closing various types of financial arrangements that optimize the economic viability of projects with unique or complex features.

3.3.5 For identified project team members (including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners), what are their qualifications and performance records?

NRG - NRG is the largest competitive power producer in the U.S. and owns and operates nearly 50,000 MW of net generation capacity nationwide, representing a diversified mix of fuel sources, generation technologies, output configurations, and geographical locations. NRG is also one of the nation's largest renewable generation owners and developers -- both at the utility and distribution scale -- with 3,000+ MW of wind generation assets and with 2,000+ MW of solar in operation, construction, and development.

NRG's ability to provide a turn-key, single point of responsibility for design, engineering, permitting, construction, financing, commissioning, and long-term operations and maintenance minimizes risk and effort for customers. A single master developer could best manage the economic risk that the assets will perform as expected and also contract with the various OEMs/sub-contractors. NRG has significant expertise in the structuring, negotiation, execution, and management of EPC arrangements for power generation projects. NRG's procurement and construction personnel are skilled at negotiating contracts with vendors and suppliers to maximize quality, limit cost, and ensure adherence to schedules.

For an efficient integrated microgrid, the coordination and optimization of DER enhances the functionality of the microgrid. The project team views it as a strength if a single, capable entity owns and operates the assets as a system to optimize performance and reduce risk and costs to microgrid customer participants.

Engineering and Construction: NRG's engineering and construction team has extensive experience across a wide array of fossil fuel and renewable energy generation technologies, and a track record for on-time and on-budget performance. The typical project execution approach is for NRG to directly manage and oversee project engineering and on-site construction, as performed by NRG-qualified contractors and suppliers. To ensure cost-effective execution in-line with requirements, NRG typically selects contractors and suppliers via competitive solicitations from among a pool of pre-qualified and well-proven contractors. NRG engages the contractors via EPC contracts with built-in risk management techniques, including, for example, date certain fixed price contracts, with appropriate retainage, liquidated damages and warranties. During the execution phase, internal NRG experts would manage construction, actively overseeing the contactors' activities to ensure on-time and on-budget delivery consistent with the project specifications. One such partner that NRG has engaged is Burns Engineering for both engineering support and equipment needs.

Operations: Consistent with NRG's normal practice, NRG would manage and operate the microgrid project utilizing a team of highly experienced internal experts, supplemented by qualified subcontractors where beneficial. NRG has a strong historical record for safety and high reliability. Depending on project and customer needs, NRG's operations and technical staff would develop and implement a strategy to deliver long-term reliable performance, utilizing tools such as 24x7 equipment monitoring, regular preventive maintenance, spare parts inventory and supply management, and performance reporting and assessment. In addition, NRG would maintain appropriate levels of insurance, and where available, obtain long-term warranties from original equipment manufacturers and construction contractors to ensure high levels of equipment performance.

NRG has significant experience in the design, engineering, and implementation of cost-effective, resilient, and efficient energy systems that include innovative solutions and clean energy to serve customer needs. NRG has operational microgrids incorporating multiple generation and storage technologies and modular, integrated control and optimization systems at locations such as Necker Island and the University Medical Center of Princeton at Plainsboro. Below are some examples of NRG's proven microgrid capabilities and successful project experience involving partnerships with host customers.

- **Necker Island** – This renewables-driven microgrid is completely islanded and integrates renewable and non-renewable generation sources: solar, wind, energy storage, and diesel generation, as well as load shifting capabilities to maximize renewable energy generation. The project is being designed and installed with the intention of providing a scalable, real life application relevant to other islands in the Caribbean.

- **Arizona State University** – NRG entered into an agreement with ASU to design, construct, and operate the Sun Devil Energy Center, a CHP plant and emergency back-up assets connected to on-campus laboratories and research facilities that require reliable and resilient energy supplies on a 24/7 basis. In addition, NRG has provided significant solar generation for the ASU campus, with over 12 MW of solar currently installed. Applications include rooftop, elevated parking arrays, and single axis ground mount solar solutions.

- **NRG Energy Center Princeton** – State-of-the-art and self-sufficient, with the lowest net energy consumption and highest reliability available for a healthcare facility, this CHP-based microgrid supplies the total energy needs of the University Medical Center of Princeton at Plainsboro – under a long-term full requirements contract to provide steam, chilled water, electricity from a gas turbine generator and solar, back-up generation, and thermal storage. NRG was selected to finance, design, build, own, operate, and maintain the sustainable energy system. The project commenced commercial operations in January 2012 ahead of schedule and on budget, and NRG's solution dramatically cuts energy bills and emissions while increasing reliability.

Burns Engineering - Burns is at the forefront of the design, development and implementation of advanced microgrids and distributed energy resources. Burns is currently performing the preliminary design of a 100+ MW microgrid for NJ Transit to power transit operations to and from Manhattan to northern New Jersey in the event of a protracted grid failure. Burns is also currently evaluating a 10-20 MW microgrid for the Port Authority of New York and New Jersey. Previous notable projects include the design and implementation of a microgrid for the Philadelphia Navy Yard, and the engineering and project management for a 16 MW microgrid at Temple University. Burns and it's teaming partners have received several Department of Energy grants to advance the development and testing of microgrid controller technology, and to deploy and test advanced micro synchrophasors for enhanced grid stability and control.

GE Energy Consulting - GE Energy Consulting (www.geenergyconsulting.com) is a core group of leading GE technical and business experts that has focused its collective energies on solving the electric power industry's most pressing challenges with a goal to "pursue and execute engagements that expand the study portfolio and help define the energy industry of the future". The foundational strength of GE Energy Consulting lies in the experience and expertise of its employees, a total staff of approximately 100, with most having advanced degrees in engineering disciplines, including more than 25 with doctoral degrees. GE Energy Consulting is distinguished by having six engineers on staff who have been elevated to the esteemed status of IEEE Fellow, the highest honor bestowed by IEEE. Cumulatively, GE Energy Consulting engineers have published hundreds of technical papers and authored or co-authored many textbooks. Our engineers on the team play an important role in the power industry by leading and participating in a number of industry organizations, including 30 IEEE Committees, Subcommittees and Working Groups, and 5 CIGRE Working Groups as well as international standards committees, such as IEC.

GE Energy Consulting has decades of experience conducting detailed engineering assessments in New York State, the Northeast and across the country. The recent interest in microgrids, driven by storm impacts in the Northeast, has resulted in a number of working opportunities with the states of New York, New Jersey, Pennsylvania, Connecticut, and Massachusetts, individual utilities in the Northeast, and various end-customers and communities. As a precursor and enabler to NY Prize, Energy Consulting was retained by NYSERDA to perform microgrid feasibility studies and develop the technical microgrid functional designs for five designated sites in New York State. The results of this work are found in the NYSERDA final report entitled Microgrids for Critical Facility Resiliency in New York State, December 2014.

3.3.6 Are the contractors and suppliers identified? If yes, who are they, what services will each provide and what is the relationship to the applicant? If no, what types of team members will be required and what is the proposed approach to selecting and contracting?

Equipment vendors have been approached for a range of hardware and software systems, including microgrid control, cogeneration and fuel cells. No decisions have been made to pre-select any technology, though the team has identified best in class and will only procure technology with proven performance record. Similarly, no contractors have been determined. The project team will commence discussions with potential contractors as part of Phase 2. Procurement of equipment and construction services will be done through a competitive process at the appropriate time.

3.3.7 Are the project financiers or investors identified? If yes, who are they and what is their relationship to the applicant? If no, what is the proposed approach to securing proposed financing? Will other members of the project team contribute any financial resources?

Subject to publice procurement rules, NRG aspires to be the project financier and ultimate owner. It is not expected that other members of the project team will contribute any financial resources. NRG would strive to finance the energy system in the most optimal, cost-effective manner, which could involve a combination of NRG and third-party funds. NRG would also take steps to increase the attractiveness of the project to sources of potential financing, as well as other project participants, such as EPC contractors. This would include efforts to structure financeable, long-term power purchase or energy services agreements with customer participants. NRG has ample balance sheet liquidity, NRG Yield (NYSE: NYLD) as a potential financing vehicle and long-term owner upon commercial operation, deep relationships with third-party capital providers, including lenders, tax equity investors and institutional investors, and experience with government grants and incentive funds, including for innovative renewable energy projects.

3.3.8 Are there legal and regulatory advisors on the team? If yes, please identify them and describe their qualifications. If no, what is the proposed approach to enlisting support in this subject area?

As an owner and operator of power generation assets and on-site energy systems nationwide, NRG is familiar with navigating the regulatory landscape, including working to identify and overcome regulatory barriers at the municipal, state, and federal levels. NRG has an experienced team in Market & Regulatory Affairs, as well as Government Affairs and Legal professionals dedicated to these issues. NRG actively comments on regulatory proceedings and has effectively helped to shape the legal and regulatory landscape within which third-party generators compete at the utility and distribution scale, both behind and in front of the meter. NRG is participating in New York State's Reforming the Energy Vision ("REV") proceeding, supporting the REV objectives of competitive markets, customer choice and participation, renewable deployment and integration, enhanced system efficiency, reliability, and resiliency. NY Prize community microgrid projects will present new challenges for regulators as well as for the parties implementing the projects, and NRG is well-positioned to work cooperatively and constructively with state regulators, utilities, customers, and other stakeholders to craft workable business models and market rules within which microgrids and DER can operate efficiently and profitably.

NRG has had a strong operating presence in New York State since 1999, with energy customers and generation assets across the state. NRG owns and operates more than 4,100 net MW of wholesale generation in New York State and has hundreds of additional MWs of demand response (through NRG Curtailment Solutions f/k/a Energy Curtailment Specialists) and retail load (through brands such as NRG Home, Green Mountain Energy, and Energy Plus), giving NRG extensive experience with the New York Independent System Operator's ("NYISO") market and the permitting, regulatory, and legal environment in the state.

Through its wholesale generation, demand response, and retail businesses in New York, NRG is fully compliant and conversant with NYISO's interconnection requirements, including metering, ancillary service provisions, operating policies, criteria, rules, guidelines and tariffs, and employs Good Utility Practice in all markets in which it operates and conducts business.

3.4 Commercial Viability - Creating and Delivering Value

3.4.1 How were the specific microgrid technologies chosen? Specifically discuss benefits and challenges of employing these technologies.

The microgrid distributed energy resources were chosen based on a number of factors. We started overall system optimization and initial asset selection, sizing and configuration by using Lawrence

Berkeley Lab's 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.

This was then 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. SUNY Oswego has a large thermal load and a significant electric base load that made it well suited to utilize cogeneration and fuel cells. The summer thermal load is limited but the cogeneration unit can participate in the summer energy markets to lower demand, or provide ancillary services. Converting the backup generators from diesel only to dual-fuel diesel/natural gas units was a compelling low cost option to ensure operability up to two weeks or more.

A key determining factor in the preliminary selection and configuration of baseload electric generating assets was the thermal baseload. Specifically, sizing of the CHP was limited to 1 MW as this best matched the summer thermal load. Sizing it above that level would result in wasted thermal energy during summer months and a reduction in overall system efficiency and economic performance. Fuel cells were added to provide high-efficiency electrical generation with limited emissions to meet electric load not met by the CHP and dual fuel backup generation. Solar PV sizing was limited to 100 kW due to available roof space and the low resilience value during outage events. Battery sizing of 100 kW reflects a need to provide stability and power quality during outage events.

3.4.2 What assets does the applicant and/or microgrid owner already own that can be leveraged to complete this project?

The Oswego Microgrid has a nameplate capacity of 9.554 MW. The average operating level of this microgrid under normal conditions is 5.17 MW over the course of a year. The Wastewater Treatment plant and SUNY Oswego both have existing assets that can be utilized in the Microgrid. The Wastewater Treatment plant has an existing 450 kW natural gas generator that can be utilized. SUNY Oswego has a total of 1.27 MW and 2.634 MW of existing natural gas and diesel backup generators, respectively, that can be utilized during emergency conditions. In addition, existing electric, gas and thermal distribution infrastructure will be utilized.

3.4.3 How do the design, technology choice, and/or contracts ensure that the system balances generation and load?

The system microgrid system includes 100 kW of battery storage that will help provide system stability. Baseloaded generation of 5 MW from the CHP and fuel cells will operate at full power and therefore require little control. Backup generation will provide load following and peaking. Reciprocating engines will be used to respond to swings in the system by operating on droop. This ensures the engines will increase or decrease power output based upon monitoring of voltage and frequency.

3.4.4 What permits and/or special permissions will be required to construct this project? Are they unique or would they be required of any microgrid? Why?

The project team does not expect that special permits will be required.

3.4.5 What is the proposed approach for developing, constructing and operating the project?

The proposed approach is to provide a P3 solution wherein NRG will build, own and operate the microgrid.

3.4.6 How are benefits of the microgrid passed to the community? Will the community incur any costs? If so, list the additional costs.

The benefits of the microgrid will redound to community stakeholders in a number of direct and indirect ways. By ensuring the long-term operational continuity of the City of Oswego's water purification and treatment related facilities in the face of a severe, protracted grid failure, the microgrid will provide significant benefits to the more than 30,000 people who rely on these facilities and services daily. The microgrid will provide continuity of source water supply to a population of 500,000 people in five counties through the Metropolitan Water Board Raw Water Pumping Station. In addition, the microgrid will help protect the roughly 8,000 students, faculty and staff who attend, teach or work at SUNY Oswego. Potential revenues and savings from the microgrid operation will also provide much needed budget relief for the City of Oswego and help keep taxes from rising.

3.4.7 What will be required of the utility to ensure this project creates value for the purchaser of the electricity and the community?

The electrical interconnection of the facilities at the Oswego Microgrid will not require major effort from the utility in order to create value for the purchase of the electricity and the community. No utility lines are required to be utilized in the event that the Microgrid is operating in island mode. Each microgrid site will be connected on the secondary of the 34.5kV utility transformers through direct boring.

3.4.8 Have the microgrid technologies (including but not limited to: generation, storage, controls) been used or demonstrated before? If yes, describe the circumstances and lessons learned.

All of the technologies incorporated in the proposed microgrid are commercialized and proven. Cogeneration, fuel cells and solar PV are established technologies, and retrofitting emergency generators to allow dual fuel operation is a well understood and proven solution to ensure long-term fuel availability.

The Microgrid Control design will 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 Describe the operational scheme (including, but not limited to, technical, financial, transactional and decision making responsibilities) that will be used to ensure this project operates as expected.

Dual fuel generators at SUNY will allow the largest generators to extend to 14 days runtime. These large reciprocating engines will operate in droop and serve to ensure system voltage and frequency regulation. The microgrid will focus on turning off the smaller diesel units which are less economical to convert to dual fuel and are less efficient. The key component is fuel cells located near the main substations of the Metropolitan Water Board, WTP, and SUNY Oswego. The fuel cells will run baseloaded to offset power consumed by all three of these facilities. SUNY will also have a 1MW CHP unit located near the central heating plant. Upon loss of utility power, all three of these facilities will island from National Grid and repower the switchgear of each facility on a selective basis. The MWB and WTP presently have no backup generators and will be repowered by the microgrid. Additionally, the fuel cells will tie into selected 13.2kV feeders at the SUNY Oswego substation. The backup generation at SUNY will serve as the overall system regulator for the microgrid and ensure system stability by responding to block loads via droop operation.

3.4.10 How does the project owner plan to charge the purchasers of electricity services? How will the purchasers' use be metered?

The project owner would enter into long-term power purchase and/or energy services agreements with the various microgrid customer participants wherein the price per kWh, price for thermal energy, and other pricing components would be established and agreed to by all parties. The microgrid owner would provide electrical and thermal energy, as well as reliability/resiliency services, to customer participants via a pricing structure that may include a combination of fixed and variable pricing components as well as a resiliency and/or subscription fee. Costs would be charged to the customer associated with the meter where the DER asset is tied, and energy usage at individual sites would all be recorded by revenue grade meters.

3.4.11 Are there business/commercialization and replication plans appropriate for the type of project?

Yes, the project's proposed P3 business and commercialization plans are appropriate for this project. Long-term power and/or purchase agreements between private parties and governmental/ institutional/non-profit entities are a proven and widely used deal structure to implement large energy infrastructure projects.

3.4.12 How significant are the barriers to market entry microgrid participants?

Absent a capable third-party with a proven track record of funding, owning and operating large, complex energy assets and infrastructure, it is unlikely that the microgrid participants would have the wherewithal to pursue this project. On the customer side, adding additional microgrid customers beyond the currently public institutional and utility entities could also be challenging due to distance, relative energy requirements, credit worthiness, and longevity as viable off-takers.

3.4.13 Does the proposer demonstrate a clear understanding of the steps required to overcome these barriers?

The project team has a comprehensive understanding of P3 structures and working experience with third-party ownership/operations structures for energy projects. NRG has successfully completed several operational microgrid projects for host customers as described in 3.3.5, and Burns has participated in several P3 projects 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 construction and facilitate ownership and operation of distributed generation resources central to the microgrid.

Overcoming barriers related to expanding the microgrid to include more customers will be very site specific and a function of proximity and any given customer’s electric and thermal loads, cost of energy, perceived need for enhanced resilience, willingness to participate and, not least, credit worthiness and anticipated longevity at the site.

3.4.14 Has the market been identified and characterized?

The market of capable private energy companies able to provide a P3 – DBOOM solution has been identified and is well understood. The market of potential microgrid customers is hard to quantify given the emerging nature of microgrids, but it will be driven by the perceived need for added resilience, energy costs, incentives and the cost and demonstrated performance of microgrids and the various distributed energy resources and technologies that will microgrids will be comprised of.

3.5 Financial Viability

3.5.1 What are the categories and relative magnitudes of the revenue streams and/or savings that will flow to the microgrid owner? Will they be fixed or variable?

The principal revenue streams for the proposed microgrid would be derived mostly from base-load thermal and electric energy sales (CHP, fuel cells), with a markedly smaller amount of renewable electricity sales from the solar PV system. Sales of baseloaded and solar electricity could earn gross annual revenues of approximately $3.1 million based on preliminary modeling and current prices for electricity and thermal energy. This amount does not include any savings that would accrue to the off-taker participants, but it is expected that a negotiated discount to current/projected business-as-usual energy costs will be necessary to incentivize the participants. Additional revenues are foreseen based on participation in NYISO demand response and energy and ancillary services markets, subject to current/future market design rules.

Specific contractual arrangements between the microgrid owner and customer participants will be further discussed in the detailed design and structuring phases; revenues would accrue to the microgrid owner via a pricing mechanism detailed in power purchase and/or energy services agreements that may include a combination of fixed and variable pricing components as well as a reliability/resiliency and/or subscription fee for premium energy services.

A sample pricing structure could be comprised of the following components: (i) electricity, (ii) hot water, (iii) emergency power, (iv) fixed O&M, (v) variable O&M, (vi) fuel energy, (vii) purchased power from the grid, and/or (viii) resiliency or subscription fees. The first three pricing components, along with the resiliency or subscription fees, would cover debt service and fees (if applicable), upfront and on-going capital recovery, and a reasonable return on equity. Fixed O&M would cover property taxes, insurance, billing & administration, etc., while variable O&M would cover maintenance, repairs, water, sales & use tax (if applicable), etc. Fuel and energy will represent recovery of costs for commodity, transportation, and emissions. This fuel energy charge would typically be based on billing heat rates for CHP, fuel cells, and emergency power and the cost of delivered fuel. The expected solar PV pricing under an ESA/PPA would be $0.15/kWh on the generation with a reasonable annual inflation adjustment factor.

3.5.2 What other incentives will be required or preferred for this project to proceed? How does the timing of those incentives affect the development and deployment of this project?

Incentives to deploy solar PV, CHP and fuel cells would be required to buy down the initial cost of these technologies. Other incentives required or preferred will depend in part on the magnitude of the NY Prize funding received in future stages. The project team believes that the NY Prize Stage 2 funding will be particularly important for communities and their partners to move forward with the microgrid development process. Absent this funding from NYSERDA, communities including Oswego will most likely be challenged to secure additional funds and proceed to a final, buildable project design.

A number of federal and state-level incentives, subject to funding availability and eligibility and changes in incentive levels and structures, will contribute to the overall financial viability of the project:

Federal Investment Tax Credit

- 30% for Solar PV (extended at 30% through 12/31/2019 and gradually stepping down each year thereafter)
- 10% for CHP (currently set to expire on 12/31/2016)

NYSERDA

- PON 2568 for CHP

NY-SUN Incentive for Small Nonresidential Applications – NY PON 3082

$0.35/Watt for first 50 kW, $0.30/Watt for each additional up to 200 kW total

Through NY State's Net Metering Law and the LIPA Tariff for Electric Service, customers with solar PV systems are entitled to net metering. When the customer's solar system generates more electricity than consumed, excess electricity is returned to the system, and the customer will be billed only for the net consumption at the end of each month.

3.5.3 What are the categories and relative magnitudes of the capital and operating costs that will be incurred by the microgrid owner? Will they be fixed or variable?

The present value of capital investment for the proposed microgrid is estimated to be $6 million before rebates and incentives, plus a $1.5 million cost estimate for initial planning/design. Operating costs will be a combination of fixed and variable and are estimated to be approximately $8 million per year including fuel with most of the costs related to variable O&M.

3.5.4 How does the business model for this project ensure that it will be profitable?

The P3-DBOOM business model will utilize long-term power purchase and/or energy service agreements with the participant off-takers that will incorporate energy adjustment and natural gas pass through clauses to ensure that the third-party owner and capital provider is reasonably assured of a return of and on investment, assuming fulfillment of the party's obligation under the contract. For electric commodity, the agreement will allow the third-party owner to increase electric rates if the utility rates or on-going costs (including fuel) increase, while still delivering a level of energy cost savings, in addition to the benefits of increased reliability/resiliency and lower emissions, for the microgrid participant off-takers compared to default utility tariff rates. This upside for the third-party owner will provide additional revenue and help protect against unforeseen circumstances and costs.

The P3-DBOOM business model also lowers the total amount of capital that has to be recovered and thus the pricing to end-users because the private entity is able to monetize tax credits and utilize accelerated depreciation on certain assets. This has the direct effect of lower project risk and enhancing profitability. Without a private firm's involvement, the value of those tax related benefits would be lost.

3.5.5 Describe the financing structure for this project during development, construction and operation.

The financing structure will be similar to other power generation projects wherein a construction loan and/or equity is used to fund construction costs that are then recovered along with a reasonable return on investment under the long-term energy off-take and services agreements. NRG has sufficient liquidity on balance sheet to fund and deliver the proposed microgrid development and construction project, assuming it meets corporate investment criteria and receives required approvals for the allocation of funds.

NRG has successfully raised financing for construction projects in the last several years that range in size from large and small utility scale to distributed and residential scale. NRG has financed 3,700+ net MW of development projects on a non-recourse basis, resulting in over $7 billion of project debt financing at competitive terms. NRG has experience structuring and closing various types of financial arrangements that optimize the economic viability of projects with unique or complex features.

3.6 Legal Viability

3.6.1 Describe the proposed project ownership structure and project team members that will have a stake in the ownership.

The proposed project ownership structure is based on a qualified private energy company with proven technical capabilities and financial wherewithal serving as the primary owner of the microgrid as well as the operator. Additional ownership may be held by a key partner, such as a specialty equipment vendor, the lead technical services/engineering firm, or the host customer. For the Oswego microgrid, the primary owner is expected to be NRG. For the Fuel Cell unit, a key vendor partner might be FuelCell Energy or Bloom Energy.

3.6.2 Has the project owner been identified? If yes, who is it and what is the relationship to the applicant? If no, what is the proposed approach to securing the project owner?

For the Oswego Microgrid, the primary owner is expected to be NRG. NRG would establish a single purpose, project-specific limited liability company that would hold and own project contracts, assets, and property, including the long-term agreements referenced in 3.1.7. This special purpose entity would most likely be wholly-owned by NRG, or majority-owned by NRG with a minority ownership encouraged by customer participants or other strategic partners..

3.6.3 Does the project owner (or owners) own the site(s) where microgrid equipment/systems are to be installed? If not, what is the plan to secure access to that/those site(s)?

The Oswego Microgrid will utilize existing land and roof space to accommodate the DER equipment. The participant off-takers - the City of Oswego, the Water Board and SUNY Oswego, all own their properties. The owner of the microgrid would be NRG, and it would seek to secure use of the available space as part of a long-term power purchase and/or energy services agreement.

3.6.4 What is the approach to protecting the privacy rights of the microgrid's customers?

P3 energy projects that include the sale of energy commodities, such as solar PV generation, from the private party to the public hosts or off-takers are commonplace and viewed as a creative means to accelerate the penetration of energy efficiency and distributed generation projects. Private firms that use this business model and implement these projects are accustomed to ensuring the privacy of their public hosts.

3.6.5 Describe any known, anticipated, or potential regulatory hurdles, as well as their implications that will need to be evaluated and resolved for this project to proceed. What is the plan to address them?

The development and implementation of "first-of-a-kind" community-based microgrids that are both reliable and economic will involve complexity and challenges. For example, state legislatures and public utility commissions may need to act to resolve legal issues related to local distribution utility exclusive franchise rights and whether microgrids serving multiple, unaffiliated end users fall under public utility regulations. If a new line is built without National Grid's involvement, the microgrid would need regulatory approval to cross public rights of way. The following issues may arise due to a utility's involvement in microgrid projects: restrictions on utility ownership of generation; ability of microgrid ownership entity to recover fixed costs for infrastructure from direct and indirect beneficiaries; ability of microgrid ownership entity to act as DR aggregator for wholesale markets; valuation of locational benefit of microgrid DERs (LMP+D).

NRG, Burn Engineering, and GE EC are well-positioned to work cooperatively and constructively with state regulators, utilities, communities, customers, and other stakeholders to lead and support the project team through the NY Prize Competition process, craft workable business models and structures within which DER and microgrids can operate, and increase the likelihood of successful development and implementation of a Oswego microgrid project, thus advancing the objectives of NY Prize and New York's REV policy initiative.

In addition, the expected use of third party capital from NRG and/or participating customers will prove out the commercial viability of the project and minimize the risk of cost assignment to National Grid's rate base customers. However, where non-participating customers will benefit from community facilities, emergency services, and/or essential retail or commercial services served by a public purpose microgrid, it may be appropriate to socialize a portion of the project's costs through National Grid's rates or other form of cost recovery under REV, as determined by the PSC.

Given the complexities involved in the design, engineering, and development of reliable and economical microgrid systems, communities and other customer participants are encouraged to partner with energy service companies, such as NRG and its project design partners, which have a proven track record and the necessary financial, technical, and regulatory expertise. As a competitive energy services provider and third-party owner/operator of DER, NRG is leading the transition to a clean renewables-driven, increasingly distributed, and grid-resilient future.

Section 4 – Benefit - Cost Analysis Summary Report

As part of NYSERDA's New York Prize community microgrid competition, the City of Oswego has proposed development of a microgrid that would serve the following facilities:

- The State University of New York (SUNY) Oswego Campus;
- The City of Oswego Water Treatment Plant;
- The Onondaga County Metropolitan Water Board-Raw Pumping Station; and
- The City of Oswego Wastewater Treatment Plant.

The microgrid would include several new distributed energy resources (DERs). A new combined heat and power (CHP) system with a capacity of 1 MW would be installed at SUNY Oswego, along with two natural gas-powered fuel cells with a combined capacity of 4 MW. In addition, a solar photovoltaic cell with battery storage, with a combined capacity of 0.2 MW, would be installed at the wastewater treatment plant. The microgrid would also incorporate three backup generators that are currently based at the wastewater treatment plant or SUNY Oswego; these generators have a combined capacity of approximately 4.4 MW and are currently used only during major power outages. Following the development of the microgrid, these generators would be relied upon to produce power under normal operating conditions.

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

METHODOLOGY AND ASSUMPTIONS

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

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

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

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.[1] 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 present value of the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

<u>Scenario 1:</u> No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).

<u>Scenario 2:</u> The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[2]

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[1] 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.]

[2] 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 4-1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 3.8 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 3.8 DAYS/YEAR
Net Benefits - Present Value	-$32,300,000	$441,000
Benefit-Cost Ratio	0.7	1.0
Internal Rate of Return	N/A	3.0%

Table 4-1: BCA Results (Assuming 7 Percent Discount Rate)

Scenario 1

Figure 4-1 and Table 4-2 present the detailed results of the Scenario 1 analysis.

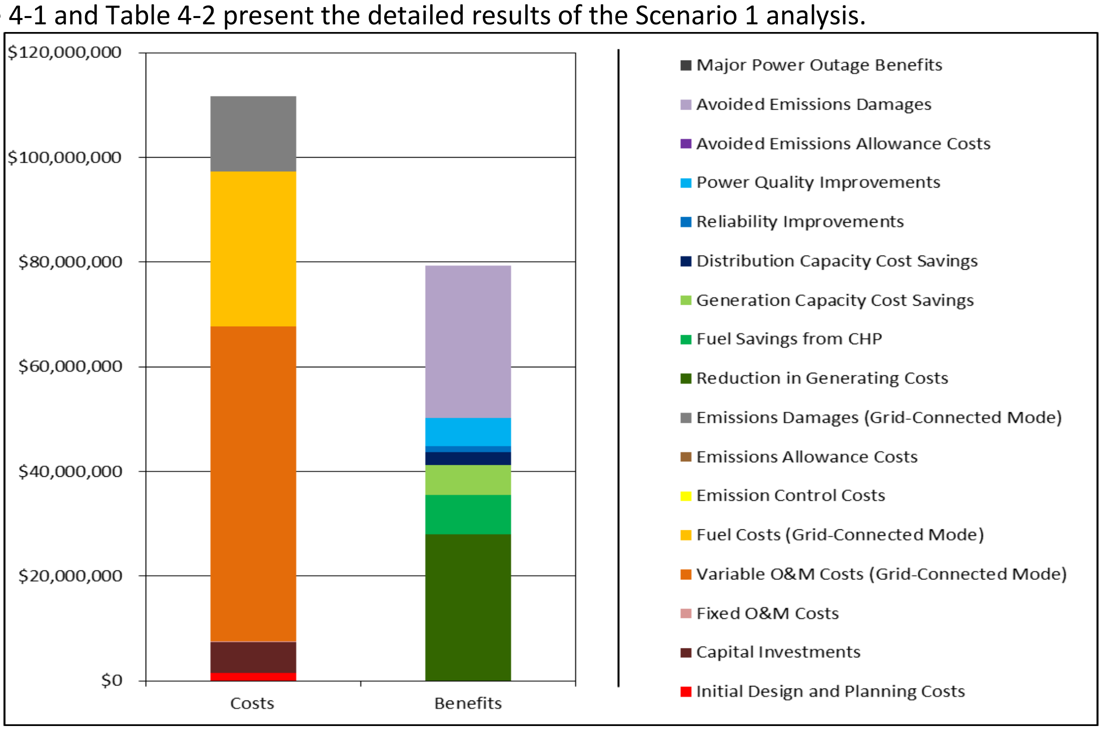

Figure 4-1: Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,500,000	$132,000
Capital Investments	$5,900,000	$464,000
Fixed O&M	$113,000	$10,000
Variable O&M (Grid-Connected Mode)	$60,300,000	$5,320,000
Fuel (Grid-Connected Mode)	$29,600,000	$2,610,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$14,300,000	$933,000
Total Costs	$128,000,000	
Benefits		
Reduction in Generating Costs	$28,000,000	$2,470,000
Fuel Savings from CHP	$7,460,000	$658,000
Generation Capacity Cost Savings	$5,780,000	$510,000
Distribution Capacity Cost Savings	$2,480,000	$219,000
Reliability Improvements	$1,090,000	$96,300
Power Quality Improvements	$5,450,000	$481,000
Avoided Emissions Allowance Costs	$15,400	$1,360
Avoided Emissions Damages	$29,100,000	$1,900,000
Major Power Outage Benefits	$0	$0
Total Benefits	$79,400,000	
Net Benefits	-$32,300,000	
Benefit/Cost Ratio	0.7	
Internal Rate of Return	N/A	

Table 4-2: Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team estimates initial design and planning costs to be $1.5 million. The present value of the project's capital costs is estimated to be $5.9 million, including costs associated with the installation of the CHP unit, transformers, fuel cell paralleling equipment, cabling, and microgrid controllers. The project team also estimates $10,000 a year in fixed O&M costs for software, licensing, and miscellaneous expenses. These costs have a present value of $113,000 over 20 years.

Variable Costs

The project team assumed power purchase agreement (PPA) structures for both of the fuel cells and solar installations, all of which would be owned and operated by a third party. To facilitate analysis, the delivered prices of the PPA structures are specified as variable costs rather than capital costs.[3] In addition to these costs, the project team reports O&M costs for the combined heat and power unit, as well as the existing emergency natural gas and diesel generators. In total, these costs have a present value of approximately $60.3 million. The model also estimates the cost of fuel. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of

[3] The value of the PPAs likely reflects the third party's financing costs and return on investment. If this is the case, the PPA will overstate the true social cost of the fuel cell and solar installations.

fuel costs from New York's 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 $29.6 million.

The analysis of variable costs also 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. The majority of these damages are attributable to the emission of CO2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $14.3 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. For the City of Oswego's proposed project, a major source of cost savings would be a reduction in demand for electricity from bulk energy suppliers, with a resulting reduction in generating costs. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $28.0 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. The CHP system at SUNY Oswego would also provide savings on heating costs due to a reduction in fuel consumption; the present value of these savings is approximately $7.5 million. These changes would curtail emissions of CO2, SO2, NOx, and particulate matter from the university's heating system and from bulk energy suppliers, yielding emissions allowance cost savings with a present value of approximately $15,000 and avoided emissions damages with a present value of approximately $29.1 million.[5]

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.[6] The project team estimates the project's impact on demand for generating capacity to be approximately 6.8 MW per year, and its impact on distribution capacity requirements to be approximately 6.0 MW per year. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $5.8 million over a 20-year operating period, and the present value of its distribution capacity benefits to be approximately $2.5 million.

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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] 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.

[6] Impacts on transmission capacity are implicitly incorporated into the model's estimates of avoided generation costs and generation capacity cost savings. As estimated by NYISO, generation costs and generating capacity costs vary by location to reflect costs imposed by location-specific transmission constraints.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, including 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 these 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 $100,000 per year, with a present value of approximately $1.1 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) – 0.96 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 116.4 minutes.[8]

The estimate takes into account the number of large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[9] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's estimate of the number of power quality events that development of the microgrid would avoid each year. In the case of the City of Oswego, the project team has indicated that approximately five power quality events would be avoided each year. Assuming that each customer in

[7] www.icecalculator.com.

[8] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for National Grid.

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

the proposed microgrid would experience these improvements in power quality, the model estimates the present value of this benefit to be approximately $5.5 million over a 20-year operating period.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.7; i.e., the estimate of project benefits is approximately 70 percent of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[10,11]

As noted above, the City of Oswego's microgrid project would serve a large university campus, as well as critical water and wastewater treatment facilities. The project's consultants indicate that at present, only the SUNY Oswego campus and the city's wastewater treatment plant are equipped with backup generators. The backup generator at the wastewater treatment plant has sufficient capacity to support ordinary levels of service; operation of this generator costs $650 per day. In contrast, the backup generators at the university are sufficient to maintain only 50 percent of normal levels of service; operation of these generators costs $11,400 per day.[12] The remaining facilities – the city 's water treatment plant and Onondaga County's raw water pumping station – could maintain service through the use of portable generators; the costs associated with doing so are listed in Table 4-3 below. In the absence of backup power – i.e., if the backup generators failed and no replacements were available – all the facilities would experience a 100 percent loss in service capabilities (see Table 4-3).

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[10] The methodology used to estimate the value of lost services was developed by the Federal Emergency Management Agency (FEMA) for use in administering its Hazard Mitigation Grant Program. See: FEMA Benefit-Cost Analysis Re-Engineering (BCAR): Development of Standard Economic Values, Version 4.0. May 2011.

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

[12] The project team notes that costs would be minimal for the operation of existing backup generation. Since the project team's estimates did not include fuel costs, we sum the costs provided by the project team with a separate calculation of fuel costs, based on the fuel consumption specifications provided by the project team.

FACILITY NAME	COST OF MAINTAINING SERVICE WITH PORTABLE GENERATOR ($/DAY)	PERCENT LOSS IN SERVICE WHEN BACKUP GENERATION IS NOT AVAILABLE
SUNY Oswego Campus[13]	NA	100%
City of Oswego Water Department-Water Treatment Plant	$3,000	100%
Onondaga County Metropolitan Water Board-Raw Pumping Station	$4,000	100%
City of Oswego Wastewater Treatment Plant[14]	NA	100%

Table 4-3: Backup Power Costs and Level of Service, Scenario 2

The information provided above serves as a baseline for evaluating the benefits of developing a microgrid. Specifically, the assessment of Scenario 2 makes the following assumptions to characterize the impacts of a major power outage in the absence of a microgrid:

- The SUNY Oswego Campus and the city's wastewater treatment plant would rely on their existing backup generators. The university would be able to maintain operations at 50 percent of normal levels, while the wastewater treatment plant would maintain full capabilities while its backup generator operates. If the backup generators fail, both of these facilities would experience a total loss of service.
- The water treatment plant and pumping station would rent portable generators, maintaining full capabilities while these generators operate. If the backup generators fail, both of these facilities would experience a total loss of service.
- In all cases, the supply of fuel necessary to operate backup generators would be maintained indefinitely.
- At each facility, there is a 15 percent chance that the backup generator would fail.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities of interest. The analysis employs the approach described below to estimate these costs.

- The impact of a loss in the city's water and wastewater treatment services is calculated using standard FEMA methodologies.
- The impact of an outage at the university assumes that the economic value of maintaining its operations is $435,000 per day. This figure is based on the university's budget for 2014, minus any capital expenditures, divided by 365 days to calculate a daily value.[15,16]

Based on these methods and the other assumptions outlined above, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the facilities of interest is approximately $760,000 per day.

Summary

[13] This facility is already equipped with a backup generator. As the baseline for this analysis, we assume that if the existing backup generator fails (15 percent failure rate), the facility would experience a total loss of service.

[14] This facility is already equipped with a backup generator. As the baseline for this analysis, we assume that if the existing backup generator fails (15 percent failure rate), the facility would experience a total loss of service.

[15] The project team notes that 400 students living in university housing would be without power in the event of an outage. We do not value this benefit separately because the benefits of maintaining electrical service to university housing are already accounted for in the approach outlined above.

[16] SUNY Oswego. "Facts and Figures." Retrieved 9 March 2016 at http://www.oswego.edu/about/leadership/annual-report-2014/facts-and-figures.html.

Figure 4-2 and Table 4-4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 3.8 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

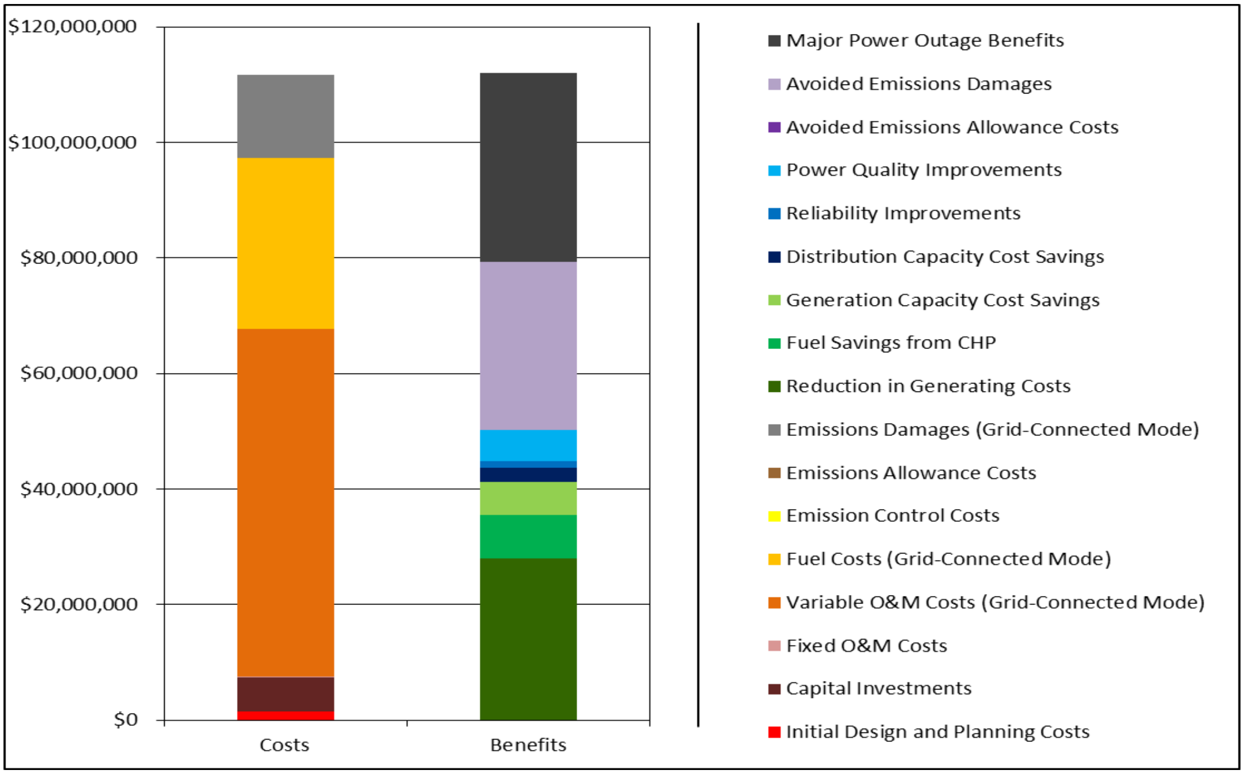

Figure 4-2: Present Value Results, Scenario 2 (Major Power Outages Averaging 3.8 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,500,000	$132,000
Capital Investments	$5,900,000	$464,000
Fixed O&M	$113,000	$10,000
Variable O&M (Grid-Connected Mode)	$60,300,000	$5,320,000
Fuel (Grid-Connected Mode)	$29,600,000	$2,610,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$14,300,000	$933,000
Total Costs	$112,000,000	
Benefits		
Reduction in Generating Costs	$28,000,000	$2,470,000
Fuel Savings from CHP	$7,460,000	$658,000
Generation Capacity Cost Savings	$5,780,000	$510,000
Distribution Capacity Cost Savings	$2,480,000	$219,000
Reliability Improvements	$1,090,000	$96,100
Power Quality Improvements	$5,450,000	$481,000
Avoided Emissions Allowance Costs	$15,400	$1,360
Avoided Emissions Damages	$29,100,000	$1,900,000
Major Power Outage Benefits	$32,700,000	$2,890,000
Total Benefits	$112,000,000	
Net Benefits	$441,000	
Benefit/Cost Ratio	1.0	
Internal Rate of Return	3.0%	

Table 4-4: Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 3.8 Days/Year; 7 Percent Discount Rate)

4.1 Facility List and Customer Description

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
SUNY Oswego Campus	Large Commercial/ Industrial (>50 annual MWh)	State University	*All other industries*	38,740.534	6,957	100%	24
City of Oswego Water Department	Large Commercial/ Industrial (>50 annual MWh)	Water Treatment Plant	*All other industries*	6,751	989	100%	24
Onondaga County Metropolitan Water Board – Raw Pumping Station	Large Commercial/ Industrial (>50 annual MWh)	Raw Water Pumping Station	*All other industries*	6,606	1,217	100%	24
City of Oswego Wastewater Treatment Plant	Large Commercial/ Industrial (>50 annual MWh)	Wastewater Treatment Plant	*All other industries*	1,356	197	100%	24

4.2 Characterization of Proposed Distributed Energy Resources

DER Type	Facility Name	Energy Source	Name plate Capacity (MW)	Avg. Annual Production Normal (MWh)	Avg. Daily Production Emergency (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
2000kW Fuel Cell	SUNY Oswego	*Natural Gas*	2.0	17,520	48	7.26	MMBtu/MWh
1000kW CHP Generator	SUNY Oswego	*Natural Gas*	1.0	8,048.7	24	13.036	MMBtu/MWh
100kW PV cell	Water Treatment Plant	*Solar*	.100	165.564	0.4536	0	N/A
100kWh Battery Storage	Water Treatment Plant	*Solar*	.100	15.1548	0.04152	0	N/A
Existing 1270kW of NG Generators	SUNY Oswego	*Natural Gas*	1.270	823.44	30.48	14.6	MMBtu/MWh
Existing 2634kW of Diesel Generators	SUNY Oswego	*Diesel*	2.634	0	63.216	11.1	MMBtu/MWh
Existing 450kW Generator	Wastewater Treatment Plant	*Natural Gas*	.450	1,238.664	10.8	9.59	MMBtu/MWh

4.3 Capacity Impact and Ancillary Services

The following resources would be available for peak load support.

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does distributed energy resource currently provide peak load support?
2000kW Fuel Cell	SUNY Oswego/MWB/Water Treatment Plant	2.0	☐ Yes
2000kW Fuel Cell	SUNY Oswego/MWB/Water Treatment Plant	2.0	☐ Yes
1000kW CHP Generator	SUNY Oswego	1.0	☐ Yes
100kW PV/Storage	Water Treatment Plant	.08	☐ Yes
Existing 1270kW of NG Generators	SUNY Oswego	1.270	☐ Yes
Existing 450kW Generator	Wastewater Treatment Plant	.450	☐ Yes

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently
SUNY Oswego Campus	5.685	0
City of Oswego Water Treatment Plant	0.08	0
Onondaga County Metropolitan Water Board – Raw Pumping Station	0	0
City of Oswego Wastewater Treatment Plant	.450	0

The microgrid operation will relieve the local distribution network by the kW generated capacity of the microgrid. The kW power offset will allow the utility and the system to provide more power to other energy consumers. If applicable, National Grid's engineering team will provide a value of what this capacity is worth in system avoided costs for the increased power availability.

The microgrid DER would be available for real (power) and reactive (voltage) local utility support, as well as black start or system restoration support as described in 2.3.6 and 2.5.2.

A CHP unit is planned for SUNY Oswego. Energy savings relative to current heating systems are projected to be approximately 96,281MMBtu per year.

No emission allowances will be purchased for the operation of the DER. For regulated NOx and Particulate Matter emissions, the generator engines meet the required limit. Estimated emission rates for the equipment are in the following table. These rates are weighted averages for all DER in the microgrid.

Emissions Type	Emissions per MWh	Unit
CO_2	0.310	Metric tons/MWh
SO_2	0	N/A
NO_x	0.00015	Metric tons/MWh
PM	0	N/A

4.4 Project Costs

The fully installed capital cost of the proposed microgrid is estimated to be approximately $5.9 million before rebates and incentives, plus a $1.5 million cost estimate for initial planning/design. Operating costs will be a combination of fixed and variable and are estimated to be in the range of $5,330,000, with most of the costs related to variable O&M. Fixed O&M costs are currently estimated at $10,000 per year.

The fully installed costs (+/- 30% estimates) and engineering lifespan for all the capital equipment is shown in the below table:

Capital Component	Installed Cost ($ in millions)	Component Lifespan (round to nearest year)	Description of Component
(2) 2000kW Fuel Cells	0	20	PPA Agreement, costs included in O&M section
1000kW CHP Unit	$4,000,000	25	Reciprocating Engine CHP
100kW Solar Panel and Storage	0	18	PPA Agreement, costs included in O&M section
Transformers	$400,000	30	Connection to SUNY, WTP, and MWB secondaries
LV Paralleling Equipment	$750,000	30	Fuel Cell paralleling
Cabling	$247,500	30	Includes directional drilling, cable costs
Communication Backbone	$500,000	30	Microgrid Controllers
Subtotal - Capital Costs	**$5.9**		
Initial Planning & Design	$1.5		Project Design, Permitting, Financing
Total	**$7.4**		

All of the new fuel-based DER will use natural gas. The gas supply should be considered unlimited for the expected design basis events. Fuel consumption is listed in the below table.

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
2000kW Fuel Cell	SUNY Oswego/Oswego MWB	Indefinitely	15,540	scfh
2000kW Fuel Cell	SUNY Oswego	Indefinitely	15,540	scfh
1000kW CHP Generator	SUNY Oswego	Indefinitely	12,780	scfh
100kWh PV/Storage	Water Treatment Plant	Indefinitely	0	N/A
Existing 1270kW of NG Generators	SUNY Oswego	Indefinitely	18,178.4	scfh
Existing 2634kW of Diesel Gen.	SUNY Oswego	14 days	75,566.4	Gallons
Existing 450kW Generator	Wastewater Treatment Plant	Indefinitely	4,231	scfh

4.5 Costs to Maintain Service during a Power Outage

Existing Backup Generation Capabilities:

Facility Name	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
					Quantity	Unit		
SUNY – Convocation	Diesel	.25	100	6	64	MMBtu/day	1	*25*
SUNY - Cayuga	Natural Gas	.04	100	0.96	19	MMBtu/day	1	20
SUNY – Central Heating	Diesel	.4	100	9.6	91	MMBtu/day	1	25
SUNY – Culkin (building)	Natural Gas	.03	100	0.72	12	MMBtu/day	1	20
SUNY – Culkin (telecom)	Diesel	.1	100	2.4	26	MMBtu/day	1	25
SUNY - Funnelle	Natural Gas	.02	100	0.48	8	MMBtu/day	1	20
SUNY - Hart	Natural Gas	.1	100	2.4	31	MMBtu/day	1	25
SUNY - Hewitt	Natural Gas	.03	100	0.72	12	MMBtu/day	1	20
SUNY - Johnson	Natural Gas	.185	100	4.44	64	MMBtu/day	1	25
SUNY - Laker	Natural Gas	.045	100	1.08	19	MMBtu/day	1	20
SUNY - Lanigan	Natural Gas	.030	100	0.72	12	MMBtu/day	1	20
SUNY – Lonis (Telecom)	Diesel	.020	100	0.48	7	MMBtu/day	1	20
SUNY - Mackin	Natural Gas	.015	100	0.36	8	MMBtu/day	1	20
SUNY - Mahar	Diesel	.012	100	0.288	5	MMBtu/day	1	20
SUNY - Onieda	Natural Gas	.06	100	1.44	20	MMBtu/day	1	20
SUNY - Onondaga	Natural Gas	.1	100	2.4	31	MMBtu/day	1	25
SUNY - Pathfinder	Natural Gas	.04	100	0.96	19	MMBtu/day	1	20
SUNY - Penfield	Natural Gas	.03	100	0.72	12	MMBtu/day	1	20
SUNY – Rice Creek	Diesel	.025	100	0.6	9	MMBtu/day	1	20
SUNY - Rich	Natural Gas	.1	100	2.4	31	MMBtu/day	1	25
SUNY - Riggs	Natural Gas	.1	100	2.4	31	MMBtu/day	1	25
SUNY - Scales	Diesel	.03	100	0.72	9	MMBtu/day	1	20

Facility Name	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
					Quantity	Unit		
SUNY - Seneca	Natural Gas	.1	100	2.4	31	MMBtu/day	1	25
SUNY - Shineman	Diesel	1.612	100	38.688	444	MMBtu/day	1	30
SUNY - Swetman	Natural Gas	.06	100	1.44	20	MMBtu/day	1	20
SUNY – Trailer (Portable)	Diesel	.037	100	0.888	9	MMBtu/day	1	20
SUNY - Tyler	Natural Gas	.03	100	0.72	12	MMBtu/day	1	20
SUNY – Village A Gen 1	Natural Gas	.06	100	1.44	20	MMBtu/day	1	20
SUNY – Village H Gen 2	Natural Gas	.06	100	1.44	20	MMBtu/day	1	20
SUNY – Village F Gen 3	Natural Gas	.035	100	0.84	12	MMBtu/day	1	20
SUNY – Wacker (Portable)	Diesel	.058	100	1.392	9	MMBtu/day	1	20
SUNY - Walker	Diesel	.03	100	0.72	9	MMBtu/day	1	20
SUNY - Waterbury	Diesel	.03	100	0.72	9	MMBtu/day	1	20
SUNY - Wilber	Diesel	.03	100	0.72	9	MMBtu/day	1	20
Wastewater Treatment Plant (WWT)	Natural Gas	.450	100	10.8	104	MMBtu/day	1	25

Cost of Maintaining Service while Operating on Backup Power:

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
N/A	Choose an item.	N/A	N/A	N/A	N/A

Cost of Maintaining Service while Backup Power is Not Available:

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Water Treatment Plant	Ongoing Measures	Open Connection Valves, purchase water	8000	$/day	As long as outage is sustained
Water Treatment Plant	One-Time Measures	Hooking up portable generator	2500	$	Year Round
Water Treatment Plant	Ongoing Measures	Daily cost of portable generator	3000	$/day	Year Round
Wastewater Treatment Plant	One-Time Measures	Hooking up portable generator	1000	$	Year Round
Wastewater Treatment Plant	Ongoing Measures	Daily cost of portable generator	2000	$/day	Year Round
Metropolitan Water Board	One-Time Measures	Hooking up portable generator	2500	$	Year Round
Metropolitan Water Board	Ongoing Measures	Daily cost of portable generator	4000	$/day	Year Round
SUNY – Convocation	One-Time Measures	Hooking up portable generator	1000	$	Year Round
SUNY - Convocation	Ongoing Measures	Daily cost of portable generator	1000	$/day	Year Round
SUNY - Cayuga	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Cayuga	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Central Heating	One-Time Measures	Hooking up portable generator	1000	$	Year Round
SUNY – Central Heating	Ongoing Measures	Daily cost of portable generator	2000	$/day	Year Round
SUNY – Culkin (building)	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY – Culkin (building)	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Culkin (telecom)	One-Time Measures	Hooking up portable generator	500	$	Year Round
SUNY – Culkin (telecom)	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
SUNY - Funnelle	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Funnelle	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Hart	One-Time Measures	Hooking up portable generator	500	$	Year Round
SUNY - Hart	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round
SUNY – Hewitt	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Hewitt	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Johnson	One-Time Measures	Hooking up portable generator	750	$	Year Round
SUNY - Johnson	Ongoing Measures	Daily cost of portable generator	1000	$/day	Year Round
SUNY – Laker	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Laker	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Lanigan	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Lanigan	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Lonis (telecom)	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY – Lonis (telecom)	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Mackin	One-Time Measures	Hooking up portable generator	350	$	Year Round

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
SUNY - Mackin	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Mahar	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Mahar	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Onieda	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Onieda	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Onondaga	One-Time Measures	Hooking up portable generator	500	$	Year Round
SUNY - Onondaga	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round
SUNY – Pathfinder	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Pathfinder	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Penfield	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Penfield	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Rice Creek	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY – Rice Creek	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Rich	One-Time Measures	Hooking up portable generator	500	$	Year Round
SUNY - Rich	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
SUNY - Riggs	One-Time Measures	Hooking up portable generator	500	$	Year Round
SUNY - Riggs	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round
SUNY – Scales	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Scales	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Seneca	One-Time Measures	Hooking up portable generator	500	$	Year Round
SUNY - Seneca	Ongoing Measures	Daily cost of portable generator	750	$/day	Year Round
SUNY – Shineman	One-Time Measures	Hooking up portable generator	3000	$	Year Round
SUNY - Shineman	Ongoing Measures	Daily cost of portable generator	4000	$/day	Year Round
SUNY – Swetman	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Swetman	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Trailer (portable)	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY – Trailer (portable)	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Tyler	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Tyler	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Village A Gen 1	One-Time Measures	Hooking up portable generator	350	$	Year Round

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
SUNY – Village A Gen 1	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Village H Gen 2	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY – Village H Gen 2	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Village F Gen 3	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY – Village F Gen 3	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Wacker (Portable)	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY – Wacker (Portable)	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Walker	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Walker	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Waterbury	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Waterbury	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round
SUNY – Wilber	One-Time Measures	Hooking up portable generator	350	$	Year Round
SUNY - Wilber	Ongoing Measures	Daily cost of portable generator	500	$/day	Year Round

4.6 Services Supported by the Microgrid

SUNY Oswego enrolls approximately 8,000 students, some 7,000 of them full-time undergraduates. SUNY Oswego's Laker Hall also serves as a State of New York planned emergency response center with the ability to accommodate up to approximately 1,200 residents. The next available SUNY emergency response center location is 45 miles south in Syracuse, NY. It is expected that the Proposed Oswego Microgrid will improve overall system efficiency at SUNY Oswego and may also allow for an increase in the capacity of the emergency response center by up to 300% by supplying uninterrupted heat and power to several additional campus buildings.

The Water Department is responsible for providing potable water to Oswego and the Town of Scriba. The Water Treatment Plant serves a population of 29,400 (18,000+ in Oswego and 7,300 in the Town of Scriba) comprised of residential, commercial, and industrial customers and also serves the fire protection needs of the community. Sithe Independence Power Station ("Independence Station"), a 1,108 MW combined cycle gas turbine power generating facility, also relies on a substantial portion of the City's water production to supply the cooling water necessary for its operation. If grid power to those connections goes down, the Water Treatment Plant will not be able to operate.

From an intake shared with the Water Treatment Plant, the Metropolitan Water Board also pumps "raw" water to its nearby water treatment plant where it is filtered, purified and tested prior to the transmission of "finished" water to the Terminal Reservoir in the Town of Clay. The Raw Water Pumping Station serves a population of 500,000 in Onondaga County as well as portions of some adjacent counties.

The west side sewer system serves approximately 10,000 people on the west side of Oswego including the entire SUNY Oswego campus as well as small portions of the Town of Minetto and accommodates combined sanitary and storm water sewers and related overflows during storm events. A failure of in the wastewater system can result in environmental and property damage caused by raw sewage entering watersheds or backing up into homes and businesses.

Estimated percent loss in the facility's ability to provide services during a power outage:

Facility Name	Percent Loss in Services When Using Backup Gen.
SUNY Oswego Campus	50%
City of Oswego Water Department	100%
Onondaga County Metropolitan Water Board – Raw Water Pumping Station	100%
City of Oswego Wastewater Department	0%

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
SUNY Oswego Campus	100%
City of Oswego Water Department	100%
Onondaga County Metropolitan Water Board – Raw Water Pumping Station	100%
City of Oswego Wastewater Department	100%

Section 5 – Feasibility Study Results

Introduction

Oswego NY is one of the snowiest towns in the United States with average snowfalls totaling 92" and some winters totaling over 300". Heavily influenced by Lake Effect Snow, the average snowfall totals in Oswego are substantially higher than the average annual snowfall for New York State, 55.3". Oswego has seen 6 weather related Presidential Disaster Declarations between 1954 and 2010 and 5 emergency declarations between 1974 and 2010. One of the most recent significant storms was in 2007 when 130" (nearly 11') of snow fell within a two week period in Oswego, breaking the previous record set in 1966. This storm crippled Oswego, virtually shutting down the city for a week and requiring an Emergency Operations Center be opened for 13 days. New York State's Transportation Infrastructure Group was called in to assist with snow removal after a Presidential Declaration for a Snow Emergency was called for in the county and $783,341 was granted to aid the county in recovering from the storm.

The proposed microgrid would enable many of the services impacted during and after snow storms to remain intact and operational in the event of a protracted power failure. The microgrid is designed to provide significantly enhanced power reliability and resilience based on the use of proven technologies such as fuel cells, combined heat and power, solar PV and battery storage.

The proposed microgrid will provide power for a number of critical and community support facilities including the SUNY Oswego Campus, City of Oswego Water Department (WTP), Onondaga County Metropolitan Water Board – Raw Water Pumping Station (MWB), and City of Oswego Wastewater Department (WWD). A large portion of the microgrid area comprises of the SUNY Oswego Campus. The project will make use of existing underground and aerial infrastructure on the campus to distribute power to SUNY Oswego and deliver power from the CHP unit to the microgrid. The connection of the rest of the microgrid will be primarily new construction. The microgrid will benefit from the close location of the MWB Raw Water Pumping Station, SUNY, and WTP's substations being located adjacent to each other.

Available land, open rooftops and very favorable constructability make it possible to cost-effectively deploy a diverse array of no/low carbon distributed energy resources. These factors together with a clear, concentrated need for enhanced resilience help to make the proposed City of Oswego microgrid a compelling "public purpose" microgrid that will yield day-to-day economic and environmental benefits when the sun is shining, and enable critical benefits and services when the grid is down.

The proposed Oswego microgrid includes 1,270kW of existing natural gas generators, 2,634kW of existing diesel generators, two (2) 2,000kW fuel cells, and one(1) 1,000kW CHP generator all located at SUNY Oswego. At the City of Oswego Waste Water Plant (WWTP), the planned microgrid will incorporate an existing 450kW dual-fuel natural gas generator. The Water Treatment Plant (WTP) will incorporate new 100kW solar/storage. Total nameplate capacity of the microgrid is 9,554 kW. The selection, sizing, configuration and optimization of DER asset operation was completed using the DER-CAM tool supplemented by other tools and best engineering practices. Site surveys and "constructability" assessments provided further guidance.

During normal operations, the additional generation installed for the microgrid will continue to operate, reducing the peak demand and energy cost of the facilities. During emergency conditions, once the DERs restart and stabilize, the microgrid will be able to meet both base and peak loads.

The DBOOM business model proposed has the benefit of shifting capital requirements as well as general performance and operational risk to third parties whose go-to-market strategies include entering into long term power purchase agreements with qualified off-takers. This enhances the project's overall appeal and financial feasibility to the City of Oswego and other microgrid participants.

The ultimate financial feasibility of the project will be a function of many factors including the results of a considerably more detailed analysis of costs and benefits that might be accomplished as part of a follow on in-depth design and costing effort. At this preliminary stage, the project appears to have a high degree of technical feasibility. However, given the low cost of power and the relatively high historical reliability of the local and regional electric grid, it is believed that based on conventional investment hurdle rates, the project will require significant external incentives to yield returns adequate enough to attract outside investment.

Conclusion and Recommendations

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

Conclusions

1. An Oswego microgrid would provide significant economic, environmental and societal benefits. These benefits would accrue to the people and City of Oswego, emergency personnel, students at SUNY Oswego, and Oswego County in general.

2. The Oswego community microgrid is technically feasible, but will require government subsidies and/or other incentives to attract private funding. Incentives could include NYSERDA grants, favorable gas tariffs, and/or credits for DER generation or capacity. Some amount of subsidies are generally needed for community microgrids in Central NY, since the zonal prices for energy and capacity alone are not sufficient to justify investment in DERs.

3. Microgrid project design and development is complex and costly. The costs to obtain, compile and analyze data from multiple facilities, and design the DERs and controls, and develop a project, are relatively high in relation to the project size. Government funding is critical for providing early stage capital to perform these tasks, and develop projects to the point where they can attract private project financing.

4. 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 uneven loads during blue-sky days, such as the water and wastewater treatment facilities.

5. Public-private-partnerships are a viable and important business model for microgrids. Specifically, P3 structures that shift financial and operational risk away from government and local entities that lack the capital as well as technical and operational expertise to design, build, own, operate and maintain microgrids can accelerate the deployment of microgrids.

6. Microgrids will benefit utility partners. Microgrids will benefit electric utilities by reducing the need for peak power facilities and/or new transmission and distribution infrastructure, providing more reliable and resilient power for utility customers. Gas-fired DERs provide additional demand for gas distribution and supply companies; also, new gas supply infrastructure needed to serve the DERs can stimulate new demand from other customers.

Recommendations

1. The Oswego microgrid project should proceed with design, development and financing, subject to adequate support from NYSERDA. These efforts should include finalizing conceptual project design, completing detailed design and permitting, securing Microgrid Energy Service Agreements (MESAs) with customers, arranging fuel supply contracts, obtaining construction bids and selecting an EPC contractor, refining financial modeling and projections, identifying a project lender and/or investor, and completing project documentation and due diligence.

2. NYSERDA should continue to promote microgrids. NYSERDA should continue to provide financial incentives and technical support for development of microgrids.

3. NYSERDA should consider microgrid energy or capacity credits. NYSERDA 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 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.

4. Utilities should do more to help facilitate development of microgrids. Gas and electric utilities should evaluate new incentives for microgrids to reflect their financial, societal and environmental benefits. Electric utilities should also expedite measures to harden local distribution infrastructure to support microgrids, and facilitate interconnection policies to streamline deployment of DERs. Gas utilities should offer favorable microgrid gas supply tariffs, and prioritize infrastructure improvements needed to serve microgrids.

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