

## **39 - Village of Florida**

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# **Village of Florida Microgrid Feasibility Study Microgrid Project Results and Final Written Documentation**

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## Abstract

Together with the Village of Florida, Booz Allen Hamilton has completed the feasibility study for a proposed microgrid. This study summarizes the findings and recommendations, results, lessons learned, and benefits of the proposed microgrid. The Project Team has determined the project will not return sufficient amounts to recover capital investments. To achieve financial viability, the project will need capital and operating subsidies from NYSERDA and other sources beyond NY Prize Phase III. The analysis of the commercial and financial viability of the project is been detailed in this document. The proposed microgrid design incorporates two proposed distributed energy resources (DER) – a 175 kilowatt (kW) natural gas reciprocating generator and a 20 kW solar photovoltaic (PV) array. This portfolio of DERs will provide reliable, low-emission electricity and to customers while providing a proof of concept for a community microgrid in an investor-owned utility (IOU) territory. Many of the takeaways of the feasibility study may be generalized across the spectrum of NY Prize and community microgrids.

**Keywords:** NY Prize, NYSERDA, distributed energy generation, energy resilience, clean energy, DER, Florida

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## Acronyms and Abbreviations

AC	Alternating Current
AMI	Advanced Metering Infrastructure
ATS	Automatic Transfer Switch
BCA	Benefit Cost Analysis
BEMS	Building Energy Management Systems
BTU	British thermal unit
CAIDI	Customer Average Interruption Duration Index
CHP	Combined Heat and Power
DADRP	Day Ahead Demand Response Program
DC	Direct Current
DER	Distributed Energy Resources
DNP3	Distributed Network Protocol
DR	Demand Response
DSASP	Demand Side Ancillary Services Program
DSP	Distributed System Platform
EDRP	Emergency Demand Response Program
EE	Energy Efficiency
EMS	Energy Management System
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
Hz	Hertz
ICCP	Inter-Control Center Communications Protocol
IEc	Industrial Economics
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IOU	Investor-Owned Utility
ISM	Industrial Scientific and Medical
IT	Information Technology
ITC	Investment Tax Credit
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
LAN	Local Area Network
LBMP	Location-Based Marginal Price
LED	Light-Emitting Diode
Mcf	One Thousand Cubic Feet of Natural Gas
MCS	Microgrid Control System
MHz	Megahertz
MMBTU	One Million British Thermal Units
MMTCO <sub>2</sub> e	Million Metric Tons CO <sub>2</sub> Equivalent
MTCO <sub>2</sub> e	Metric Tons CO <sub>2</sub> Equivalent
MW	Megawatt
MWh	Megawatt-hour

NYISO	New York Independent System Operator
NYPSC	New York Public Service Commission
NYS DEC	New York State Department of Environmental Conservation
NYSERDA	New York State Energy Research and Development Authority
O&M	Operation and Maintenance
O&R	Orange & Rockland
OPC	Open Platform Communication or OLE (Object Link Embedded) Process Control
OPF	Optimal Power Flow
PCC	Point of Common Coupling
PLC	Programmable Logic Controller
PPA	Power Purchase Agreement
PV	Photovoltaic
RAID	Redundant Array of Independent Disks
REV	Reforming the Energy Vision
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SCOPF	Security Constrained Optimal Power Flow
SOA	Service Oriented Architecture
SOW	Statement of Work
TCP/IP	Transmission Control Protocol/Internet Protocol
T&D	Transmission and Distribution
VAC	Volt Alternating Current

## Executive Summary

Booz Allen Hamilton was awarded a contract by the New York State Energy Research and Development Authority (NYSERDA) through its New York Prize initiative to conduct a feasibility study of a community microgrid concept in the Village of Florida (Florida). This deliverable presents the findings and recommendations from the previous four tasks, discusses the results and lessons learned from the project, and lays out the environmental and economic benefits for the project. The design demonstrates the Village can improve energy resilience with emergency island mode capabilities and comply with the greater New York Reforming the Energy Vision (REV) initiative by constructing 195 kW of new, clean energy generation capability. The study concludes the technical design is feasible, but the project will not return sufficient amounts of revenue to recover capital investments. To achieve financial viability, the project will need capital and operating subsidies from NYSERDA and other sources beyond NY Prize Phase III.

The Florida microgrid project will tie together five facilities (four of which are critical per NYSERDA's definition) and two small load clusters of commercial and residential facilities: the Village Clerk, Florida Police, Seward Senior Center, Florida Fire and Rescue, and the Florida Library. The two load clusters include two residential facilities and four commercial facilities. Figure ES-1 lists all the facilities under consideration for the microgrid concept at this time, and Figure ES-2 shows their locations in the Village of Florida.

**Table ES-1. Prospective Microgrid Facilities**

Facilities in the Village of Florida's proposed microgrid, including their classifications as public, health, or school. The table also denotes critical and important facilities.

Name on Map	Property	Classification	Critical / Important
1	Florida Village Clerk	Public	Critical
2	Police Department	Public	Critical
3	Seward Senior Center	Residential	Critical
4	Fire and Rescue Department	Public	Critical
5	Public Library	Public	Important
6	Load Cluster 1 (2 Residential Buildings)	Residential	Additional
7	Load Cluster 2 (4 Commercial Buildings)	Commercial	Additional

### Figure ES- 1. Schematic of Microgrid with Facilities and DERs

Figure shows the proposed microgrid and the locations of the facilities and DERs in the Florida microgrid.



In order to meet the energy needs of these critical and important facilities, the microgrid system will incorporate the following proposed generation assets.

- One proposed 175 kW natural gas-fired reciprocating generator
- One proposed 20 kW solar PV array

The proposed generation assets should have adequate capacity to provide 100% of the electricity requirements of the facilities in Table ES-1, above, during emergency outage conditions. When the solar arrays are operating close to their maximum production capacity, the microgrid's generation capacity will approach 195 kW, with 175 kW of continuous load. Aggregate demand from all facilities proposed within the microgrid footprint averaged 49 kW and never exceeded 171 kW in 2014. The backup power supplied by the microgrid will ensure essential services remain accessible during long-term grid outages, providing relief for residents in and around the Village of Florida. With the addition of these generation assets, the Village could experience reduced emissions during peak demand events, reduce the need for local diesel backup, and could benefit from a more resilient and redundant energy supply to critical services.

The proposal envisions an ownership model wherein a special purpose vehicle (SPV) owns the generation assets and microgrid controls and the local utility, Orange & Rockland (O&R), owns the new and upgraded distributed infrastructure. The Project Team believes this hybrid model offers the greatest benefits and flexibility to the utility and customer base within the Village.

Given the capital expenditures, it is anticipated that the SPV will be owned by private investors. O&R will leverage its energy domain expertise to operate and maintain the microgrid components and control infrastructure. The SPV will receive revenue from the sale of electricity to O&R, while paying O&R a fixed amount per kilowatt hour (kWh) generated and distributed to support the utility's microgrid component costs. In Florida, the proposed ownership model provides the greatest benefits to the utility and customer base within the Village, ensuring that revenues and costs are relatively in balance.

The microgrid will incur initial capital costs of \$860,000 as well as yearly operation, maintenance, and fuel costs totaling \$150,000 per year. Overall revenue streams from the project are estimated at \$110,000 per year and will be captured primarily through the sale of electricity from the 175 kW natural gas-fired reciprocating generator and the 20 kW solar PV array during grid-connected mode. Other revenues from the proposed microgrid will include tax credits and incentives.

The high capital costs and negative operating cash flows make the investment a difficult one. Assuming the SPV will sell electricity to O&R at their current supply charge, the microgrid will produce negative operating cash flows from year to year. The Florida microgrid qualifies for relatively few of the available state and federal incentives for DERs—the Federal Investment Tax Credit (ITC) and NY Sun program. These two incentives may recover around 30% of the solar capital costs. Annual revenues will not exceed the annual costs of production, and will not return sufficient amounts to recover capital investments. To achieve financial viability, the project will need capital and operating subsidies from NYSERDA and other sources beyond NY Prize Phase III.

The Florida microgrid concept, with new reliable and renewable generation and the integration of existing energy resources, provides the Village with an energy resilience solution that is technically sound. While the ability to island three critical and other important community facilities is a significant addition to the resilience of the Village in times of emergency and extended grid outages, the microgrid does not produce the necessary revenues to make the project feasible without significant subsidies and incentive support.



## 1. Introduction

The Village of Florida (Florida) is seeking to develop a community microgrid to improve energy service resilience, accommodate distributed energy resources, and reduce greenhouse gas (GHG) emissions. Working with the Florida and O&R, a team from Booz Allen Hamilton (hereafter Booz Allen or the Project Team) designed a preliminary microgrid concept that will connect five critical and important facilities and two residential groups with two proposed generation assets. The design proposes a new 175 kW natural gas-fired reciprocating generator and a new 20 kW solar PV array. Section 2 of this document describes the configuration further. In this document, the Project Team discusses the observations, findings, and recommendations from the entirety of the analysis. Within the document, Booz Allen also explores avenues for further development, discusses project results, and shares lessons learned regarding configuration, capabilities, environmental and economic benefits, and implementation scenarios.

Florida and its residents seek to improve the resilience of energy service and lower their environmental footprint. More specifically, the Village faces several challenges that could be mitigated with a community microgrid:

- Several key services in the Village have access to emergency back-up generation, but this back-up generation is not built for continuous operation during a long-term grid outage. A microgrid could ensure critical services and businesses in the Village have a stable, reliable power supply for the entire duration of a long-term power outage by tying natural gas generators with solar PV arrays.
- Electricity service in the region has occasionally been interrupted by extreme weather events such as winter storms. For example, several homes, schools, and traffic signals experienced persistent outages throughout the winter of 2014. A microgrid could provide electricity to critical facilities during extreme weather events, and may expand in the future to include more homes, businesses, and government buildings.
- In order to improve its energy profile and reduce its carbon footprint, the community prefers low-emission options for distributed energy resources. An integrated microgrid adds value to advanced distributed energy resource technologies, increasing the viability of natural gas-fired reciprocating generators or solar arrays and decreasing reliance on diesel backup.

## 2. Microgrid Capabilities and Technical Design and Configuration

This section provides a combined overview of the criteria assessed in Task 1 - Microgrid Capabilities and Task 2 – Technical Design and Configuration. The tasks were combined and address all of the criteria in the following order: microgrid capabilities, DER characterization, load characterization, proposed microgrid infrastructure and operations, electric and thermal



infrastructure characterization, microgrid building and controls, and IT and telecommunications infrastructure.

## 2.1 Project Purpose and Need

The Florida microgrid will improve the resilience of the local electricity grid in emergency outage situations, accommodate distributed energy generation, and reduce reliance on high emissions diesel assets, such as the generation at Florida Fire and Rescue, during outage events. Florida experiences the usual range of extreme weather that faces the region, including torrential rain, snow, wind, and flooding, all of which may impact the larger grid's ability to safely, reliably, and efficiently deliver electricity to customers. Avoiding outages has significant monetary value to the connected facilities. Interruptions to the power supply can derail operations, cause damage to machinery, and render direct health/safety equipment ineffective. Florida has several municipal and commercial facilities in close physical proximity and electrically adjacent. This proximity encourages the construction of a microgrid because several important facilities can be incorporated into the design without the need for extensive, new distribution infrastructure.

The Project Team estimates that the microgrid's main DERs will generate an instantaneous average output of approximately 150 kW of electricity throughout the year.<sup>1</sup> Although Florida is not currently considered a critical congestion point on the NY State grid, this generation capacity will reduce the amount of power that must be transmitted to the Village from the larger grid, which may result in lower congestion costs to O&R in the surrounding area. The project could serve as a model for the critical congestion points in the area, providing data on how distributed energy resources affect required transmission capacity for NYSERDA and the NY Independent System Operator (NYISO). Coupled with other distributed energy resource projects in the area or elsewhere, the aggregate reduction of load on the transmission system could be material.

Florida faces several challenges that could be resolved with a community microgrid:

- Florida has incurred costly damages from power losses during major storms. The most pronounced incident occurred during Hurricane Lee, when parts of the Village were without power for up to four days.
- O&R area customers face significant price volatility, with the highest monthly market prices in recent years being double the lowest. A microgrid could help stabilize and reduce prices.
- A microgrid would help secure power to critical facilities and infrastructure identified in the Village's Multi-Jurisdictional, Multi-Hazard Mitigation Plan. Several facilities designated in the plan (including the Florida Village Clerk, Police Station, and Seward Senior Center) are in need of natural gas backup generation.

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<sup>1</sup> Natural gas capacity factor: 85% (EPA; <http://www3.epa.gov/chp/documents/faq.pdf>); Solar PV capacity factor: 14% (NREL PV Watts Calculator)

- A microgrid could relieve lower Hudson Valley transmission congestion, which is among the most significant in New York. It would also bolster reliability in the face of the potential retirements of nearby plants (e.g., the Indian Point nuclear plant).
- Because two PV projects are already under consideration, the Village is a strong platform for potential distributed and renewable generation. A microgrid would enable a business model whereby these resources are more financially viable than they would be in isolation, thus incentivizing the construction of renewable and distributed energy resources in a competitive market framework.

## 2.2 Microgrid Required and Preferred Capabilities (Sub Tasks 1.1 and 1.2)

The NYSERDA statement of work (SOW) 63525 outlines 15 required capabilities and 18 preferred capabilities each NY Prize microgrid feasibility study must address. Table 1 summarizes required and preferred capabilities met by the proposed microgrid design in greater detail.

**Table 1. Microgrid Capabilities Matrix**

Table lists NYSERDA's required and preferred capabilities and annotations of whether or not the Florida microgrid will meet these criteria.

Capability	Required/ Preferred	Microgrid will meet (Y/N)
<b>Serves more than one, physically separated critical facilities</b>	Required	Y
<b>Primary generation source not totally diesel fueled</b>	Required	Y
<b>Provides on-site power in both grid-connected and island mode</b>	Required	Y
<b>Intentional islanding</b>	Required	Y <sup>2</sup>
<b>Seamless and automatic grid separation/restoration</b>	Required	Y
<b>Meets state and utility interconnection standards</b>	Required	Y
<b>Capable of 24/7 operation</b>	Required	Y
<b>Operator capable of two-way communication and control with local utility</b>	Required	Y
<b>Load following while maintaining the voltage and frequency when running in parallel to grid</b>	Required	Y
<b>Load following and maintaining system voltage when islanded</b>	Required	Y
<b>Diverse customer mix (residential, commercial, industrial)</b>	Required	Y
<b>Resiliency to wind, rain, and snow storms</b>	Required	Y
<b>Provide black-start capability</b>	Required	Y
<b>Energy efficiency upgrades</b>	Required	Y
<b>Cyber secure and resilient to cyber intrusion/disruption</b>	Required	Y
<b>Microgrid logic controllers</b>	Preferred*	Y
<b>Smart grid technologies</b>	Preferred*	Y
<b>Smart meters</b>	Preferred	N
<b>Distribution automation</b>	Preferred*	Y
<b>Energy storage</b>	Preferred	N
<b>Active network control system</b>	Preferred*	Y
<b>Demand response</b>	Preferred	Y <sup>3</sup>

<sup>2</sup> While the system will be technically capable of intentional islanding, doing so would cut power flow to other customers on the included feeders and thus would not be feasible for economic purposes.

<sup>3</sup> The system is technically capable of providing demand response, but it will not qualify for DR programs (both load and generation assets will be taken offline simultaneously).

Capability	Required/ Preferred	Microgrid will meet (Y/N)
Clean power sources integrated	Preferred	Y
Optimal power flow (OPF) (economic dispatch of generators)	Preferred	Y
Storage optimization	Preferred	N
PV observability, controllability, and forecasting	Preferred	Y
Coordination of protection settings	Preferred	Y
Selling energy and ancillary services	Preferred	N <sup>4</sup>
Data logging features	Preferred	Y
Leverage private capital	Preferred	Y
Accounting for needs and constraints of all stakeholders	Preferred	Y
Demonstrate tangible community benefit	Preferred	Y
Identify synergies with Reforming the Energy Vision	Preferred	Y
* capability is characterized as preferred by NYSERDA but is a required component in this design		

The sections that follow address how the microgrid will meet these capabilities in more detail.

#### 2.1.1 Serving Multiple, Physically Separated Critical Facilities

At this stage of the study, the Florida and the Booz Allen team, in cooperation with O&R, have identified four critical facilities, one important facility, and two additional load clusters to be connected to the microgrid, including a police station, a Village Clerk, several public buildings, and an animal hospital. See Table 2 for a full list of prospective facilities to be tied into the microgrid.

**Table 2. Florida Critical, Important, and Additional Facilities**

Critical, important, or additional facilities, their addresses, and their classifications as critical or important.

Name of Facility	Address	Classification
Florida Village Clerk	33 South Main Street	Critical
Police Department	1 Cohen Circle	Critical
Seward Senior Center	Cohen Circle	Critical
Fire and Rescue Department	19 South Main Street	Critical
Public Library	4 Cohen Circle	Important
Load Cluster 1 (2 Residential Buildings)	6-22 South Main Street	Additional
Load Cluster 2 (4 Commercial Buildings)	6-22 South Main Street	Additional

The proposed microgrid footprint occupies approximately 222,000 square feet in Florida. Facilities will communicate over O&R's WAN, utilizing the existing IT fiber optic backbone. Utilizing industry standard protocols, such as Distributed Network Protocol (DNP3), Open Platform Communication (OPC), Modbus, 61850, and Inter-Control Center Communications Protocol (ICCP) (IEC 60870-6) will enable the remote monitoring and control of distributed devices, regardless of manufacturer. The microgrid design is flexible and scalable in order to accommodate future expansion and technologies.

#### 2.2.2 Limited Use of Diesel Fueled Generators

Florida has established a preference for a natural gas-fired generator over diesel to serve as the primary energy source. As a comparatively low-emission, highly reliable fuel, natural gas is an

<sup>4</sup> Microgrid has the capability to sell energy and ancillary services, but it may only sell energy in normal operation.

ideal source of energy for the proposed community microgrid. Electricity from the 20 kW solar PV array will supplement energy from the reciprocating generator. The solar array will operate at maximum capacity during the summer and will offset some of the greenhouse gas emitted by the natural gas generator.

#### 2.2.3 Local Power in both Grid-Connected and Island Mode

The microgrid will provide on-site power in both grid-connected and island mode. In island mode, the MCS will optimize on-site generation as needed to maintain a stable and reliable power flow. In grid-connected mode, the microgrid will optimize the use of available assets to reduce energy costs when possible and export to the O&R grid when economic and technical conditions align. The proposed generation assets will function continuously in grid-connected mode, reducing local dependence on grid-supplied power. In island mode, the solar PV array will supplement the reciprocating generator's output to meet critical loads.

#### 2.2.4 Intentional Islanding

The microgrid will intentionally switch to island mode when doing so results in a more stable and reliable environment. Transitions to island mode will comply with New York State standardized interconnection requirements as well as local utility and building codes, which will ensure equipment and personnel safety throughout each phase of the switch.

The MCS will automatically start and parallel the generation assets. Once the available power sources are synchronized with the grid (and each other), the system is ready to disconnect from the larger grid, and it will begin by opening the incoming utility line breakers. After completing the transition to island mode, the MCS must maintain system voltage and frequency between acceptable limits and adjust generator output to match aggregate load.

#### 2.2.5 Resynchronization to O&R Power

When operating in island mode, the microgrid will constantly monitor the status of the larger grid and will re-connect when conditions have stabilized. Signals from the MCS will prompt re-connection when monitored operational variables satisfy predetermined conditions. The MCS will be capable of both pre-programmed and human-controlled re-connection using synchronization and protection equipment.

An additional breaker at the point of common coupling (PCC) is required to connect the new microgrid generation. The control system will trigger the opening or closing of this breaker as appropriate during system transitions. Additional information can be found in Section 2.7.7.

#### 2.2.6 Standardized Interconnection

The microgrid design complies with New York Public Service Commission (NYPSC) interconnection standards. Table 3 outlines the most significant state interconnection standards that apply to this microgrid project. O&R customers connecting to the grid via DER projects must also follow the New York State Standard Interconnection Requirements.

**Table 3. New York State Interconnection Standards<sup>5</sup>**

Table outlines New York State interconnection standards by category (common, synchronous generators, induction generators, inverters, and metering) and a description of the standard.

Standard Category	Description
<b>Common</b>	Generator-owner shall provide appropriate protection and control equipment, including a protective device that utilizes an automatic disconnect device to disconnect the generation in the event that the portion of the utility system that serves the generator is de-energized for any reason or for a fault in the generator-owner's system
	The generator-owner's protection and control scheme shall be designed to ensure that the generation remains in operation when the frequency and voltage of the utility system is within the limits specified by the required operating ranges
	The specific design of the protection, control, and grounding schemes will depend on the size and characteristics of the generator-owner's generation, as well as the generator-owner's load level, in addition to the characteristics of the particular portion of the utility's system where the generator-owner is interconnecting
	The generator-owner shall have, as a minimum, an automatic disconnect device(s) sized to meet all applicable local, state, and federal codes and operated by over and under voltage and over and under frequency protection
	The required operating range for the generators shall be from 88% to 110% of nominal voltage magnitude
	The required operating range for the generators shall be from 59.3 hertz (Hz) to 60.5 Hz
<b>Synchronous Generators</b>	Requires synchronizing facilities, including automatic synchronizing equipment or manual synchronizing with relay supervision, voltage regulator, and power factor control
	Sufficient reactive power capability shall be provided by the generator-owner to withstand normal voltage changes on the utility's system
	Voltage regulator must be provided and be capable of maintaining the generator voltage under steady state conditions within plus or minus 1.5% of any set point and within an operating range of plus or minus 5% of the rated voltage of the generator
	Adopt one of the following grounding methods: <ul style="list-style-type: none"> <li>• Solid grounding</li> <li>• High- or low-resistance grounding</li> <li>• High- or low-reactance grounding</li> <li>• Ground fault neutralizer grounding</li> </ul>
<b>Induction Generators</b>	May be connected and brought up to synchronous speed if it can be demonstrated that the initial voltage drop measured at the PCC is acceptable based on current inrush limits
Source: NYS Standardized Interconnection Requirements and Application Process, NYS PSC	

### 2.2.7 24/7 Operation Capability

The project concept envisions a natural gas reciprocating generator as the main generation source for the community microgrid. The Village's existing natural gas supply line can support 24/7 continuous operation for proposed reciprocating generator.

### 2.2.8 Two Way Communication with Local Utility

There is currently no automation system in place which would allow communication between the microgrid operator and the existing electrical distribution network in Florida. The new automation solution proposed in this report will serve as a protocol converter to send and receive

<sup>5</sup> New York State Public Service Commission. Standardized Interconnection Requirements and Application Process for New Distributed Generators 2 MW or Less Connected in Parallel with Utility Distribution Systems (2014). Available from [www.dps.ny.gov](http://www.dps.ny.gov).

all data available to the operator over O&R's WAN using industry standard protocols such as DNP3, OPC, Modbus, 61850, and IEC 60870-6).

#### 2.2.9 Voltage and Frequency Synchronization when Connected to the Grid

Microgrid controllers will automatically synchronize the frequency and voltage of all DER-generated power, which will include a rotating energy source as well as inverter-based energy sources. Synchronization is key to maintaining a stable power network. The larger grid also requires constant synchronization of energy sources, but the comparatively higher electrical and mechanical inertia filters out most fast dynamics. In contrast, the microgrid will be sensitive to fluctuations in load or generator output. It is therefore crucial to constantly monitor and regulate generator output against aggregate load in real time.

#### 2.2.10 Load Following and Frequency and Voltage Stability when Island

The microgrid's control scheme in island mode is quite similar to that of the larger transmission system. The system maintains frequency by controlling real power generation and regulates voltage by controlling reactive power availability. If generation matches the load plus the system losses (real and reactive), system frequency and voltage should stay within acceptable limits. Other factors, such as network topology and the distribution of generation and loads, can also affect the frequency and voltage stability. The Project Team will consider these factors and develop a microgrid design that accounts for them in the next phase of the NY Prize competition. The comparatively small size of the microgrid introduces new, fast, and dynamics-related problems that will be carefully studied during the engineering design phase.

In island mode, the MCS will maintain control of the generating units to maintain voltage and frequency. In addition, the MCS will manage generation control to maintain the demand supply balance.

#### 2.2.11 Diverse Customer Mix

At present, the microgrid design includes five facilities and two load clusters: Florida Village Clerk, Police Department, Seward Senior Center, Fire and Rescue Department, Public Library, Load Cluster 1, and Load Cluster 2. This customer mix includes residential, commercial, and government loads, and these facilities provide beneficial services to the Village of Florida during outages. It may be possible for more facilities to be connected to the microgrid in the future (such as the Seward Public School on North Main Street). Table 4 lists all the facilities currently being considered in the microgrid concept design, and Figure 2 shows them on a map.



**Table 4. Village of Florida List of Prospective Microgrid Facilities**

Properties, addresses, and classifications for each facility proposed for the Florida microgrid.

Name on Map	Property	Address	Classification
F1	Florida Village Clerk	33 South Main Street	Public*
F2	Police Department	1 Cohen Circle	Public*
F3	Seward Senior Center	Cohen Circle	Residential*
F4	Fire and Rescue Department	19 South Main Street	Public*
F5	Public Library	4 Cohen Circle	Public**
F6	Load Cluster 1 (2 Residential Buildings)	6-22 South Main Street	Residential
F7	Load Cluster 2 (4 Commercial Buildings)	6-22 South Main Street	Commercial
			*Critical Facility **Important Facility

**Figure 2. Map of Microgrid Coverage Area**

Figure provides a detailed map of the approximately 222,070 square feet coverage area illustrating where all facilities are located relative to each other and the main streets within Florida.



#### 2.2.12 Resiliency to Weather Conditions

Florida is exposed to the normal range of weather conditions that affect the northeast United States. Extreme weather events include, but are not limited to, winter ice and snow storms and summer heat during peak times. Florida is also subject to hurricanes and flooding, including recent disruptions due to Hurricane Lee.

By implementing line fault notifications and deploying other sensors, microgrid owners can ensure the network is as resilient as possible to storms and other unforeseen forces of nature. The natural gas reciprocating generator, the microgrid's main generation asset, will be protected from extreme weather by a new enclosure near the Florida Village Clerk's office building.

The microgrid's information technology (IT) system is primarily based on wireless communication. Each wireless unit will be housed inside a weather-proof enclosure to ensure resiliency during storms. Each distributed intelligent electronic device (IED) and DER will require a short length of physical wire to connect to the nearest network switch. Network switches will intentionally be placed near the IED or DER that they serve, which makes disruption of a wired connection extremely unlikely. In the event that an IED loses contact with the MCS, it is programmed to act on predetermined set points.

The distribution lines in Florida will not be buried to provide extra resiliency to storms, wind, and falling trees. The Project Team evaluated the possibility of trenching and burying distribution lines and found the cost to be prohibitively high. Hardening possibilities for overhead lines include replacing wooden utility poles with steel or other reinforced material, though this would come at a significant cost. The switchgear will already be encased and an obstruction free right-of-way for the lines is the only way to protect the wires themselves from damage.

#### 2.2.13 Black-Start Capability

The proposed natural gas reciprocating generator will be equipped with black-start capabilities. If the Florida grid unexpectedly loses power, the MCS will initiate island mode by orchestrating the predefined black-start sequence. The natural gas reciprocating generator will require an auxiliary source of direct current (DC) power to have the ability to start multiple times in case of failure. It will ramp up to 60 Hz and prepare to supply each of the microgrid loads. After the generator is on-line and providing a stable power supply, the MCS will synchronize output from the solar array and bring it on-line.

#### 2.2.14 Energy Efficiency Upgrades

Energy efficiency (EE) is critical to the overall microgrid concept. Florida has been taking steps to reduce its total energy consumption. In 2010, Florida renewed the Village Clerk, Seward Senior Center, and other village buildings for energy saving light-emitting diode (LED) lights, new insulation, and efficient windows. Three school buildings upgraded to automatic LED lighting systems also to improve EE. In 2015, Florida is currently working on a new solar project with SolarCity at Golden Hill Elementary School, aiming \$3,000 electricity saving per month.



The Project Team estimates the reduction potential for the seven facilities to be approximately 8.5 kW. Facilities will seek to qualify for existing O&R and NYSERDA EE incentive programs to help finance the upgrades.

#### 2.2.15 Cyber Security

The microgrid management and control system network data will be fully encrypted when stored or transmitted. Network segmentation by function, network firewalls, and continuous monitoring of data activity will protect the microgrid from cyber intrusion and disruption. Access to the microgrid management and control center will be limited to authorized personnel. Activating and analyzing security logs may provide an additional level of security. The operating system and firewall will be configured to record certain suspicious events, such as failed login attempts.

Locating the logical controllers, or IEDs, at or near loads may make the IT system more vulnerable to hackers. A practical tool to prevent unauthorized access into the IT network is a program called Sticky media access control (MAC), used to monitor the unique address of the device and its designated network port. If the device is ever disconnected, the program will disable that port and prevent an unauthorized device from entering the IT system.

#### 2.2.16 Use of Microgrid Logic Controllers

Microprocessor-based IEDs serving as microgrid logic controllers are described below in Section 2.7.1. The role of the IEDs is to provide monitoring and control capabilities of the object being controlled. The Project Team believes this is a required capability for this proposed microgrid.

#### 2.2.17 Smart Grid Technologies

The microgrid will offer a distributed network architecture, allowing smart grid technologies to connect to the grid via multiple protocols including DNP3, OPC, Modbus, 61850, IEC 60870-6, and more as required. The Project Team believes this is a required capability for this proposed microgrid.

#### 2.2.18 Smart Meters

Florida does not have smart meters installed throughout its coverage area. While ideal, smart meters are not required for the Florida microgrid because the control sequence is performed at the feeder level.

#### 2.2.19 Distribution Automation

The automation solution outlined in this study includes IEDs that are distributed at or near individual loads. Their role is to control the load and communicate monitored variables to the control system servers for processing, viewing, and data logging. IEDs can operate based on automated signals from the MCS or pre-programmed independent logic in case of a loss of communication with the MCS. The Project Team believes this is a required capability for the proposed microgrid.

#### 2.2.20 Energy Storage

The Project Team's analysis of battery storage technologies found their cost to be prohibitively high. Despite this, the MCS will be equipped with the capability to fully utilize and optimize the

storage resources—including charging and discharging cycles for peak demand shaving—in case the Village reevaluates its options in the future. The price of battery storage technology is constantly decreasing, and by “stacking” different uses of energy storage (i.e., microgrid resiliency, frequency regulation, and PV integration), microgrid owners may soon be able to achieve a competitive leveled cost of storage.<sup>6</sup>

#### 2.2.21 Active Network Control System

The microgrid will be under continuous and close monitoring and control when it operates in either grid-connected or island mode. Both monitoring and control will be decomposed into central (slow) and distributed (fast) components. A fast and reliable communication network is needed for such a hierarchical approach to be successful. All controllable components on the microgrid will communicate bi-directionally with the MCS via MODBUS, OPC, DNP3 TCP/IP, or other protocols as required. The communication infrastructure will be based on the Village’s fiber optics backbone partitioned using gigabit Ethernet switches owned by O&R.

#### 2.2.22 Demand Response

The Village does not currently participate in demand response (DR) programs for O&R or the NYISO.

The MCS has the capability to participate in DR programs by increasing generator output or curtailing flexible loads in response to a signal from O&R. Doing so may allow the Florida microgrid to participate in O&R’s Commercial System Relief Program (CSRP) or Distribution Load Relief Program (DLRP), which would provide the utility with load relief on the hottest days. O&R provides comparatively lucrative capacity payments to participants that choose the Reservation Payment Option, paying \$4/kW-month and \$0.5/kWh reduced in the CSRP, \$3/kW-month and \$0.5/kWh reduced in the DLRP for the Reservation Payment Option, and \$1/kW-month in the DLRP for the Voluntary Participation Option. The Reservation Payment Option requires participation in a one-hour test event while the Voluntary Participation Option does not require a test event.<sup>7</sup>

However, the electricity usage in the buildings in Cohen Circle where the proposed generation assets will be located is relatively small (the 2014 peak demand in the Public Library was only 31 kW while the 2014 peak demands at the Florida Village Clerk, Seward Senior Center, and Police Department were smaller than 15 kW). Therefore, payments from these DR programs will not represent significant sources of revenue. The Project Team was unable to determine whether back-feeding to the O&R grid can qualify for these DR programs.

The NYISO has three other DR programs that could benefit Florida:

- Emergency DR Program (EDRP)
- Day-Ahead DR Program (DADRP)

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<sup>6</sup> Lazard’s Levelized Cost of Storage Analysis, Version 1.0.

<sup>7</sup> Data from

<http://www.oru.com/programsandservices/incentivesandrebates/greenteam/businessprograms/demandresponseprogramsdetails.html>, accessed 5/18/2016

- Demand Side Ancillary Services Program (DSASP)

The EDRP is a voluntary program that helps ensure the reliability of the bulk power grid during energy shortages. Through this program, businesses and companies are paid by the NYISO to reduce their energy consumption when requested.

In the DADRP, energy users bid load reductions into the NYISO day-ahead energy market, permitting flexible loads and resulting in increased supply. The DSASP gives eligible retail customers the opportunity to bid into the day-ahead and real-time markets.

#### 2.2.23 Clean Power Sources Integration

The proposed energy sources—natural gas and solar energy—will provide the microgrid with reliable and relatively low-emission electricity.

#### 2.2.24 Optimal Power Flow

Florida microgrid is expected to include two new proposed generation sources. An economic dispatch will comprise of the pre-determined priority list which will take into account generation availability, balancing run-times, and fuel costs. The MCS will fully utilize the optimum output of generation sources at the lowest cost in a unique approach that includes fuel cost, maintenance, and energy cost as part of security constrained optimal power flow (SCOPF).

#### 2.2.25 Storage Optimization

If the microgrid expands to include energy storage in the future, the storage system will require intelligent controls to work in unison with the microgrid controls. The MCS will fully utilize and optimize the storage resources by managing the charge and discharge of storage systems. Possible uses for storage include reducing peak demand, participating in NYISO frequency regulation markets, shifting solar PV output to match aggregate load, and increasing system reliability by providing an energy bank.

#### 2.2.26 PV Monitoring, Control, and Forecasting

The microgrid's PV inverter will usually operate at its maximum power point (MPP) because there is no associated operation and maintenance (O&M) costs. In some rare situations, the PV array might have to reduce its output for load following in island mode or to participate in frequency control. In such situations, the control is almost exclusively local with the output set point communicated by the central controller. As with other renewable energy sources, power output is weather and time dependent.

The microgrid power management system includes high resolution solar forecasting. Solar forecasting can increase the value of integrated PV and storage systems by intelligently deploying storage to smooth the natural spikes in the daily PV output curve. However, the Florida microgrid design does not include battery storage.

#### 2.2.27 Protection Coordination

Microgrid protection strategies can be quite complex depending on the network topology and distribution of load and generation. The existing protection scheme assumes unidirectional power

flow of a certain magnitude. The microgrid introduces the possibility of bidirectional power flow in both grid-connected and island mode, which may complicate the necessary protection strategy.

#### 2.2.28 Selling Energy and Ancillary Services

It is unclear whether the microgrid will be permitted to back-feed through Florida's main substation into the broader O&R transmission system. If allowed, the microgrid will sell excess energy from the solar array and reciprocating generator to O&R.

Most lucrative NYISO ancillary service markets (such as the frequency regulation market) require participants to bid at least 1 megawatt (MW) of capacity. Thus, the microgrid's reciprocating generator will not be capable of participating in most ancillary service markets. Other ancillary service markets, such as spinning and non-spinning reserves, do not provide competitive payments to small-scale generators. For this reason, the Project Team has concluded the microgrid will likely not participate in NYISO ancillary service markets unless the reciprocating generator can be expanded.

Overbuilding the reciprocating generator could provide microgrid owners with interesting options. Microgrid owners could sell extra electricity capacity into NYISO frequency regulation or installed capacity (ICAP) energy markets. With one extra MW of electricity capacity, the microgrid could also participate in the novel NYISO Behind the Meter: Net Generation program. Further discussion of these programs is outside the scope of this feasibility study, but the Project Team will consider these options in Phase II of the NY Prize competition.

#### 2.2.29 Data Logging Features

The microgrid control center includes a Historian Database to maintain real-time data logs. The Historian Database can also display historical trends in system conditions and process variables.

#### 2.2.30 Leverage Private Capital

The microgrid project will seek to leverage private capital where possible in order to develop components of the microgrid. The Project Team is actively developing relationships with investors and project developers that have expressed interest in NY Prize. As the project concept matures, the Project Team will continue to engage these groups to better understand how private capital can be leveraged for this specific project. The Project Team currently envisions continuous operation of the reciprocating generator and solar array and the sale of energy under a custom long-term power purchase agreement (PPA) with O&R. Investors will receive revenue from electricity sales and possibly from participation in ancillary service or DR programs. More detail is provided in Section 3.3.3

#### 2.2.31 Accounting for Needs and Constraints of Stakeholders

Developing the best possible value proposition for the community, utility, local industry, and other community stakeholders is at the center of this feasibility study.

#### 2.2.32 Demonstrate Tangible Community Benefit

The project's success and acceptance rely on its ability to provide benefits to the community. Active participation from the Village government, utility, and community groups is crucial to

designing a microgrid that meets the community's needs. Additional detail about costs and benefits by stakeholder group can be found in Section 3.2.3.

## 2.3 Distributed Energy Resources Characterization (Sub Task 2.3)

As described above, the proposed microgrid includes two new DERs in Florida. This section will discuss the benefits of the proposed resources and how they will meet the microgrid's objectives in greater detail.

### 2.3.1 Existing Generation Assets

The only existing generation resource in the Florida microgrid footprint is a 20 kW natural gas backup generator at the Fire and Rescue Department. However, due to the generator's small capacity and the costs associated with adding a new switchgear, the Project Team decided not to incorporate it into the microgrid.

### 2.3.2 Proposed Generation Assets

The two proposed generation assets include a 175 kW natural gas-fired continuous duty reciprocating generator and a 20 kW PV array, shown in Table 5. The natural gas generator will be located at Cohen Circle on land next to the Seward Senior Center and will utilize the four-inch natural gas line supplying the Seward Senior Center.

The proposed 20 kW solar PV array will be placed on the Public Library's roof or in the parking lot next to the Public Library. It will be easily incorporated into the microgrid system with inverters able to synchronize in both grid-parallel mode and islanded mode. However, the array will not be outfitted with grid paralleling switchgear or controllers because it is small and its output will have relatively little effect on power stability in island mode.

**Table 5. Proposed Generation Assets**

Table describes the proposed gas-fired reciprocating generator and solar array. Included are their capacity, fuel, and address.

Name	Description	Capacity (kW)	Fuel	Address
DER1	Recip. Natural Gas Generator	175	Natural Gas	Cohen Circle (next to Seward Senior Center)
DER2	Solar PV Array	20	Sunlight	4 Cohen Circle

The design proposes a 175 kW reciprocating generator because both the electrical and thermal loads in Florida are relatively small. The electric load is not nearly large enough to sustain a combined cycle turbine with a heat recovery system, and there is no adequate thermal off-taker to merit addition of combined heat and power (CHP) capability. The Project Team analyzed the benefits and costs of several generator technologies and found that a small scale reciprocating natural gas generator provided the best combination of energy resiliency, cost, and efficiency.

### 2.3.3 Generation Asset Adequacy, Resiliency, and Characteristics

The proposed design provides Florida with two energy resources. In grid-connected mode, the proposed PV array and natural gas-fired generator will operate in parallel with the main grid. In island mode, the PV array and natural gas-fired generator will supply all the loads. The proposed natural gas-fired generator is capable of meeting the microgrid's peak demand during island mode, ensuring adequate power is available when the solar PV array generates little power due to weather or time of day.

To avoid power supply disruptions and to protect the microgrid generation assets from damage, the Project Team has proposed equipment locations at elevated areas of the town not prone to flooding. In addition, the existing four-inch natural gas pipeline that will feed the proposed natural gas-fired reciprocating engine is buried to protect it from severe weather. The team is still considering options to safeguard the generator from severe weather, but, as a minimum, the generator will be protected from rain, snow, strong winds, or falling trees by a container. The proposed PV will be industry standard and physically resilient to most weather events, however it cannot be containerized and, as noted above, its output may be negatively affected by overcast weather conditions.

The microgrid's IT system is primarily based on wireless communication. Each wireless unit will be housed inside a weather-proof enclosure to ensure resiliency during storms. Each distributed intelligent electronic device and DER will require a short length of physical wire to connect to the nearest network switch. Network switches will intentionally be placed near the IED or DER that they serve, which makes disruption of a wired connection extremely unlikely. In the event that an IED loses contact with the MCS, it is programmed to act on predetermined set points.

The distribution lines in Florida will not be buried to provide extra resiliency to storms, wind, and falling trees. The Project Team evaluated the possibility of trenching and burying distribution lines and found the cost to be prohibitively high. Hardening possibilities for overhead lines include replacing wooden utility poles with steel or other reinforced material, though this would come at a significant cost. The switchgear will already be encased and an obstruction free right-of-way for the lines is the only way to protect the wires themselves from damage.

The natural gas reciprocating engine will be capable of supplying reliable electricity by providing:

- Automatic load following capability – generation units and controls will be able to respond to frequency fluctuations within cycles, allowing the microgrid to maintain demand and supply balance in island mode.
- Black-start capability – the generator will have auxiliary power (batteries) for black starts and can establish island mode grid frequency. After the gas-fired generator has stabilized the frequency, the main microgrid controller will synchronize the solar array inverters to match the natural gas unit’s frequency and phase.
- Conformance with New York State Interconnection Standards.<sup>8</sup>

## 2.4 Load Characterization (Sub Task 2.2)

The Project Team sized proposed DERs according to electricity from Florida’s load points. The load characterizations below describe the electrical loads served by the microgrid.<sup>9</sup> Descriptions of the load sizes to be served by the microgrid along with redundancy opportunities to account for downtime are included.

### 2.4.1 Electrical Load

The Project Team evaluated seven primary electrical loads for the Florida microgrid: the Florida Village Clerk, the Police Department, the Seward Senior Center, the Fire and Rescue Department, the Public Library, Load Cluster 1 (two residential buildings), and Load Cluster 2 (four commercial buildings). Proposed facilities are listed in Table 6 and their loads are summarized in Table 7. Typical 24-hour load profiles for each facility can be found in the Appendix.<sup>10</sup> Florida’s proposed community microgrid will incorporate a fire department, four village government buildings, two residential buildings, and four commercial buildings, all within close proximity to the primary O&R feeders on South Main Street and Cohen Circle.

**Table 6. Village of Florida List of Prospective Microgrid Facilities**

Table lists potential microgrid facilities, including their addresses, and classifications.

	Property	Address	Classification
1	<b>Florida Village Clerk</b>	33 South Main St	Public
2	<b>Police Department</b>	1 Cohen Circle	Public
3	<b>Seward Senior Center</b>	Cohen Circle	Residential
4	<b>Fire and Rescue Department</b>	19 South Main St	Public
5	<b>Public Library</b>	4 Cohen Circle	Public
6	<b>Load Cluster 1</b>	6-22 South Main Street	Residential
7	<b>Load Cluster 2</b>	6-22 South Main Street	Commercial

<sup>8</sup> New York State Public Service Commission. Standardized Interconnection Requirements and Application Process for New Distributed Generators 2 MW or Less Connected in Parallel with Utility Distribution Systems (2014). Available from [www.dps.ny.gov](http://www.dps.ny.gov).

<sup>9</sup> Estimated loads are based on metering data from O&R.

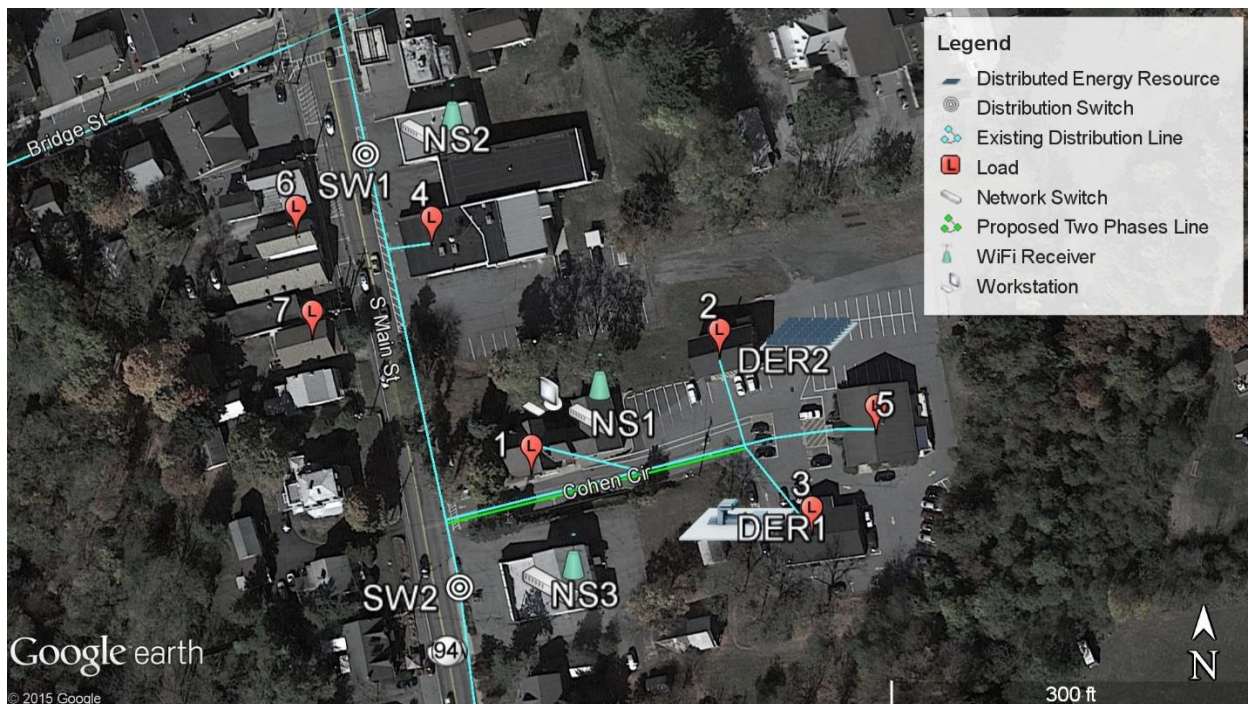
<sup>10</sup> The Project Team is unable to get real 24-hour load profiles from O&R. The 24-hour load profiles are estimated using the monthly load data.



After extensive consultation with O&R representatives, the Project Team determined two new automatic switches will be needed to reliably isolate loads and generation in islanded mode. The design also includes upgrading the existing single phase line on Cohen Circle to three phases. This design prevents potential phase imbalances at main feeder on South Main Street. Figure 2 provides an illustration of the proposed microgrid design and layout, including loads, switches, existing electrical infrastructure, and proposed electrical infrastructure.

**Figure 2. Florida Equipment Layout**

Figure shows the microgrid equipment layout, illustrating DERs, distribution lines, load points, workstations, network switches, and proposed distribution switches.



O&R provided the Project Team with twelve months of metering data for connected facilities (January through December 2014), summarized in Table 7. The aggregate peak demand in 2014 was 171 kW, and the average demand was 49 kW.



**Table 7. Florida's 2014 Microgrid Load Points**

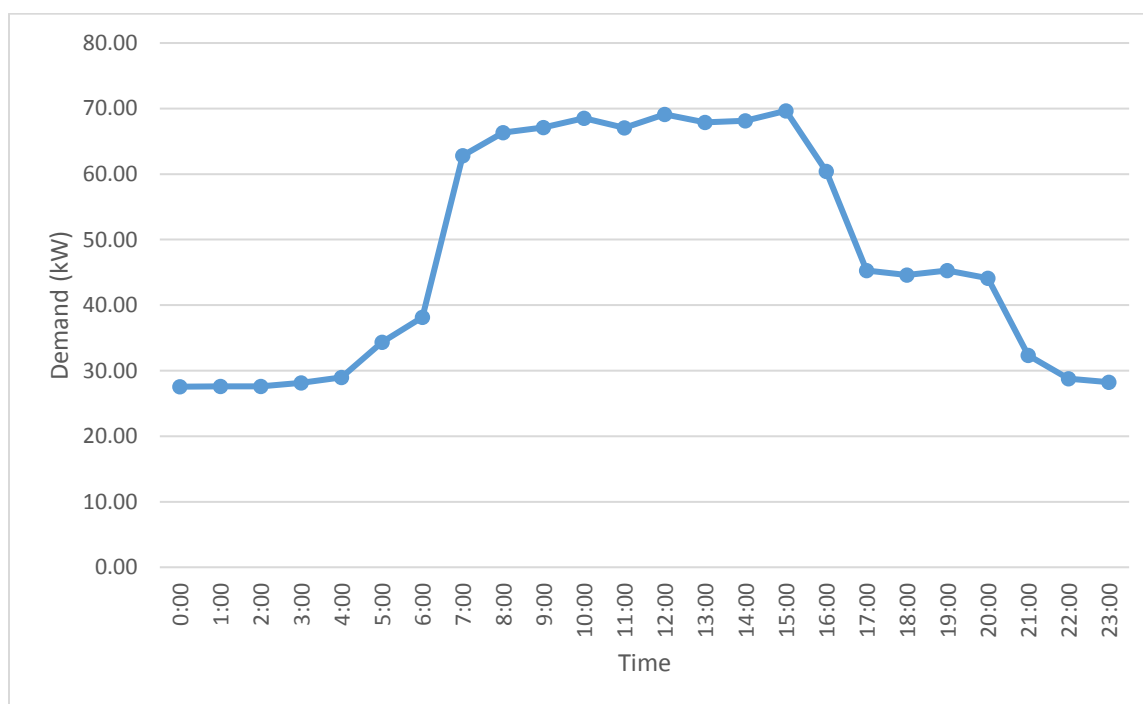
Table displays the microgrid electric demand in kW, the electric consumption in kWh, and the thermal consumption in million British Thermal Units (MMBTUs).

	Electric Demand (kW)		Electric Consumption (kWh)			Thermal Consumption (MMBTU) <sup>11</sup>		
	2014 Peak	2014 Average	2014 Annual	2014 Monthly Average	2014 Weekly Average	2014 Annual	2014 Monthly Average	2014 Weekly Average
<b>Microgrid Loads</b>	171	49	426,407	35,534	8,264	49,941	4,162	968

Figure 3 provides a typical aggregate hourly load profile for Florida. The aggregate hourly load rapidly rises at 7:00 in the morning, very slowly increases and reaches its peak at 15:00 in the afternoon, and decreases back to the night-time baseline from 16:00 to 21:00.

**Figure 3. Typical Month 24-Hour Cumulative Load Profile from 2014 Metering Data**

Figure illustrates the typical 24-hour cumulative load profile. The figure represents the sum of individual facility typical 24-hour load profiles from 2014.



<sup>11</sup> Despite the thermal load indicated here, this thermal consumption is basically heating produced by a system which cannot be replaced by a CHP unit. No sufficient thermal off-taker exists to support a CHP facility in Florida.

The proposed 175 kW natural gas generator and proposed 20 kW PV array will operate continuously in both grid-connected and islanded mode. Although the output of the solar array will be variable (due to weather conditions and insolation) throughout the year, they will typically be most productive when facility demand is highest.

When the solar array is operating close to their nameplate capacity, the microgrid's generation capacity will approach 195 kW, with a firm 175 kW from the natural gas generator. The proposed natural gas engine is rated at net output and therefore there is no parasitic load against the nameplate. Moreover, the engine is slightly oversized and should always out produce peak demand. Aggregate demand from microgrid facilities averaged 49 kW and never exceeded 171 kW in 2014.<sup>12</sup> The proposed DERs should therefore have adequate capacity to supply the microgrid facilities with electricity in island mode. The proposed reciprocating generator is highly flexible and can turn down to 50% of rated output with no loss in performance.

The Project Team expects some degree of natural load growth after construction of the microgrid. Because generators are sized to approximately match current facility demand, significant load growth could threaten the reliability of the microgrid's electricity supply in island mode. Microgrid facilities can mitigate this threat by investing in energy efficiency upgrades or intelligent building energy management systems (BEMS) that respond to commands from the main microgrid controller. Microgrid owners may also invest in additional generation sources, such as small dual fuel generators or battery storage systems.

#### 2.4.2 Thermal Consumption

The facilities to be connected by the proposed microgrid have minimal thermal energy demand. The facilities are relatively small and lack year-round steam usage, which means incorporating a combined heat and power unit is not economically feasible.

## 2.5 Proposed Microgrid Infrastructure and Operations (Sub Task 2.1)

The existing distribution system infrastructure will be expanded and modified to accommodate microgrid operations. The microgrid will support two fundamental modes of operation: grid-connected (normal or grid paralleling) and islanded (emergency) modes. Details concerning the infrastructure and operations of the proposed microgrid in normal and emergency situations are described below.

#### 2.5.1 Grid Connected Parallel Mode

The microgrid will most often operate in grid-connected mode. In this mode, the proposed 175 kW gas-fired reciprocating engine generator and 20 kW PV array will operate continuously, supplying energy to microgrid-connected facilities and, potentially, other loads within the Village of Florida. The microgrid design does not include diesel backup generators. Refer to Table 5 for a complete list of microgrid DERs.

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<sup>12</sup> This number represents the sum the individual monthly peak demands from connected facilities. It therefore assumes that all facilities reached their peak demands at the same time, which is unlikely. The true peak demand was almost certainly less than 171 kW, but the Project Team was unable to obtain synchronized real-time load data for all included facilities.

If the main grid experiences a contingency while the microgrid is connected, the parallel mode control scheme allows for the export of a predetermined amount of active and reactive power from microgrid distributed energy resources. By injecting power into the larger grid, the microgrid will contribute to stabilizing frequency and voltage and potentially avert outages. If the 175 kW natural gas-fired generator has sufficient excess capacity, it will be used for fast ramping its generation as necessary to fulfill the power requirement.

#### 2.5.2 Intentional Islanded Mode

The proposed energy management and control scheme will balance generation with microgrid demand and maintain adequate frequency, voltage, and power flow across the microgrid network in islanded mode. Islanded mode can be intentionally used during forecasted O&R grid outages or disturbances to maintain electricity supply for microgrid facilities—the system will manage the new natural gas generator and solar array to match aggregate demand in real time. Because the output of the solar array cannot be controlled and the design does not include diesel backup generators, the natural gas generator alone will provide flexible real-time response. Refer to the simplified one-line diagram in Figure 4 for a detailed device representation showing proposed generation assets and their utility interconnection points.

## 2.6 Electrical and Thermal Infrastructure Characterization (Sub Task 2.4)

This section describes the electrical and thermal infrastructure of the proposed microgrid. The infrastructure resiliency, point of common coupling, and proposed infrastructure are also fully discussed below.

#### 2.6.1 Electrical Infrastructure

The Village of Florida’s electric distribution system is owned and operated by O&R. Electricity enters the Florida microgrid area from the existing feeder on South Main Street, shown in Figure 4 below. Power will first pass through the proposed automatic switch on South Main Street (SW1 on Figure 4), and loads on South Main Street and load on Cohen Circle. The new automated switch (SW2 on Figure 4) will isolate the microgrid as needed. Upgrading the current single phase line on Cohen Circle to three phase is required to connect the proposed natural gas generator and main feeder on South Main Street. This upgrade to a three-phase line will prevent potential imbalances while injecting power from DERs to the existing feeder on South Main Street.

The following tables (Table 8 to Table 10) describe the microgrid components and are referenced per the tables throughout the rest of the document. For a list of all DERs, see Table 5.

**Table 8. Florida’s Distributed Switches Description**

Table outlines all three distributed electrical switches with their descriptions and statuses as new or requiring an upgrade. Table also provides their labels for Figure 2 and Figure 4.

Name	Description	New/Upgrade
<b>SW1</b>	Automatic switch for feeder isolation	New
<b>SW2</b>	Automatic switch for load shedding and microgrid sequence control	New
<b>SW3</b>	Original equipment manufacturer (OEM) generator breaker	New

**Table 9. Florida’s Network Switch Description**

Table outlines all three IT network switches with their description, status as existing or proposed, and address.

Name	Description	Status	Address
<b>NS1</b>	Near Energy Management System (EMS) and Workstation for communication	Proposed	33 South Main St
<b>NS2</b>	Near Switch 1 for communication	Proposed	19 South Main St
<b>NS3</b>	Near Switch 2 for communication	Proposed	24 South Main St

**Table 10. Florida’s Server Description**

Table describes the workstation and servers, their status as proposed, and their addresses. The microgrid servers and workstation will be placed at Florida Village Clerk.

Name	Description	Status	Address
<b>Workstation</b>	Operator/Engineer workstation	Proposed	33 South Main St
<b>Server1</b>	Primary EMS and Supervisory Control and Data Acquisition (SCADA)	Proposed	33 South Main St
<b>Server2</b>	Secondary EMS and SCADA	Proposed	33 South Main St

The O&R distribution grid in Florida consists of medium-voltage lines (13.8 kilovolt (kV)). All loads currently have their own transformers to step incoming power down to low voltage.

### Figure 4. Florida One-Line Diagram

Figure provides a one-line diagram for Florida illustrating interconnections and lay-out.

### REDACTED PER NDA WITH O&R

#### 2.6.2 Points of Interconnection and Additional Investments in Utility Infrastructure

The proposed equipment investments required for microgrid operation are listed in Table 11. The proposed point of common coupling between O&R's feeder and the microgrid is located at South Main Street (SW1 in Figure 4).

**Table 11. List of Components**

Table lists all the coupling components as well as distribution devices.

Electrical Device	Quantity	Purpose/Functionality
Microgrid Control System (MCS) Protocol Converter (Siemens SICAM PAS or equivalent)	1 Primary 1 Backup	Control system responsible for operating the microgrid sequencing and data concentration under all operating modes.
Automated Pole Mount Circuit Breaker/Switch (Siemens 7SC80 relay or equivalent)	2	New breakers/switches to be installed at O&R's distribution overhead feeder to isolate the feeder on South Main Street and downstream loads from the microgrid.
Generation Controls (OEM CAT, Cummins, etc.) (Load Sharing Woodward or equivalent)	1	Serve as the primary resource for coordinating the paralleling load matching and load sharing of spinning generation.
PV Inverter Controller (OEM Fronius or equivalent)	1	Controls PV output and sends data to the main microgrid controller for forecasting.
Network Switch (RuggedCom or equivalent)	3	Located at IEDs and controllers for network connection, allowing remote monitoring and control.

All microgrid devices require a reliable source of DC power. Each device (or cluster of devices) will have a primary and backup power supply source. During normal operation, a 120 volt alternating current (VAC) power source will power an alternating current (AC)/DC converter to power the microgrid devices and maintain the charge of the DC battery banks. When normal AC voltage is unavailable (most likely due to an issue elsewhere in O&R's distribution grid), the battery bank can provide DC power to devices for at least one week. The power supplies shall not exceed 60% power utilization from the device current draw.

#### 2.6.3 Basic Protection Mechanism within the Microgrid Boundary

The power system protection system senses grid variables, including voltage, current, and frequency, and takes necessary actions (such as de-energizing a circuit line) to maintain these variables at appropriate levels. Some protection schemes are based on the assumption that power flows in one direction. Microgrid operations, particularly during island mode, might require bidirectional power flow. This will introduce difficulties for protection coordination. At a later design stage, protection studies accounting for the key characteristics of island mode will have to be performed, which include possible bidirectional power flows and very low fault currents.

The current design includes controls that can prevent back-feeding of power to the larger O&R grid. However, the microgrid is capable of exporting energy back to O&R.

#### 2.6.4 Thermal Infrastructure

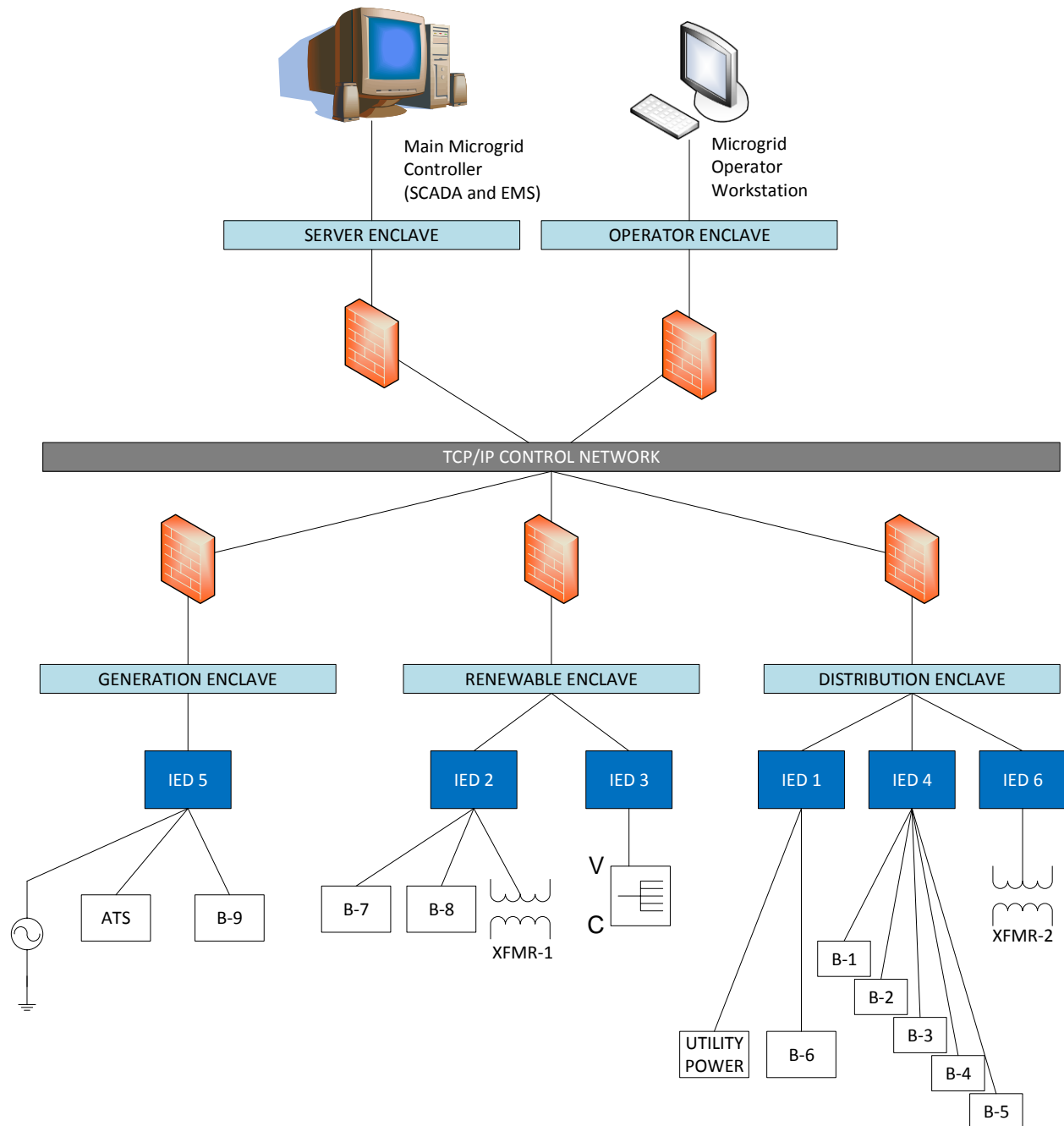
There is currently natural gas infrastructure in Florida. Because the design does not include thermal cogeneration, there is no need for new thermal conveyance infrastructure. At Cohen Circle, there is a four-inch high-pressure natural gas line that O&R has confirmed will provide an adequate pressure and supply of fuel to the 175 kW natural gas-fired generator.

### **2.7 Microgrid and Building Control Characterization (Sub Task 2.5)**

This section provides a more detailed description of the microgrid's modes of operation. The microgrid control system will include an EMS and a SCADA based control center (see Figure 5), hereafter collectively referred to as the main microgrid controller. Distributed intelligent electronic devices will communicate with the main microgrid controller over the local Transmission Control Protocol/Internet Protocol (TCP/IP) network. In grid-parallel mode, the microgrid will synchronize frequency and voltage magnitude with the main grid and will have the potential to export excess electricity to O&R. When controllers detect an outage or emergency disturbance on the main grid, the microgrid will switch to island mode. In these situations, the microgrid will disconnect from the larger grid and proceed with the programmed black-start sequence (described in Section 2.7.6) to start power flow through included lines and devices. When power returns after an outage, the main microgrid controller will manage re-synchronization to the O&R grid (described in Section 2.7.7).

**Figure 5. Diagram of a Typical Microgrid Control System Hierarchy**

The following network diagram illustrates a typical microgrid control network with a generator, breakers, transformers, an automatic transfer switch (ATS), IEDs (which could be actuators, meters, accumulators, or programmable logic controllers (PLCs)), a renewable energy source, and the main microgrid controller with SCADA and EMS server and client workstation node.



### 2.7.1 Microgrid Supporting Computer Hardware, Software and Controls Components

The following is a preliminary list of hardware components needed for Florida's microgrid.

- Energy sources – The microgrid requires DERs in order to supply electricity to connected facilities. To some degree, flexible loads that can be reduced during peak demand events may also be considered as energy sources.
- Microgrid Control System – The MCS is composed of an Energy Management System and SCADA based control center. The MCS is responsible for logging relevant data, regulating generator output, curtailing flexible loads (where possible), and managing transitions between modes of operation.
- Distribution system breakers, switches, and controls – Distributed equipment is crucial to forming a microgrid from a non-contiguous set of loads.
- Distribution System Upgrades – Two additional phase (medium voltage) distribution lines on Cohen Circle will be necessary to upgrade the existing single-phase branch feeder to a three-phase branch. This will prevent power imbalance of existing feeder on South Main Street.
- Generator controls/relays – These components will be installed at each generating unit/inverter. They will control generator output based on signals from the MCS.

The proposed system uses a Service Oriented Architecture (SOA) software platform that will serve as the messaging and integration platform for the monitoring and control of distributed equipment. The SOA system supports almost any power device or control system from any major vendor and therefore ensures communication networkability and interoperability between competing vendor systems. The computer hardware and software required for a fully automated operational microgrid design are as follows:

- SOA software platform – The SOA platform facilitates the monitoring and control of included power devices and control systems.
- Two Redundant Array of Independent Disks (RAID) 5 servers (including 1 primary, 1 backup) for the MCS – The MCS will include an EMS and a SCADA-based control center and will optimize the operation of the microgrid. This includes determining which critical loads will be supplied, integrating PV output into the energy portfolio (including high resolution solar forecasting), and controlling the charge/discharge of energy storage wherever applicable. The system combines information on power quality, utilization, and capacity in real time, which allows the community and control algorithms to balance electricity supply with microgrid demand.
- Historian database server – Historian database collects and logs data from various devices on the network.
- Applications server (one or more) – Depending on the software and hardware vendors' preference, application servers may be used for numerous purposes. Common uses for an application server include, but are not limited to, backup and recovery, antivirus, security



updates, databases, a web server, or use as some other software depending on how the SCADA and EMS vendors configure their platform.

- Operator workstations for SCADA and EMS – Workstation computers, sometimes called thin-clients, allow operators to view real-time data and control the microgrid from the SCADA control room or a remote location. Users must have proper access rights and permissions to operate workstation computers.
- Intelligent Electronic Device distribution switches: Automated pole mount circuit breaker/switch (Siemens 7SC80 relay or equivalent) – The microprocessor-based logic controllers in the field, also referred to as IEDs, are programmed to act on predetermined set points. They can also be manually overridden by the MCS or a human operator. The control system host servers continuously poll these logic controllers for data using discrete or analog signals. Resulting data is processed by the IEDs connected to control elements. Two new IEDs will be installed at South Main Street.
- Generation Controls (OEM CAT, Cummins, etc.) – These components are the primary resources for controlling the output of spinning generators.
- PV Inverter Controller (OEM Fronius or equivalent) – This component will control PV output and send data to the MCS for forecasting.

Use of the listed hardware, software, and resources must be synchronized to maintain stable and reliable operation.

#### 2.7.2 Grid Parallel Mode Control

When the microgrid connects to the main grid, every generator will synchronize its voltage (magnitude and angle) and frequency with the voltage (magnitude and phase) and frequency of the electrically closest main grid point, or the point of common coupling in Florida. After initial synchronization, the generator voltage phase will drift away from the main grid's voltage phase, which will allow the flow of active and reactive power. The generator's voltage magnitude and frequency will be maintained as close as possible to the main grid's voltage magnitude and frequency. During grid parallel mode, generation assets will follow the Institute of Electrical and Electronics Engineers (IEEE) 1547 standard for interconnecting distributed resources with electric power systems. The IEEE 1547 and other DER interconnection standards required by utilities are applicable to synchronous, asynchronous, and inverter-based generation.

A utility might have additional technical and economic requirements if the microgrid plans to export energy or provide ancillary services to the distribution grid. The proposed natural gas-fired generator is capable of providing ancillary services to O&R's grid to enhance the reliability of the system. It can provide reactive power and frequency response services on demand, but providing reactive power support may diminish the rotating generator's ability to generate real power.

#### 2.7.3 Energy Management in Grid Parallel Mode

The proposed microgrid will integrate software and hardware systems to ensure control of the system (observability, controllability, reliability) and system's optimal performance. Microgrid

control is based on a two level hierarchical control, central (slow) and local (fast). Optimization of microgrid performance involves three distinct phases: measurement and decision, scheduling and optimization, and execution and real time optimization.

Data logging features will allow the main microgrid controller to measure historical performance and track significant trends. Human operators can use this data to manage generator output and schedule maintenance for generators and microgrid components. The microgrid executive dashboard will collect and filter information on the current operating strategy as well as performance metrics for SAIFI (System Average Interruption Frequency Index), SAIDI (System Average Interruption Duration Index), and CAIDI (Customer Average Interruption Duration Index), all adjusted to reflect the high sampling frequency of the system. Other performance metrics include power interruptions (defined as 50% variance of predicted voltage to measured voltage for 10 minutes or longer), voltage violation (defined as variance of actual voltage to predicted voltage for 5 minutes), and frequency violations (defined as variation to predicted frequency of more than 0.2 Hz for more than 10 minutes). The executive dashboard will calculate daily, weekly, and monthly rolling totals for all of these metrics.

After analyzing historical trends and monitoring real-time data, the main microgrid controller will optimize operation of the microgrid by managing generator output and flexible loads. In grid-connected mode the MCS will prioritize the deployment of renewable generation and will aim to offset electrical demand charges whenever possible.

#### 2.7.4 Islanded Mode Control

The transition to island mode can be either unintentional or intentional. Unintentional islanding is essentially the main microgrid controller's programmed response to an outage at the level of the distribution or transmission system. An outage at the distribution system level can occur within or outside the microgrid, and the microgrid islanding scheme must be able to handle either situation. MCS relays at the PCC will recognize low voltage, and the appropriate switches will open automatically (disconnecting the microgrid from the larger grid). Any existing on-line generation will be isolated and ramped down via generation breakers. All microgrid loads and distribution switches will then be switched open via designated circuit breakers and relays to prepare for local generation startup. Using the natural gas generator's black-start capabilities, the MCS will commence island mode operation. The main generator will ramp up to 60 Hz and prepare to supply each of the microgrid loads. After the natural gas generator is on-line and power flow through the microgrid is stable, the main microgrid controller will synchronize output from the solar arrays (voltage and frequency) and bring them on-line. In steady state, their phases will be different, just as they are during grid-connected steady state operation.

Unlike the unintentional transition to island mode, the intentional transition is seamless and closed (it does not require a black start). The microgrid will intentionally switch to island mode if:

- The O&R grid has an expected outage that could potentially affect transmission power to Florida substations.

- The O&R grid needs to perform network maintenance work, thereby isolating loads in the Florida area.

The intentional transition to island mode begins when the system operator sends the command to prepare for islanding. The main microgrid controller will automatically start and parallel the generation assets. Once the available power sources are synchronized, the system is considered ready to implement islanded operation and will begin opening the incoming utility line breaker.

#### 2.7.5 Energy Management in Islanded Mode

After completing the transition to island mode, the main microgrid controller will perform a series of operational tests including power flow, short circuit, and voltage stability to ensure the microgrid is operating as expected and that power flow is stable and reliable.

The microgrid must also be capable of handling any contingencies that may occur within the islanded system. These contingencies include:

- Generator that do not start. The natural gas generator is currently the microgrid's only connected spinning generator, but the microgrid may expand in the future to include backup generators or new generators.
- Generators that trip off unexpectedly during microgrid operation.
- Switchgear that fails to operate.
- Switchgear that fails to report status.
- Loss of power from the natural gas generator.
- Loss of power from the solar array.

The MCS will optimize the microgrid's operation by managing generation assets. Proposed DERs will provide stable, sustainable, and reliable power. The MCS will continuously balance generation and load in real-time by monitoring relevant variables (i.e., system frequency and voltage) and adjusting generator output as necessary. The main microgrid controller will first deploy energy from renewable generation assets and adjust the natural gas generator output to match remaining electricity demand. The microgrid design relies on the natural gas generator's fast ramp rate to compensate for changing output from the solar array.

Battery storage was considered in a number of alternative designs to compensate for the intermittency of the solar array. The Booz Allen team, however, found the cost of battery storage to be prohibitively high for Florida's microgrid system. The analysis considered the potential of using storage for three purposes:

- System reliability: short-term backup, often used for voltage or frequency support or to smooth intermittent renewable ramp rates.
- Energy shifting: storing excess generation for a few hours, usually to offset higher priced periods (e.g., shifting excess solar generation from 1-3 PM to 4-6 PM when grids tend to peak).

- Longer term storage: storing energy from intermittent renewables for later use to firm up the supply to 24 hours or to improve/extend island mode operation.

The analysis indicated that storage was not needed to improve system reliability (the natural gas generator's fast ramp rate provides an acceptable level of reliability). The high cost of battery storage and absence of time-of-use energy rates made using storage to shift generation or extend island mode operation economically unfeasible.

#### 2.7.6 Black Start

The proposed natural gas-fired reciprocating generator will be equipped with black-start capabilities. If the O&R grid in Florida's vicinity grid unexpectedly loses power, the microgrid controller will initiate island mode by orchestrating the predefined black-start sequence. The microgrid then enters unintentional islanding mode. This mode of operation will require the generators to have a DC auxiliary support system with enough power to start the generator multiple times in case it fails to start the first time.

When the larger grid unexpectedly loses power, the main microgrid controller orchestrates the black-start sequence as follows:

1. PCC breaker opens.
2. All active generation is disconnected.
3. The main microgrid controller waits a pre-set amount of time (approximately 30 seconds) in case O&R power comes back.
4. The main microgrid controller disconnects the isolation switch (SW2 in Figure 4).
5. The microgrid generators are synchronized with each other (if more generators are added in the future). One will usually provide reference voltage and frequency.
6. The main microgrid controller reconnects generation to serve the microgrid loads.

The MCS will manage any contingencies that arise during the black-start operation (e.g., breakers do not respond to trip commands, and the microgrid does not properly disconnect from the larger grid). The MCS will allow operators to designate some generators as unavailable for participation in the microgrid (e.g., if it requires maintenance) so that the generation dispatch and load shedding algorithms can accommodate a reduced available capacity.

#### 2.7.7 Resynchronization to O&R Power

When power returns to the O&R grid, the microgrid controller will coordinate a safe and orderly re-connection to the main grid. The system first waits a predefined, configurable time period to ensure power is permanently restored and then commences resynchronization to the O&R power supply. As a final check, the system operator will either receive an automated notification or directly contact O&R to confirm that power flow on the main grid is on-line and stable.

While in emergency island mode, the system will constantly monitor the status of the utility feeder at the PCC and determine when appropriate levels of current and voltage have been restored. When power has been restored, the control system will synchronize and parallel the microgrid generation with the utility service through the utility circuit breaker at the switch on

the feeder (SW1 in Figure 4). Before the microgrid system starts paralleling with the utility, it will balance the generation and load so as not to exceed either minimum or maximum export limits or time durations set forth in the utility interconnection agreement. Once power is restored and the main breaker is closed, the other isolation switch (SW2 in Figure 4) will close to serve power to other loads in Florida.

## **2.8 Information Technology and Telecommunications Infrastructure (Sub Task 2.6)**

The existing IT and telecommunication infrastructure at Florida is best suited for a wireless microgrid communication system. The communication system and network switches (which have local backup batteries) will communicate wirelessly with the base station located at the Florida Village Clerk, which is electrically served by the microgrid in island mode. During the intermittent stage, or black-start sequence mode, the headend IT network equipment and base station for the IT network communications system will be powered by their backup batteries. The microgrid design will require minimal additional hardware (i.e., the network switches, WiMax Base Station, WiMax subscriber units, servers, and computers required to manage a microgrid) to seamlessly integrate with the IT system.

### **2.8.1 Existing IT & Telecommunications Infrastructure**

Florida already takes advantage of its existing fiber optic backbone ring and existing Ethernet switches for reliable Internet and local area network (LAN) activities, making convergence quite feasible. The wireless components of the control system, which work on open architecture protocols, use a TCP/IP Ethernet-enabled component that controls each of the uniquely addressed modules to wirelessly communicate via a standard, non-licensed radio frequency mesh 900 megahertz (MHz) industrial scientific and medical (ISM) band signal network.

### **2.8.2 IT Infrastructure and Microgrid Integration**

New hardware and software will be required to ensure compatibility between the existing IT infrastructure and proposed microgrid system. There are seven main components required for any microgrid system to successfully integrate with an IT/telecommunication infrastructure: host servers, application servers, operator workstations, network switches, network-attached logic controllers, data transmission systems (either fiber optic or Ethernet cables), and the vendor agnostic SOA software that facilitates the monitoring and control of virtually any power device or control system. All of these critical parts work together and serve a specific role.

### **2.8.3 Network Resiliency**

Cyber Security falls into the two primary stages: design and planning as one and continuous operations as the other stage. Cyber Security is especially important for the microgrid control system considering it now utilizes TCP/IP protocols for compatibility amongst the distribution system. This convergence has also introduced vulnerabilities to the MCS because the MCS vendors have historically lagged behind in implementing security patches rolled out by Windows, or PC-based security teams.

For the planning stage, assuming the microgrid will utilize enterprise-level remote monitoring and control, design considerations shall address cyber security by assigning roles to network-attached components on the operator's WAN thereby controlling data flow and access permissions over the integrated MCS and overarching IT architecture. For example, our design utilizes a network segmentation scheme by function (separate segments/enclaves for servers, operators, generation, and distribution), in addition to network firewalls, for clean and continuous monitoring and control of data flow. The firewall routes noncritical traffic such as utility's unrelated corporate printers and other drivers, email, and all other non-essential internet services (which could be backdoors for hackers into the MCS) to a dedicated demilitarized zone (DMZ) usually consisting of a single security hardened server.

Because the logic controllers will be located at or near loads, the distributed equipment will take the IT system to the "edge" of the microgrid operator's network, where it is potentially more vulnerable to hackers. Sticky MAC is an inexpensive and practical program that can help prevent unauthorized access and protect the National Grid IT network. Every network attached device has a unique, unchanging media access control (MAC) interface. The sticky MAC program is configured to monitor the unique address of the device and its designated network port. If the device disconnects, the program disables the port and thus prevents an unauthorized device that may have malicious code from entering the IT system.

Physical security measures, such as electronic badge access or cipher combination hardware locksets, should also be considered. The Project Team recommends implementing physical security at the perimeter of the control center building and network communication closets where the switches reside.

The data transmitted throughout the proposed Florida microgrid will be encrypted, but several additional intrusion protection measures can easily be implemented. One simple and inexpensive method is to disable any of the 65,535 TCP ports not used to make the microgrid system work (depending on final configuration, only a few TCP ports will need to be active). More TCP ports will need to be active if the available enterprise-level monitoring and control access will be utilized.

Activating and analyzing security logs is also important. As a rule, the operating system and firewall can be configured so that certain events (e.g., failed login attempts) are recorded. The security portion (software that resides on the control system servers) will be configured so that only operators and engineers with specific login credentials can access and control the microgrid.

In the event of a loss of communication with the IT system, the microgrid will continue to operate. The programmed logic code for the network attached controllers is stored locally in each module, giving the controllers the ability to operate as standalone computers in the event of a disruption between the IT system and microgrid. However, long periods of separation from the network will hamper controls, historian logging, and firmware updates from upstream servers.

Cyber Security will also be considered during operations stage. It is given that these systems will continue to have security flaws. Although the MCS vendors in the past used to perform only minimal software regression tests for bugs; in recent years, the MCS vendors have been working on these issues continuously to mitigate security risks. It is important to note that the proposed MCS network attached components can be upgraded online as software updates become available. The MCS could be upgraded automatically whenever an update is available or manually after testing the updates in a non-production environment. In either case, a networked server is used to deliver the updates. Each approach has its own benefits and drawbacks. Automatic upgrading installs updates as soon as they are available but they might not function as expected in the given heterogeneous environment. Upgrading manually allows for testing to ensure correct functioning but the upgrades might be delayed. In either case, a networked server is used to deliver the updates. It is strongly recommended that these updates be tested or simulated first in a non-production environment. The simulated model is easy to mimic with artificial (input/output) I/O points. Any reputable control systems programmer/integrator does such testing before the commissioning stage; the same I/O model and hardware configuration could be used for the security update tests in the future. Our team considers the safety and availability of the microgrid to be the most critical aspects of the microgrid. Testing and/or simulation of the system responses to software updates is important because it allows the owner or operator to identify any anomalies which the software updates might introduce to the overall system before full deployment in the field. Additional considerations will be given at the next phase of the Prize initiative.



## **2.9 Microgrid Capability and Technical Design and Characterization Conclusions**

After thorough examination of existing utility infrastructure and energy demand requirements, the Project Team has provided a reliable microgrid design. Control components will efficiently manage the real-time operation of the microgrid by communicating with distributed IEDs. The proposed design is resilient to forces of nature and cyber threats and offers full automation and scalability at every level. The SOA-based framework ensures interoperability and compatibility between components, regardless of final vendor.

In conclusion, the project is technically feasible; however, there are several barriers to project completion, which are outlined below.

- An existing single phase line must be upgraded to three phase.
- The utility (O&R) must agree to the new interconnection and electrical distribution network because it will incorporate O&R lines and switches.
- The village government must agree to host the proposed reciprocating gas-fired generator and solar array.
- The existing and proposed generation assets and microgrid components must be available for maintenance at all times.

The Team is working with the facilities to ensure they will allow a third party to service the generation assets and microgrid components located on their land. These facilities have considerable incentive to support the project because construction and interconnection will guarantee a reliable power supply and possibly provide distributed energy resource asset owners with new sources of revenue. The Project Team therefore expects these operational challenges to be resolved by the time of construction.

The proposed design includes two new automatic switches to isolate microgrid regions, two new DERs operating in both island mode and grid-connected mode, and two new phase lines to prevent phase imbalance on the existing feeder. Existing natural gas infrastructure in Florida will be adequate for the continuous operation of the proposed natural gas reciprocating generator.

## **3. Assessment of Microgrid's Commercial and Financial Feasibility (Task 3)**

The conclusions in this section of the document are predicated on several fundamental assumptions:

- Private investors will own the DERs and microgrid controls, and O&R may own the new and upgraded distribution infrastructure. O&R has indicated to the Project Team a preliminary potential interest in participating in the operation of the project and potentially owning the hardware on their lines.

- The proposed 175 kW natural gas-fired reciprocating generator and the proposed 20 kW solar array will sell electricity to O&R at the average local supply charge (the price O&R currently pays to purchase electricity, excluding transmission, distribution, and capacity charges). It may be most economically advantageous to assume direct PPAs with the facilities, however this proposal assumes the lower risk scenario of sales to the utility.
- O&R, as the local expert in energy distribution and the current owner and operator of the Village's distribution infrastructure, may operate the microgrid. If O&R decides not to take on an operational role, this role could be executed by a third party private entity such as Con Ed Solutions or Constellation. O&R's existing infrastructure is used extensively in the preliminary microgrid design, so operational participation from the utility is vital to the project's success.
- The current regulatory, legal, and policy environment will stay consistent. The proposal falls within the existing legal frameworks.

Preliminary analyses indicate that by selling electricity at O&R's average supply price the project will not generate sufficient funds to support variable operations and maintenance costs nor recover capital expenditures, even with the award of NY Prize Phase III funding.

This feasibility study does not consider the possibility of O&R accepting a higher supply price for electricity because this could pass higher prices on to customers (without public funding or state incentives) and therefore contradict one of the project's central goals. SPV investors will be eligible for approximately \$15,000 from and the Federal ITC. The microgrid design relies on the SPV to finance the construction of the natural gas reciprocating generator, the solar PV array, and the microgrid controls, while O&R may construct the required distribution infrastructure. However, simply selling electricity at O&R's average supply price will not generate sufficient cash flow to attract investor interest in the project in the absence of NY Prize.

### **3.1 Commercial Viability – Customers (Sub Task 3.1)**

The Florida microgrid will include five facilities and two load groupings along Cohen Circle and South Main Street; these are described below in Table 12 and include a wide range of municipal services and commercial space. The SPV will own the proposed DERs and controls, and O&R may own and operate the control infrastructure as well as operate the DERs. It is assumed that private investors would support the SPV, while O&R will contribute useful expertise to the day-to-day operation of the microgrid. Private investors and the utility will provide the majority of the capital outlay required for this project.

Several facilities in the footprint will provide critical services to the Village during emergency situations, including the Village Clerk, the Police Department, and local Fire and Rescue. Although the remaining facilities do not provide critical services, they can serve as shelters during emergencies and otherwise remain operational during an outage. The project is proposed such that there are minimal new lines required and only limited upgrades to the existing distribution lines. The project will affect several groups of stakeholders in the Florida community

that are not physically connected to the microgrid; the benefits and challenges to these stakeholders are discussed further in this section.

### 3.1.1 Microgrid Customers and Investors

Two proposed generators will provide power to the Florida microgrid: a 175 kW natural gas reciprocating engine and 20 kW PV array. The microgrid will enter island mode when it detects an outage or disturbance on the larger O&R system. The microgrid will also have the technical ability to enter island mode for economic reasons but will not be permitted to do so as it would adversely affect downstream loads. In their day-to-day operations, most of the connected facilities serve the Florida and Orange County communities, and will make their services available to a larger group of stakeholders during emergency situation.

The Table 12 below identifies each of the direct microgrid customers and the scenarios during which they will purchase electricity from the microgrid.

**Table 12. Microgrid Customers**

List of facilities that will be connected to the microgrid.

Property	Address	Classification	Critical Service	Back-up Generation	Normal vs Island Mode
Florida Village Clerk	33 South Main Street	Public	Yes	No	Both
Police Department	1 Cohen Circle	Public	Yes	No	Both
Seward Senior Center	Cohen Circle	Public	Yes	No	Both
Fire and Rescue Department	19 South Main Street	Public	Yes	Yes	Both
Public Library	4 Cohen Circle	Public	No	No	Both
Load Cluster 1 (2 Residential Buildings)	6-22 South Main Street	Residential	No	No	Both
Load Cluster 2 (4 Commercial Buildings)	6-22 South Main Street	Commercial	No	No	Both

Cash flows from electricity sales will not cover variable costs and the project will yield negative operating revenues. The Federal ITC may cover 30% of the capital cost of the solar array, however given the small size of the solar array this will provide only marginal overall cost benefit. The Florida microgrid is unlikely to be financially viable, even with a Phase III award.

### 3.1.2 Benefits and Costs to Other Stakeholders

Prospective stakeholders in the Florida microgrid extend beyond direct investors and facilities to include other O&R customers, existing generation asset owners, residents of the areas surrounding Florida, and Orange County. Direct benefits will accrue to the Village, County, proposed distributed energy resource asset owners, connected facilities, and local utility. The surrounding communities and larger state of New York will enjoy indirect benefits from the microgrid (further discussed in Section 3.2.3). During an emergency power outage, the microgrid will maintain power to public and municipal services, commercial clusters, and a senior center.

Each of the municipal facilities provides a public service and many can be opened as emergency shelter as needed, providing basic life support and sustenance, and the commercial facilities will be able to continue business operations through an outage.

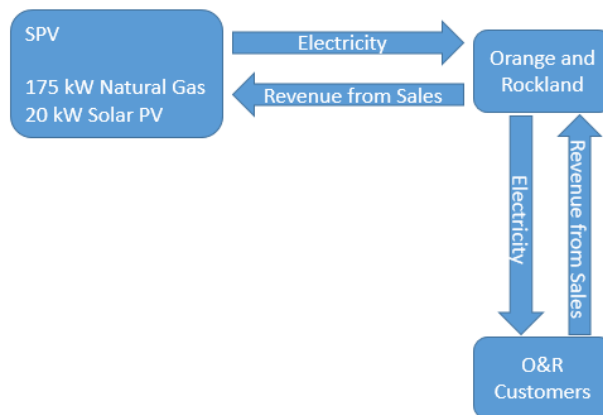
The natural gas units and the solar arrays together possess a maximum generation capacity of 195 kW, which is 175 kW of continuous load reduction for the larger O&R grid from the natural gas engine during both peak demand events and normal periods of operation and 20 kW of variable support from the PV array. As this generation is sufficient to cover the peak demands of the connected facilities, it will obviate the need to run existing 20 kW diesel backup at Fire and Rescue and limit the need future diesel backup within the footprint, reducing emissions and future backup generation investments.

### 3.1.3 Purchasing Relationship

The SPV will own the DERs and microgrid controls while O&R may own all new distributed infrastructure on their system as well as the associated controls and software. In grid-connected mode, the SPV will sell electricity from the proposed reciprocating generator and solar array to O&R under a long-term PPA.<sup>13</sup> Microgrid facilities will maintain the current utility-purchaser relationship with O&R during grid-connected mode. Electricity will flow through the existing distribution system and rates will be captured through the existing billing mechanism. In island mode, however, the facilities will be electrically disconnected from the larger grid and directly supplied by the proposed generation assets. Associated usage will be captured by the microgrid software and revenues remitted to the SPV as appropriate. Islanded operation contracts will be established during development and construction and will address the order in which islanded facilities are brought back on-line following an island event and the associated cost for participating in the microgrid. See Figure 6 and 7 below for the purchasing relationships.

**Figure 6. Normal Operation Purchasing Relationship**

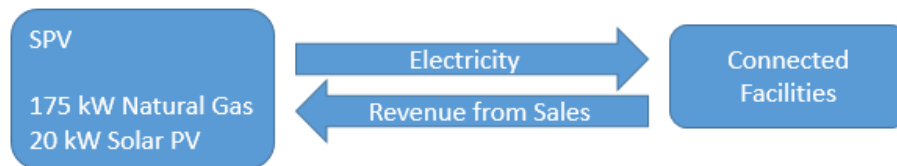
Figure describes the value streams and purchasing relationships between the various entities during normal operation.



<sup>13</sup> The proposed solar array will not qualify for net metering because it will be owned by the SPV, which does not own a metered facility in the area.

### Figure 7. Islanded Operation Purchasing Relationship

Figure describes the value streams and purchasing relationships between the various entities during islanded operation.



#### 3.1.4 Solicitation and Registration

The Village and utility will work with identified facilities in Table ES-1 to participate in the project. This outreach will include informal discussions and, ultimately, signed agreements of participation in the microgrid and acceptance of the tariff or fee structure. Formal registration of facilities with the microgrid will be managed by programming the logic controllers to include or exclude the facility from islanded services based on their agreement with the utility. The Project Team views registration as an operational feature of the microgrid and not a legal requirement.

Electricity purchases by the customer facilities from O&R will follow existing contractual and purchase relationships. Electricity sales from proposed generation assets will follow purchase agreement or unique procurement model. Islanded operation contracts will be established during development and construction and will address the order in which islanded facilities are brought back online following an island event and the associated cost for participating in the microgrid. All of the aforementioned contracts are proposed, and none are currently in force.

#### 3.1.5 Energy Commodities

The microgrid's generation assets will produce electricity, but will have no ability to participate in DR or other paid ancillary service programs due to their small size and location on the middle of a feeder. Proposed generation assets include a 175 kW natural gas-fired reciprocating engine and a 20 kW solar PV array. Together these DERs will provide up to 195 kW of electricity for the microgrid and the larger Florida community. O&R will distribute the purchased electricity in load agnostic fashion across its grid.

The Project Team conducted an extensive survey of the included facilities and surrounding footprints to determine if there are proximate thermal loads with which to intertie the microgrid. The Project Team found none and therefore there is no CHP proposed for the microgrid. In the future if a thermal load develops within the existing footprint or reasonably nearby, the natural gas generator may be retrofitted for thermal offtake or otherwise upgraded to support CHP requirements.

### 3.2 Commercial Viability – Value Proposition (Sub Task 3.2)

The microgrid will provide value to Florida, private investors, O&R, direct participants, and the larger State of New York. The proposed natural gas unit and solar array will reduce the Village's reliance on high emissions diesel generators during outages, and provide stable energy resources to critical and important facilities in emergency situations. SPV owners will receive stable revenues from the proposed energy generation resources. The benefits, costs, and total value of the microgrid project are discussed in detail below.

Table 13 below provides an overview of the Florida microgrid project, including an analysis of project strengths, weaknesses, opportunities, and threats.

**Table 13. Florida Microgrid SWOT**

Strengths, weaknesses, opportunities, and threats (SWOT) associated with the Florida microgrid project.

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• O&amp;R participation in operation and ownership may demonstrate to other IOUs the value of community microgrids in their service territories and prove out a win-win for the utility and ratepayers.</li> <li>• Allows for the use of existing transmission and distribution (T&amp;D) infrastructure, thereby reducing the potential cost burden of constructing new lines and feeders (microgrid project will only require isolation switches to disconnect the microgrid from the feeder and downstream loads).</li> <li>• Draws on O&amp;R's expertise to operate the microgrid (load aggregation, load following, voltage regulation, and other requirements).</li> <li>• Engages key critical facilities as well as local residents and businesses.</li> </ul>	<ul style="list-style-type: none"> <li>• Separating some capital costs from the revenues necessitates further agreement between revenue drivers (DERs) and distributed infrastructure owners (O&amp;R). DER owners may balk at paying revenue into non-revenue generating components.</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Encourages collaboration between local government, private investors, and investor-owned utility. Because most communities are served by IOUs, this model could serve as a template for future projects.</li> <li>• Demonstrates the feasibility of reducing load on the larger grid with distributed energy resources.</li> <li>• Provides a proof point for utility operated microgrids in partnership with silent DERs investor group.</li> <li>• Provides data for O&amp;R and NYSEDA on the benefits of using non-CHP natural gas reciprocating generators as DER assets. The market for non-CHP recip. generators is far larger than the market for CHP because it is not limited by thermal demand.</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in regulatory requirements could impact the proposed business model and stakeholder goals</li> <li>• Increases in natural gas prices will significantly raise the microgrid's marginal cost of producing electricity, which may prompt a re-negotiation of O&amp;R's purchasing price.</li> </ul>

Although there are several valuable strengths and opportunities associated with the hybrid ownership model, there are also weaknesses and threats that must be addressed and, if possible, mitigated.

- **Financial** – SPV members will seek a long-term PPA, or some other form of long-term purchase agreement, with O&R to guarantee steady future revenue streams. As long as

the agreement reliably guarantees fair compensation for generator output over the project lifespan, SPV members must be content with flexible compensation rates and a low amount of risk. O&R's average supply price of electricity is insufficient for the SPV to recover capital investments and is unlikely to cover even variable costs of generation. This weakness is partially offset by NY Prize Phase III funding, however with consistently negative operating cash flows, capital subsidies will not bring the project into financial positivity.

- **Organizational Competition** – This business model requires collaboration among groups of stakeholders that may have different motivations for participation in the microgrid project. O&R may construct and own non-revenue generating control and switchgear with an expectation of financial support from DER revenues. DER owners will see revenues from their assets and may be disinclined to support the non-revenue assets. Further, though O&R will have no ownership interest in the generation assets, they may have day-to-day operational responsibility for them under a long-term O&M contract with the DER SPV owners. This arrangement may misalign incentives if O&R can source electricity from other suppliers at a lower rate than the price paid to the SPV. Given the SPV will cede operational control to O&R and will exist in a silent investment capacity, the SPV will have little immediate recourse in addressing lower than expected revenues. Open communication and early agreement between O&R and private DER investors regarding operational parameters, volumes of electricity to be purchased, and the price per unit of electricity will be paramount for the smooth operation of the microgrid.
- **Regulatory** – Utilities in New York State cannot own generation assets unless they demonstrate why full vertical integration provides value to their customers. The State of New York wishes to avoid situations in which a single entity monopolizes energy generation and distribution resources. Utilities may not purchase DERs, and microgrid investors that purchase distribution infrastructure may be considered utilities. To avoid this regulatory threat, the SPV will purchase only new generation assets, while O&R will retain ownership of existing power lines and new distribution infrastructure. The proposed business model will therefore function within the existing regulatory landscape and may provide evidence that privately owned generation assets can successfully sell electricity over a utility-owned power distribution platform.

### 3.2.1 Replicability and Scalability

The Florida microgrid is a largely replicable and scalable model and is being designed with industry standard equipment and software that can be applied to diverse existing infrastructure.

*Technical Replicability.* The proposed microgrid technology does not present a barrier to project replicability. The primary components of the microgrid, including the proposed generation assets, switches, SCADA, and the EMS, are widely available and could be repeated in any given location. All interconnections with the O&R grid are industry standard. Natural gas infrastructure is an essential component of the project's replicability; without a steady natural gas supply, other



cities would have to sacrifice the reliability (by relying on solar or wind power) or emissions efficiency (by using diesel or fuel oil) that make this project feasible.

*Organizational Replicability.* Because most municipalities in NYS follow a similar electricity model in which the local IOU distributes power purchased from third-party owned generation assets, the project's power distribution structure is easily replicable. Private DER and microgrid controller ownership that contracts the local utility to operate the DERs, coupled with utility distributed infrastructure ownership, is both replicable and desirable as it brings private capital into the energy arena and provides a platform for utilities to realize revenue from the projects. A model in which an IOU has operational control over the generation assets but without any financial stake in them is not one that has been widely implemented. It is the opinion of the Project Team, however, that the proposed model provides a path ahead for grid-integrated microgrids in a fashion that engages utilities, which may otherwise be skeptical of their value proposition. The model may also promote innovations in rate calculations and help change the services that IOUs are expected to provide. Its replicability expands the potential market for resulting innovations to include a larger part of New York State. As such, this project presents a valuable opportunity for NYSERDA to examine the changing role of the investor-owned utility in energy generation and distribution.

The proposed generation assets qualify for a relatively small total incentive payment—the ITC may offset around 30% of the solar array's capital cost, but the natural gas reciprocating generator is not covered by any state or federal incentive programs. The project's commercial viability would therefore depend on NYSERDA NY Prize Phase III funding and additional operating subsidies, neither of which will not be available to most, or any, community microgrid projects. This hinders the project's replicability.

*Scalability.* The microgrid is scalable, however the electrical infrastructure is such that any upsize of the footprint would require somewhat significant investment. With increased generation size and additional breakers, the microgrid could expand on the feeder to include additional facilities. A switch to remote-controllable AMI across a wider footprint could allow for selective access to the microgrid and a preference for critical facilities.

### 3.2.2 Benefits, Costs, and Value

The microgrid will provide both direct and indirect benefits to a wide range of stakeholders. SPV owners will receive stable cash flows for the lifecycle of the project, the Town and citizens will benefit from a more resilient electricity system, and the community will have access to shelter and municipal during emergency grid outages. Preliminary analysis indicates cash flows from electricity sales and incentive programs will not cover variable generation costs. The project will generate insufficient returns to recover capital costs and the project's financial attractiveness does not materially improve with NY Prize Phase III funding. Projected costs and benefits are discussed in Table 14 through Table 19.

Neither customers nor local residents are not projected to bear any of the project's costs. The tables below provides an overview of the benefits and costs to members of the SPVs, direct

microgrid customers, citizens of Florida and surrounding municipalities, and the State of New York.

**Table 14. Benefits, Costs, and Value Proposition to SPV Owners**

Describes the benefits, costs, and value proposition to SPV owners.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>SPV (Private Investors)</b>	<ul style="list-style-type: none"> <li>- Investors will receive annual cash flows from electricity sales from the natural gas reciprocating generator and PV array, and microgrid connection or participation fees</li> <li>- NY Prize Phase III funding would recover 50% of capital costs</li> </ul>	<ul style="list-style-type: none"> <li>- Initial capital outlay will be moderate because the SPV must purchase and install generation assets</li> <li>- Forecasted capital costs for the PV and NG reciprocating engine are \$50,000 and \$230,000, respectively</li> <li>- Ongoing DER maintenance</li> <li>- Financing costs associated with initial capital outlay will persist for many years</li> </ul>	<ul style="list-style-type: none"> <li>- Low-risk returns resulting from long-term purchase contracts make the DERs an attractive investment</li> <li>- However, the cost of the controls and subsidizing the distributed infrastructure will bring the project into the negative</li> </ul>

**Table 15. Benefits, Costs, and Value Proposition to O&R Utilities**

Describes the benefits, costs, and value proposition to O&R.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>Orange &amp; Rockland Utilities</b>	<ul style="list-style-type: none"> <li>- The utility will continue to sell electricity to customers</li> <li>- The utility will avoid loss of revenues in emergency outage situations</li> <li>- Local generation reduces the amount of power that must be imported from the larger grid; this may defer future transmission &amp; distribution investments</li> <li>- The utility will realize cost savings on decreased line congestion</li> </ul>	<ul style="list-style-type: none"> <li>- The utility will be responsible for electricity purchases from the natural gas units and PV arrays</li> <li>- Costs would be recouped through sales to existing O&amp;R customers</li> <li>- SPV will partially support distributed infrastructure costs</li> </ul>	<ul style="list-style-type: none"> <li>- The utility can serve as a market connector without the costs associated with constructing and operating distributed energy resource assets</li> <li>- The utility will enjoy improved grid resilience by integrating local generation assets with local distribution networks</li> <li>- O&amp;R will have a new supply of electricity that is valued at their average supply charge, but they will have a slightly reduced T&amp;D cost in the area</li> </ul>

**Table 16. Benefits, Costs, and Value Proposition to the Village of Florida**

Describes the benefits, costs, and value proposition to Florida.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>Village of Florida</b>	<ul style="list-style-type: none"> <li>- The microgrid will provide resilient and redundant energy supplies to critical services</li> <li>- Meet NY state energy goals by encouraging DER construction and improving energy resilience</li> <li>- Connection of numerous local municipal and commercial facilities</li> <li>- Further integration as a smart community</li> <li>- Reduced requirement for diesel backup</li> </ul>	<ul style="list-style-type: none"> <li>- The Village will not bear the microgrid costs</li> </ul>	<ul style="list-style-type: none"> <li>- Critical services will remain energized during outages</li> <li>- The microgrid project will serve as a catalyst for customers becoming more engaged in energy service opportunities and will inspire residential investment in DERs, such as solar PV and battery storage, as citizens see benefits associated with avoiding peak demand hours, producing enough electricity to be independent from the larger grid, and selling electricity in a local market</li> <li>- Generating electricity with solar PV arrays and a natural gas-fired recip. system will offset the need for emergency diesel backup</li> </ul>

**Table 17. Benefits, Costs, and Value Proposition to Connected Facilities**

Describes the benefits, costs, and value proposition to connected facilities.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>Connected Facilities</b>	<ul style="list-style-type: none"> <li>- Resilient and redundant energy supply to operations</li> <li>- Access to a local market for distributed energy generation makes investments in small DERs more attractive to connected facilities</li> </ul>	<ul style="list-style-type: none"> <li>- Potential for slightly higher electricity prices during island mode, however this cost is not currently contemplated as the amount of time expected in island mode is minimal and the contracting mechanisms to create this cost are unclear</li> </ul>	<ul style="list-style-type: none"> <li>- Maintain operations during emergency outages and provide valuable critical services to Florida</li> <li>- Potential for partnerships and a local market for excess generation will encourage industrial stakeholders to build large-scale generation assets</li> <li>- Local market for excess energy makes investments in small DERs (such as solar panels) profitable for connected facilities</li> </ul>

**Table 18. Benefits, Costs, and Value Proposition to the Larger Community**

Table describes the benefits, costs, and value proposition to the larger community.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>Community at Large</b>	<ul style="list-style-type: none"> <li>- Access to a wide range of critical services during grid outages</li> </ul>	<ul style="list-style-type: none"> <li>- Because the larger community will not be connected to the microgrid, this stakeholder group will not bear any significant costs</li> </ul>	<ul style="list-style-type: none"> <li>- Potential for reconnect in outages if generation assets are out-producing the demanded critical loads and the footprint of the microgrid is expanded</li> <li>- Future expansion of the microgrid could bring more facilities into the design—however, Florida will likely need to install AMI meters in facilities or O&amp;R would need to allow expanded footprint on their lines</li> </ul>

**Table 19. Benefits, Costs, and Value Proposition to New York State**

Table describes the benefits, costs, and value proposition to New York State.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>New York State</b>	<ul style="list-style-type: none"> <li>- DERs will offset high-emission diesel assets during peak and emergency demand events</li> <li>- Indirect benefits (such as outages averted) will demonstrate the benefits of microgrids paired with DER assets to citizens across the state and reduce load on the larger grid</li> <li>- Each microgrid accelerates NY State's transition from old macrogrid technology to newer, smarter, smaller technologies</li> </ul>	<ul style="list-style-type: none"> <li>- Depending on financing plans, growth of microgrid popularity, and increased use of natural gas-fired generators, the state may need to develop additional plans for expanding natural gas infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>- Successful construction and operation of a community microgrid will demonstrate the tangible value of microgrid projects</li> <li>- Indirect benefits associated with microgrids will encourage and inspire citizens to strive for DERs in their own communities</li> <li>- SPV model aligns with REV goals—this project provides an example of investor-owned generation assets selling electricity over a utility-owned power distribution platform</li> </ul>

### 3.2.3 Demonstration of State Policy

The proposed microgrid represents a major step towards achieving New York State energy goals; it will provide a local platform for excess energy generation throughout the year, help the community adapt to climate change, and expand renewable energy in the Village. The proposed microgrid supports the New York State Energy Plan by providing a power distribution platform for locally-owned DERs. The ownership model has the potential to be extremely successful by leveraging private capital as well as local utility expertise, and it is replicable. The proposed organizational construct provides an approach that has not yet been implemented on a large scale in NY State with private finance having full ownership of the generation assets while the local utility retained full operational control. While there are potential barriers to such an arrangement, the Project Team believes that this somewhat novel approach to the microgrid incentivizes both

investors and the utility sufficiently to gain buy-in. Further, when the utility desires to be engaged in the ownership and operation of the microgrid from the outset, it creates strong momentum for success. Table 13, above in Section 3.2.1, outlines the strengths and weaknesses of this proposed model and the opportunities that it may present. This project could therefore serve as a valuable example of innovative, profitable cooperation between IOUs, municipalities, and private investors.

By coordinating the microgrid as a local distributed system platform (DSP), the Florida microgrid will act as a distributed resource and will provide local grid stabilization through injections and withdrawals of power. As more distributed resources are added throughout the Village, the microgrid can be tuned to provide continual support for these assets (e.g., by providing ancillary services) and will diversify and enhance its portfolio of revenue streams.

### **3.3 Commercial Viability – Project Team (Sub Task 3.3)**

The Project Team includes O&R, the Florida government, Booz Allen Hamilton, Siemens AG, and Power Analytics. It may expand to include financiers and legal advisors as the project develops. Details on the Project Team can be found in this section.

#### **3.3.1 Stakeholder Engagement**

The Project Team has been engaged and in communication with local stakeholders from the outset. Booz Allen and its partners in the Village have also communicated with each of the proposed facilities to gauge electric and thermal demand and discuss other aspects of the project development. Several prospective facilities were unwilling to share electric and thermal load information, making it difficult to accurately gauge all potential loads. Further, data collection from public facilities was time-intensive and did not always yield the sought after information.

#### **3.3.2 Project Team**

The Florida microgrid project is a collaboration between the public sector, led by the Village of Florida, and the private sector, led by O&R and Booz Allen Hamilton with significant support from Power Analytics and Siemens. Each of the private sector partners is well qualified in the energy and project management space, and Florida has strong interest in improving its energy reliability and expanding its clean energy generation capacity. Tables 20 and 21 below provide information about the Project Team.

**Table 20. Project Team**

Table provides background on Booz Allen Hamilton, Siemens AG, Power Analytics, and O&R.

<b>Booz Allen Hamilton</b>	<b>Headquarters: McLean, VA</b>	<b>Annual Revenue: \$5.5 B</b>	<b>Employees: 22,700</b>
<b>History and Product Portfolio:</b> Booz Allen was founded in 1914. In the ten decades since its founding, Booz Allen has assisted a broad spectrum of government, industry, and not-for-profit clients including the American Red Cross, all branches of the Department of Defense, the Chrysler Corporation, NASA, and the Internal Revenue Service. Booz Allen’s energy business includes helping clients analyze and understand their energy use and develop energy strategies, recommending technology solutions to achieve their energy goals, and executing both self- and 3 <sup>rd</sup> party funded projects including energy efficiency, renewable energy, and smart grids.			
<b>Siemens AG</b>	<b>Headquarters: Munich, Germany; U.S. Headquarters: Washington, DC</b>	<b>Annual Revenue: €71.9 B</b>	<b>Employees: 343,000</b>
<b>History and Product Portfolio:</b> Siemens AG was founded in 1847 and is now one of the world’s largest technology companies. Siemens AG specializes in electronics and electrical engineering, operating in the industry, energy, healthcare, infrastructure, and cities sectors. Siemens AG develops and manufactures products, designs and installs complex systems and projects, and tailors a wide range of solutions for individual requirements. The Siemens Microgrid Team develops comprehensive solutions leveraging the strength of Siemens’ portfolio – from generation sources such as gas, wind, and solar, to transmission & distribution products, to control software solutions and services.			
<b>Power Analytics</b>	<b>Headquarters: San Diego, CA</b>	<b>Annual Revenue: \$10-15M</b>	<b>Employees: 50</b>
<b>History and Product Portfolio:</b> Founded 25 years ago, Power Analytics is a privately-held small business that develops and supports electrical power system design, simulation, and analytics software. The Company’s worldwide operations include sales, distribution, and support offices located throughout North America, South America, Europe, Asia, and Africa and Australia.			
<b>Orange &amp; Rockland Utilities</b>	<b>Headquarters: Pearl River, NY</b>	<b>Annual Revenue: \$13 B (Con Ed<sup>14</sup>)</b>	<b>Employees: 1,100</b>
<b>History and Product Portfolio:</b> Orange and Rockland Utilities, Inc., a wholly owned subsidiary of Consolidated Edison, Inc., is an electric and gas utility headquartered in Pearl River, NY. O&R and its two utility subsidiaries, Rockland Electric Company and Pike County Light & Power Co., serve a population of approximately 750,000 in seven counties in New York, northern New Jersey and northeastern Pennsylvania.			

<sup>14</sup> Con Ed is the corporate parent of O&R, which does not separately report revenue.

**Table 21. Project Team Roles and Responsibilities**

Roles, responsibilities, and expectations for each member of the Project Team during development, construction, and operation of the microgrid.

Team Member	Roles and Responsibilities		
	Project Development	Construction	Operation
Orange & Rockland Utilities	O&R will work with the Project Team to develop the concept and provide input. They may further provide the financial support for the purchase of microgrid control systems and infrastructure.	O&R may provide a share of the initial capital outlay that corresponds to the microgrid control infrastructure.	O&R may provide the necessary domain expertise to operate and maintain the microgrid and DERs. This includes responsibility for switching to island mode and regulating voltage and frequency across the microgrid's loads in both grid-connected and island mode.
Village of Florida	The Village will serve as the main conduit to representatives of the critical and important facilities and other interests in the Village.	As the liaison, the Village will coordinate with all local and state parties as needed.	As the liaison, the Village will coordinate with all local, regional, and state parties as required.
Booz Allen	BAH is responsible for the delivery of the Feasibility Study and its component parts. This includes serving as the central clearinghouse of data, design, and proposal development as well as the key POC for NYSERDA on this task.	BAH will serve in an advisory and organizational role, working in a similar prime contractor capacity to provide overall design, costing, and construction management services.	BAH would serve in an outside, advisory capacity upon completion of the microgrid and during its operation.
Siemens	Siemens is the engineering and technology partner of this project. They will develop the technical design and system configuration in concert with BAH engineers and the Power Analytics team.	Siemens will have primary responsibility for the shovel-in-the-ground construction and installation of hardware and generation assets.	Ensuring proper functioning and maintenance of the microgrid technology components throughout.
Power Analytics	Power Analytics is the partner for energy software solutions. The PA team, in conjunction with Siemens and Booz Allen, is responsible for the design of the SCADA and system software components and controls.	Power Analytics will lead the installation of control and energy management software following hardware installation and in concert with Siemens.	Provide IT systems support; may play an active role in system management through the EnergyNet software platform.



Team Member	Roles and Responsibilities		
	Project Development	Construction	Operation
Suppliers	There are no suppliers required during this development phase, however project partners and suppliers Siemens and Power Analytics are closely involved in feasibility and design portions of the project. BAH is in touch with several additional suppliers of hardware and software including Duke Energy, O&R Solutions, Enel Green Power, Anbaric Transmission, Bloom, and Energize.	Siemens or another engineering and technology firm will be the hardware supplier, including switches and other physical controls. Power Analytics or another software company will be the EMS and SCADA provider, responsible for software and server components.	The installer of the hardware and software will continue to provide maintenance and advisory services as require to ensure proper and efficient functioning of their components. The software provider will work in cooperation with O&R to assess the best approach to daily operations of the software system.
Financiers/Investors	The SPV will be created during the project development phase. Investors for DERs. Investors may include any of the entities mentioned in the row above.	Debt and equity investors will supply the cash required to complete the construction and installation of generation assets and microgrid controls.	Generation asset owners will realize revenues from the sale of electricity and thermal resources. O&R will realize revenues from payments from DER owners.
Legal/Regulatory Advisors	Regulatory advice is housed within Booz Allen. Further counsel will be retained as necessary to create the SPV and arrange financing.	Legal and regulatory will be a combination of Booz Allen, the Town, Orange & Rockland, and any outside counsel required.	Legal and regulatory will be the responsibility of the Town, the utility, and any investors in the SPV.

### 3.3.3 Financial Strength

The principal shareholders in the microgrid project are the DER owners (private investors) and O&R. Private investors that do not publish financial statements are not discussed in this section.

O&R is wholly owned by Con Edison, and thus does not provide separate financial statements and is financially supported by Con Edison. Moody's Investor Service rates Consolidated Edison, Inc., at an A3 credit rating. According to the Moody's rating scale, "Obligations rated [A] are judged to be upper-medium grade and are subject to low credit risk". This rating reflects the supportiveness of the US regulatory environment. Although Con Ed's credit ratings fell in 2009, Con Ed's regulatory environment has since become more benign. There are few serious competitors in Con Ed's space (metropolitan New York), and Con Ed has invested in several innovative initiatives that should improve reliability of service and relationships with customers.

### 3.4 Commercial Viability – Creating and Delivering Value (Sub Task 3.4)

The specific technologies included in the microgrid design will enable rapid and efficient transitions between grid-connected and island mode based on signals from a SCADA control center. The proven efficacy of proposed microgrid components enhances the replicability and scalability of the design. This section will discuss the technical components of the microgrid and why they were chosen.

#### 3.4.1 Microgrid Technologies

The specific technologies included in the microgrid design were chosen to meet the goals of providing reliable and efficient power in both grid-connected and island mode, achieving automatic load following, and developing black-start capability.

Solar PV array and the natural gas unit were chosen as generator technologies to reduce GHG emissions and enhance the reliability of the power supply. The natural gas unit will be capable of automatic load following (responding to load fluctuations within cycles, allowing the microgrid to maintain system voltage and frequency), black starts, and adjusting generation output. The solar PV system will provide a renewable component to the microgrid generation mix and represents a more appropriate addition than expanded natural gas generation. It will provide emission-free electricity during daylight hours, however, PV generation will face the same problems in Florida that it does elsewhere in the northeast United States: variable weather conditions and long periods of darkness in the winter. This reduces its effective capacity to an average of 14% of rated capacity, as opposed to 85% for the natural gas units.

The Florida microgrid includes numerous components that have been previously used and validated. Solar PV and natural gas are both widely used technologies, with more than 6 gigawatts (GW) of solar PV installed in 2015 in the United States. Nationwide there are hundreds of GW of installed natural gas generating capacity and it is the single largest source of generation in the country. The switch components are all industry standard and are widely used in utilities worldwide, and the Intelligent Electronic Devices, which are robust and safe via embedded electrical protections, are similarly standard across the industry. Siemens microgrid technologies are recognized worldwide for their flexibility, reliability, and expandability—successful examples of Siemens microgrid technology at work include the Parker Ranch and Savona University microgrids.<sup>15</sup> Team partner Power Analytics has similarly successful implementations of its Paladin software in microgrid environments, including the 42 MW, 45,000 person UC San Diego microgrid project.<sup>16</sup>

#### 3.4.2 Operation

SPV investors will contribute funds to O&R's operation and maintenance of the DERs. As the project's subject matter expert, owner of the distribution infrastructure, and operator of the DERs and microgrid, O&R will provide decision making regarding the logistics of day-to-day

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<sup>15</sup> Siemens case studies; available from <http://w3.usa.siemens.com/smartgrid/us/en/microgrid/pages/microgrids.aspx>.

<sup>16</sup> <http://www.poweranalytics.com/company/pdf/M-12-GE-PPT-X-001-03%202012%20UCSD%20Virtual%20summit.pdf>.

operation. Regular maintenance and checks of equipment will be conducted based on manufacturer or installer recommendations and will ensure the proper function of all grid elements. The microgrid is a classic shared value entity; the utility, Village, and investors will benefit, and the continued success of the grid requires support and collaboration from all three.

O&R will have final authority on decisions regarding the microgrid that are not automatic elevations to the state or NYPSC. Decisions regarding the proper level of generation from local assets, load following, and other similar issues will be addressed automatically in real-time by the logic controllers and the MCS. The decision algorithms will be programmed upon installation with input from the utility and with the ability to alter or revise them if operations dictate that to be the appropriate action. Interactions with the O&R power grid will be automatically governed by the microgrid controllers.

This analysis assumes O&R will purchase electricity from the SPV and distribute it across its grid. The facilities will continue to be billed for electricity via the regular O&R billing mechanism and cycle. O&R's revenue should be sufficient to cover the supply cost of electricity (from the DERs) as well as O&R-imposed delivery and capacity charges. Additional fees may be imposed upon microgrid participants as a percentage of their electricity cost. However, given the limited amount of time forecasted in island operation and the commensurately limited time that the customers will need to rely on the microgrid, the fee will be marginal or simply inapplicable.

#### 3.4.3 Barriers to Completion

The primary barriers to completion of the Florida microgrid proposal are financial and in the coordination of operations. The microgrid will require somewhat significant capital costs for the generation assets and the control infrastructure. The Village is not in a position to provide any significant support, and the utility prefers to limit its equity reach to distribution assets. Private investors, therefore, will be solicited to support the project's generation assets. However, the consistently negative operating cash flows will make it difficult to attract private investment. Additionally, coordination between the SPV and O&R is an absolute requirement to the smooth and successful operation of the project. The utility may operate all of the assets and infrastructure and agreements will be required to formalize the operating parameters, generator down-time, and other decisions that impact operations and revenue streams. The issue of negative operating cash flows may be insurmountable without annual subsidies to close the gap between revenues and operating costs.

#### 3.4.4 Permitting

The Florida microgrid will require permits and permissions depending on the ultimate design choices, including Village, the Town of Warwick (in which the Village of Florida sits), and County approval for generator installations. Distributed energy resource assets may require zoning variances or approvals as accessory uses on municipal property (see section 3.6.2 for more details). Florida is not in any EPA criteria pollutant nonattainment zones; however, the natural gas unit will require air quality permits pursuant to the Clean Air Act.

### 3.5 Financial Viability (Sub Task 3.5)

The distributed energy resource assets included in the microgrid design will produce revenue streams from electricity sales to O&R. These assets will require significant initial capital outlay as well as annual operation and maintenance costs. The microgrid project qualifies for federal solar tax credits through the ITC program. Private investors will use a mix of debt and equity to finance their shares. This section will discuss the revenues, costs, and financing options associated with the microgrid project in more detail.

#### 3.5.1 Revenue, Cost, and Profitability

The microgrid has a number of savings and revenue streams, as outlined in Table 22. The revenues will sum to approximately \$110,000 per year, which will not exceed the yearly generation costs (estimated to be around \$150,000 per year). See Table 22 for the total savings and revenues and Table 23 for the total capital and operating costs.

**Table 22. Savings and Revenues**

Expected revenues and savings directly associated with operation of the microgrid and its DERs.

Description of Savings and Revenues	Savings or Revenue	Relative Magnitude	Fixed or variable
Electricity sales from 175 kW reciprocating engine <sup>17</sup>	Revenue	~\$110,000/yr	Variable
Electricity sales from 20 kW solar PV <sup>18</sup>	Revenue	~\$2,000/yr	Variable
<b>Total Revenue</b>		<b>\$110,000/yr</b>	Variable

<sup>17</sup> Based on O&R supply charge in the area of \$0.085/kWh and an 85% capacity factor.

<sup>18</sup> Based on O&R supply charge and a 14% capacity factor.

**Table 23. Capital and Operating Costs**

Expected costs from construction and operation of the microgrid.

Description of Costs <sup>19</sup>	CapEx or OpEx	Relative Magnitude	Fixed or Variable
175 kW Natural Gas reciprocating engine	Capital	~\$230,000	Fixed
20 kW Solar PV array	Capital	~\$50,000	Fixed
Microgrid Control Systems	Capital	~\$450,000	Fixed
Distributed Equipment	Capital	~\$75,000	Fixed
IT Equipment (Wireless stations and cabling)	Capital	~\$45,000	Fixed
New Distribution Lines	Capital	\$12,000	Fixed
<b>Total CapEx</b>		<b>\$860,000</b>	Fixed
Design considerations and simulation analysis	Planning and Design	\$250,000	Fixed
Project valuation and investment planning	Planning and Design	\$50,000	Fixed
Assessment of regulatory, legal, and financial viability	Planning and Design	\$25,000	Fixed
Development of contractual relationships	Planning and Design	\$25,000	Fixed
<b>Total Planning and Design</b>		<b>\$350,000</b>	Fixed
175 kW Natural Gas fuel <sup>20</sup>	Operating	~\$60,000/yr	Variable
175 kW Natural Gas O&M	Operating	~\$20,000	Fixed
20 kW Solar PV Maintenance	Operating	~\$500/yr	Fixed
Microgrid Components O&M	Operating	~\$70,000	Fixed
<b>Total OpEx</b>		<b>\$150,000/yr</b>	Variable

The proposed microgrid will qualify for a single incentive program, the Federal ITC. The program may recover around 30% of the total PV capital cost, though this may decrease over time as the ITC steps down. Other possible sources of incentive revenue include NYSERDA Phase III NY Prize funding (up to \$5 million, but will not exceed 50% of capital costs). See Table 24 for a list of available incentive programs.

Given the location of the proposed microgrid on the O&R feeder structure, the microgrid will not be able to island for economic purposes. Therefore, DR payments are not available to the microgrid. There is also no potential for the microgrid to island when the location-based marginal price (LBMP) rises above the cost of DERs production.

<sup>19</sup> Capital and maintenance costs are from Siemens based on industry standard costs.

<sup>20</sup> Based on natural gas cost of \$5.08/Mcf (\$47 per MWh generated) for 85% of total available hours.

**Table 24. Available Incentive Programs**

State incentive programs that were included in the commercial/financial feasibility analysis and whether the incentive is required or preferred for the microgrid project to be feasible.

Incentive Program	Value	Required or Preferred
NYSERDA NY Prize Phase II	~\$350,000	Required
NYSERDA NY Prize Phase III	~\$500,000	Required
Federal Solar ITC	~\$15,000	Preferred

### 3.5.2 Financing Structure

The development phase is characterized by the negotiation and execution of the construction financing and debt structure and agreements with any equity partners. Awards from Phase II of the NY Prize Community Microgrid Competition will supply most of the funding for project design and development, with the SPV and O&R providing capital for any costs that exceed available NYSERDA funding. We anticipate NYSERDA to supply 75% of the required funds for Phase II with the balance coming from a cost-share. This is based on our understanding of the Phase II cost structure as described in NYSERDA RFP-3044. Florida and their Project Team will provide needed in-kind services consisting primarily of system expertise and support.

Development will conclude with formal contract relationships between the utility and the customers of the microgrid, available and relevant rate and tariff information from the NYPSC, and firm financing for the construction of the project.

The SPV and O&R will leverage Phase III funding from NYSERDA to complete the construction phase. Phase III NY Prize funding, which will provide up to \$5 million to the SPV for microgrid and DER equipment and installation, will cover half of the capital cost of the project (estimated to be approximately \$860,000 in total), and private and utility funding will represent the balance of the financing.

We assume the Village will grant the physical space to site the DERs at no cost because it is the primary beneficiary of the proposed microgrid. The SPV will maintain ownership over all generation assets and controls and O&R over the distributed infrastructure.

## 3.6 Legal Viability (Sub Task 3.6)

Like any infrastructure project that involves the development of public and private land, the Florida microgrid project will require legal and regulatory agreements for ownership, access, zoning, permitting, and regulation/oversight. This section considers the various legal aspects of the microgrid project and discusses the likelihood of each becoming an obstacle to the project's success.

### 3.6.1 Regulatory Considerations

#### *State and Utility Regulation*

The new DERs will be regulated under relevant the State code; however, the process for constructing small distributed energy resources in New York is well established. The microgrid will comply with all rules governing the interconnection of generation assets to the grid, and, given O&R's close participation in the project, the Project Team does not envision any onerous requirements.

#### *Local Regulation*

Section 67-15 of the Florida Municipal Code describes the requirements for new utility connections, generally that new connections to existing infrastructure happen below grade and that "a preconstruction meeting of utility company representatives, the applicant, and the Planning Board is required." This implies an approval role for the Planning Board, however given the Project's ongoing collaboration with the community, and the inclusion of several critical Village facilities, this is not expected to be an onerous process. NY Town Law empowers municipalities to adjudicate concerns related to franchising and the extension of utility infrastructure across public rights of way. The Village of Florida lies within the Town of Warwick and each municipality holds jurisdiction over elements of the permitting and approval process.

#### *Air Quality*

Natural gas generators may be subject to a variety of federal permits and emission standards depending on the type of engine, the heat or electrical output of the system, the amount of electricity delivered to the grid versus used on-site, and the date of construction. The specific details associated with the proposed natural gas units in Florida will determine the applicability of the regulations below. CAA regulations applicable to Reciprocating Internal Combustion Engine systems will apply. These regulations include:

- National Emission Standards for Hazardous Air Pollutants (NESHAP) for Stationary Reciprocating Internal Combustion Engines (RICE): 40 CFR part 63 subpart ZZZZ
- New Source Performance Standards (NSPS) for Stationary Compression Ignition (CI) Internal Combustion Engines (ICE): 40 CFR part 60 subpart IIII
- NSPS for Stationary Spark Ignition (SI) ICE: 40 CFR part 60 subpart JJJJ

Per EPA guidance, these regulations apply to all engine sizes, regardless of the end use of the power generated. However, further review and analysis must be conducted when details of the type and size of the generation system are confirmed. There may be positive dispensation given for the fact that the natural gas units will replace far more emissions-heavy diesel generating assets

New York state has enacted amendments to Environmental Conservation Law Articles 19 (Air Pollution Control) and 70 (Uniform Procedures), and DEC amended regulations 6NYCRR Parts,



per the 1990 Amendments to the Clean Air Act. With this demonstration of authority, DEC received delegation of the Title V operating permit program from the US Environmental Protection Agency (EPA). Title V Permits are required for all facilities with air emissions greater than major stationary source thresholds. New York's air pollution control permitting program combines the federal air operating permitting program with long-standing features of the state program. The primary rules for applications are found in 6NYCRR:

- [200](#) (General Provisions)
- [201](#) (Permits and Certificates)
- [621](#) (Uniform Procedures)
- [231](#) (New Source Review in Non-attainment Areas and Ozone Transport Regions)

Final application of these rules will depend on the size and technology of the selected natural gas unit.

### **3.7 Project Commercial and Financial Viability Conclusions**

The project will follow a hybrid ownership model wherein a Special Purpose Vehicle (SPV) owns both DERs and the microgrid controls, and the utility, O&R, may own the new and upgraded distributed infrastructure. The Project Team recommends O&R assume operational responsibility for the DERs in order to successfully integrate the new generation into the existing O&R distribution system and maintain electrical fidelity on the grid. Given the high operating costs and the moderate revenues tied to the relatively small generating assets, the microgrid will generate negative operating cash flows and may, therefore, be an unviable project even with NY Prize.

In addition to revenues from electricity sales, the microgrid will provide indirect financial and non-financial benefits to Florida citizens, SPV shareholders, O&R, and the larger Orange County community. Improved energy resilience enhances the local population's safety and quality of life during emergency outages, and local energy generation reduces the strain on the larger energy transmission and distribution infrastructure. Future expansion of the microgrid could maintain electric service to more facilities in Florida, providing citizens with access to pharmacies, gas, and groceries in outage situations.

Permitting and regulatory challenges should be reasonably straightforward. The primary regulatory hurdles will be obtaining permits for the natural gas systems under the Clean Air Act and obtaining zoning permission for the siting of the generation. Both proposed assets will be sited on municipal property and this is not expected to be an onerous process.

The estimates and value propositions in this document are predicated on several assumptions. First, private investors will own the DERs, and O&R may own the control and distribution infrastructure. O&R has indicated to the Project Team a preference to own and operate the distribution assets related to the microgrid and private investors have indicated initial interest in the project. Second, the natural gas-fired reciprocating generator and the solar array will sell

electricity to O&R at the average local supply charge, the price O&R currently pays to purchase electricity, excluding transmission, distribution, and capacity charges. O&R, as the local expert in energy distribution and the current owner and operator of the Village's distribution infrastructure, may operate the microgrid. O&R's existing infrastructure is used extensively in the preliminary microgrid design, so operational participation from the utility is vital to the project's success. Lastly, the current regulatory, legal, and policy environment will stay consistent as this proposal falls within the existing frameworks.

## 4. Cost Benefit Analysis

Section 4 Cost Benefit Analysis is made up of seven sections in addition to the introduction:

- **Section 4.1** analyzes the *facilities connected to the microgrid* and their energy needs.
- **Section 4.2** discusses the *attributes of existing and proposed DERs*, including factors such as nameplate capacity and expected annual energy production.
- **Section 4.3** analyzes *potential ancillary services sales and the value of deferring transmission capacity investments*.
- **Section 4.4** reviews the *overall costs* associated with construction and installation of the microgrid as well as the fuel, operation, and maintenance costs required over the lifetime of the microgrid.
- **Sections 4.5 and 4.6** discuss the *community benefits* of maintaining power during a grid-wide outage and outline the costs associated with operating the microgrid in island mode.
- **Section 4.7** presents the Industrial Economics (IEC) *benefit-cost analysis report and associated Project Team commentary*.

### 4.1 Facility and Customer Description (Sub Task 4.1)

The Florida microgrid will include seven facilities from various rate classes and economic sectors. There are three primary rate classes based on type of facility and annual electricity consumption: residential, small commercial (less than 50 megawatt hours (MWh) per year), and large commercial (greater than 50 MWh per year).

The Florida microgrid will include seven facilities from various rate classes and economic sectors. Two of the proposed microgrid facilities belong to the large commercial rate class requiring approximately 346.3 MWh of electricity per year. Three of the proposed microgrid facilities belong to the small commercial rate class requiring approximately 51.07 MWh of electricity per year. Two of the proposed microgrid facilities belong to the residential rate class requiring approximately 29.05 MWh of electricity per year. Additionally the average aggregate demand in 2014 was 0.048 MW and rose as high as 0.171 MW.

There are three kinds of facilities in the microgrid: public, residential and commercial. The public facilities represent the largest electricity loads with the Florida village clerk office, police department, fire department, and public library comprising 66.2% of the microgrid's total annual electricity usage, respectively. The residential facilities are Seward Senior Center and the Load

Cluster 1 which consumes approximately 8.4% of the microgrid's total annual usage. The commercial facility is the Load Cluster 2 that consumes approximately 25.4% of the microgrid's total annual usage.

The combination of existing and proposed generation assets included in the microgrid design will be capable of meeting 100% of average aggregate facility energy usage during a major power outage, but may approach their generation limits if several large facilities simultaneously reach peak energy use. Some of the facilities do not operate 24 hours a day, such as the Florida village clerk's office and the Load Cluster 2, and will only operate 12 hours per day during grid-connected mode. However some critical facilities that normally operate less than 24 hours per day may need to operate continuously in emergency island-mode situations. For information on each facility's average daily operation during a major power outage, see Table 25.

**Table 25. Facility and Customer Detail Benefit<sup>21</sup>**

Table provides details about each facility and customer served by the microgrid, including average annual electricity usage, 2014 peak electricity demand, and hours of electricity required during a major power outage.

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<sup>21</sup> Load data was provided to Booz Allen by O&R.

## 4.2 Characterization of Distributed Energy Resource (Sub Task 4.2)

The microgrid design incorporates distributed energy resources, including one proposed natural gas unit, and one proposed solar PV array. The proposed natural gas unit and combined solar PV array will produce an average of 0.1515 MW of electricity throughout the year.<sup>22</sup>

As shown in Distributed Energy Resource Peak Load Support Table 26, the natural gas generator has a nameplate capacity of 0.175 MW and will operate nearly continuously. Assuming a capacity factor of 85%, the natural gas unit will produce approximately 1,303 MWh of electricity over the course of the year. If a major power outage occurs, the natural gas unit will produce an average of 3.57 MWh of electricity per day, which would provide more than 100% of the microgrid's average daily demand. Assuming a heat rate of 9.5 one million British Thermal Units (MMBTU) per MWh,<sup>23</sup> the natural gas unit will incur a fuel cost of approximately \$47/MWh.<sup>24</sup>

Limited by weather conditions, natural day-night cycles, and assuming a capacity factor of 14% the 0.02 MW solar PV array is expected to produce a combined 24.53 MWh per year. Because many outages are caused by severe weather events, solar panels cannot be relied upon to provide energy during emergency outages without supplementary battery storage. However, on average, the solar array will produce a combined 0.067 MWh of electricity per day, which represents 5.8% of average daily electricity demand. Maintenance costs for the solar array will be around \$400 per year,<sup>25</sup> which means the marginal cost of producing solar electricity will be about \$34/MWh.<sup>26</sup>

See Table 26 for a detailed list of all proposed and existing distributed energy resources in Florida.

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<sup>22</sup> NG generator capacity factor: 85% (EPA estimate for 10 MW generator, <http://www3.epa.gov/chp/documents/faq.pdf>), Solar array capacity factor: 14% (NREL PV Watts Calculator).

<sup>23</sup> 2013 EIA average for natural gas fired Gas Turbine ([http://www.eia.gov/electricity/annual/html/epa\\_08\\_02.html](http://www.eia.gov/electricity/annual/html/epa_08_02.html)).

<sup>24</sup> Price of natural gas: \$5.08 per Mcf (average CHGE supply price from 2013-2015).

<sup>25</sup> Annual fixed O&M cost: \$20/kW per year (NREL, [http://www.nrel.gov/analysis/tech\\_lcoe\\_re\\_cost\\_est.html](http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html)).

<sup>26</sup> Capital cost: \$2,400/kw (Siemens estimate),

Variable cost: 30 years of production at a cost of \$20/kW per year (Siemens lifecycle estimate, NREL),

Discount rate: 7% (industry standard discount rate; NREL <http://www.nrel.gov/docs/fy13osti/58315.pdf>).

**Table 26. Distributed Energy Resources**

Table lists DERs incorporated in the microgrid, including their energy/fuel source, nameplate capacity, estimated average annual production under normal operating conditions, average daily production in the event of a major power outage, and fuel consumption per MWh generated (for fuel-based DERs).

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Expected Daily Production During Major Power Outage (MWh)	Potential Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
							System fuel	Units of MMBTUs
DER1 - Natural Gas Unit	Near the Seward Senior Center	Natural Gas	0.175	1,303.05	3.57	4.2	9.26 Mcf	9.5 MMBTUs
DER2 - Solar PV Array	Near the Seward Senior Center	Sunlight	0.02	24.53	0.067	0.16 <sup>27</sup>	N/A	N/A

<sup>27</sup> Assumes 10 hours of production (daylight) at 80% of capacity.

### 4.3 Capacity Impacts and Ancillary Services (Sub Task 4.3)

#### 4.3.1 Peak Load Support

The microgrid's proposed generation assets will operate nearly continuously throughout the year, providing a constant level of load support to the greater grid. Although continuous operation will limit the natural gas unit's ramp-up capability during peak demand events, it will also maximize revenue for owner of the microgrid. See Table 27 for the maximum generation capacities of the proposed and existing DERs.

The proposed solar array will be at its most productive on days with peak solar irradiance when peak demand events are common, thus providing peak load support when it is most needed. They will provide around 0.0028 MW (including capacity factors) of load support on average over the course of a year. However, their generation depends on weather conditions and time of day, therefore solar array is not a reliable source of peak load support.

**Table 27. Distributed Energy Resource Peak Load Support**

Table shows the available capacity and impact of the expected provision of peak load support from each DER.

Distributed Energy Resource Name	Facility Name	Available Capacity (MW)	Does distributed energy resource currently provide peak load support?
DER1 - Natural Gas Unit	Near the Seward Senior Center	Maximum of 0.175	No
DER2 - Solar PV Array	Near the Seward Senior Center	Maximum of 0.02	No

#### 4.3.2 Demand Response

DR programs require facilities to curtail load or expand generation using generators or battery storage in response to forecasted or real-time peak demand events on the larger grid. See Section 2.2.22 for additional detail on the inability of Florida to participate in DR programs.

#### 4.3.3 Deferral of Transmission/Distribution Requirements

The 0.1515 MW of average local generation produced by the DERs will slightly reduce the amount of electricity imported from the larger NYISO and O&R power lines. Although these power lines will last up to one hundred years if well maintained,<sup>28</sup> they can only transmit a limited amount of power. As demand for electricity in Florida increases, the lines may need to be supplemented to handle additional load.

The microgrid will include the installation of new distribution lines, in lieu of using the existing distribution line in Florida. Therefore any electricity generated by the microgrid DERs will represent a reduction in the capacity of the existing distribution lines.

<sup>28</sup> Professor John Kassakian, MIT: <http://engineering.mit.edu/ask/how-do-electricity-transmission-lines-withstand-lifetime-exposure-elements>.



#### 4.3.4 Ancillary Service

None of the existing and proposed generation resources in Florida will participate in ancillary services markets. Although the natural gas generator can change output quickly enough to qualify for some paid NYISO ancillary service programs, it will not have sufficient capacity to participate. Most paid NYISO ancillary service programs require at least 1 MW of output regulation, which represents more than the natural gas unit's maximum output. If the natural gas generator runs at projected levels, it will never have the minimum regulation capacity available.

Although the natural gas unit will not participate in paid NYISO ancillary service programs, it will provide many of the same ancillary services to the local Florida grid. For example, the natural gas generator will provide frequency regulation as a by-product of its operation. The Florida microgrid connected facilities will receive the benefits from provided ancillary services, but these will not be paid services and will not generate any new revenue streams—no goods are being bought or sold. Instead, provision of ancillary services will represent a direct value to microgrid connected facilities.

#### 4.3.5 Development of a Combined Heat and Power System

Due to lack of thermal off-takers within a technically feasible distance of the generation site, the Project Team decided to use natural gas generators instead of combined head and power units. Therefore there is no proposed CHP unit for the Florida microgrid.

#### 4.3.6 Environmental Regulation for Emission

The microgrid's generation assets will drive a net 233 MTCO<sub>2</sub>e (metric tons CO<sub>2</sub> equivalent) increase in GHG emissions in Florida as compared to the New York State energy asset mix. The proposed generation assets will produce approximately 1,327 MWh of electricity per year. The proposed natural gas unit will emit approximately 715 MTCO<sub>2</sub>e per year,<sup>29</sup> while the solar array emit none. The current New York State energy asset mix would emit approximately 481 MTCO<sub>2</sub>e to produce the same amount of electricity.<sup>30</sup> The microgrid's generation assets will therefore result in a net increase in emissions by 233 MTCO<sub>2</sub>e.

The microgrid's generation assets will not need to purchase emissions permits to operate and will not exceed current New York State emissions limits for generators of their size. The New York State overall emissions limit was 64.3 MMTCO<sub>2</sub>e in 2014, and will begin decreasing in the near future. The state sells an "allowance" for each ton of CO<sub>2</sub>e emitted in excess of the limit at allowance auctions, but does not require assets under 25 MW to purchase allowances. The natural gas unit is defined as a "small boiler" by NYS Department of Environmental Conservation (NYS DEC) limits (fuel input of 10-25 MMBTU/hour). The NYS DEC is currently developing output-based emissions limits for distributed energy resource assets. These limits on SO<sub>2</sub>, NO<sub>x</sub>, and particulate matter (to be captured in 6 NYCRR Part 222) should be published in

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<sup>29</sup> Natural Gas Unit Emissions Rate: 0.51 MTCO<sub>2</sub>e/MWh (assuming 117 lb CO<sub>2</sub>e per MMBTU; EIA, <http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11>).

<sup>30</sup> Assuming an asset mix of 15% coal, 31% natural gas, 6% oil, 17% hydro, 29% nuclear, 1 % wind, 1% sustainably managed biomass, and 1% "other fuel". This adds up to around 0.36 MTCO<sub>2</sub>e/MWh. Info from EPA ([http://www3.epa.gov/statelocalclimate/documents/pdf/background\\_paper\\_3-31-2011.pdf](http://www3.epa.gov/statelocalclimate/documents/pdf/background_paper_3-31-2011.pdf)).

late 2015 or early 2016. The main source of emissions regulations for small boilers is currently the EPA 40 CFR part 60, subpart JJJJJ—however, this law does not include gas-fired boilers.

The natural gas generator will require an operating permit in addition to other construction permits. The costs of obtaining this permit will be in line with the cost of a construction permit and not comparable to the price of emissions allowances.

Table 28 catalogs the CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and Particulate Matter (PM) emissions rates for the natural gas unit.

**Table 28. Emission Rates**

Table shows the emission rates for each DER per MWh and per year. Notice the rates vary drastically for each emissions type (CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>).

Distributed Energy Resource Name	Location	Emissions Type	Emissions Per MWh (Metric Tons/MWh)
DER1 - Natural Gas Unit	Near the Seward Senior Center	CO <sub>2</sub>	0.508
		SO <sub>2</sub>	9.09358E-07 <sup>31</sup>
		NO <sub>x</sub>	0.006309834
		PM	1.19237E-07

## 4.4 Project Costs (Sub Task 4.4)

### 4.4.1 Project Capital Cost

The microgrid design requires the following new pieces of distributed equipment:

- A control system to provide one point of control for operating the microgrid and synthesizing real-time electricity data from the connected facilities.
- Intelligent Electronic Devices to interface with the 13.8 kV distribution feeder.
- Automated breakers installed throughout Florida to allow the microgrid to isolate and maintain power to the microgrid connected facilities.
- Grid-paralleling switchgear to synchronize each generator's output to the system's frequency.

The total installed capital cost of the distributed equipment is estimated to be \$585,000, \$12,000 for the IT infrastructure, and \$12,000 for overhead powerline installation.<sup>32</sup> The Project Team estimates the natural gas unit and solar PV array will carry an installed cost of \$227,500 and \$48,000, respectively.<sup>33</sup> This brings the total installed capital cost \$860,000. If the powerlines were to be installed underground, the capital cost would increase to \$1.21 million not including interconnection fees and site surveys. Additionally the estimated capital cost does not account for

<sup>31</sup> "Natural Gas-fired Reciprocating Engines" – EPA, <http://www3.epa.gov/ttnchie1/ap42/ch03/final/c03s02.pdf>.

<sup>32</sup> Cost estimate provided by Travers Dennis - Con Ed.

<sup>33</sup> Natural Gas Generator Capital Cost: \$1,300/kW (Siemens estimate), Solar PV Capital Cost: \$2,400/kW (Siemens Solar PV estimate).

any financial incentives or tax credits that may lower the overall cost of the microgrid. See Tables 29 and 30 below for estimated installed costs for each microgrid component.

The Project Team estimates nearly every piece of microgrid equipment has a useful lifespan of 20 years. The only component with a shorter lifespan will be the microgrid control system (Siemens SICAM PAS or equivalent), which will be replaced by more advanced software after 7-8 years.

Table 29 details capital cost, including equipment such as the microgrid control system and centralized generation controls that will allow the operator and electronic controllers to manage the entire microgrid. Hardening measures for the distributed equipment have been embedded into their reported costs.

**Table 29. Distributed Equipment Capital Cost**

Estimated costs and lifespan of the distributed equipment associated with the microgrid.

Distributed Equipment Capital Costs				
Capital Component	Quantity	Installed Cost (\$ (+/- 30%))	Component Lifespan (Years)	Purpose/Functionality
Microgrid Control System (Siemens SICAM PAS or equivalent)	1 Primary 1 Back-up	\$50,000	7 - 8	Control system responsible for operating the microgrid sequencing and data concentration under all operating modes.
Microgrid Control Center (Siemens MGMS or equivalent)	1	\$300,000	20	Provides data trending, forecasting, and advanced control of generation, loads and AMI/SCADA interface, interface to NYISO for potential economic dispatch.
Automated Pole Mount Circuit Breaker/Switch (Siemens 7SC80 relay or equivalent)	2	\$60,000	20	Upgraded breakers/switches at 2 distribution overhead switches. Isolate feeders from microgrid
Generation Controls (OEM CAT, Cummins, etc.)	1	\$4,000	20	Serves as the primary resource for coordinating the paralleling load matching of spinning generation.
PV Inverter Controller (OEM Fronius or equivalent)	1	\$4,000	20	Controls PV output and sends data to SCADA and EMS for forecasting.
Network Switches	3	\$2,250	20	Located at IEDs and controllers for network connection, allowing remote monitoring and control.
WiMax Base Station	1	\$8,000	20	Located near microgrid control cabinet. Communicates wirelessly with WiMax subscriber units for remote control and monitoring of breakers and switches. Should be installed at high location.

Distributed Equipment Capital Costs				
Capital Component	Quantity	Installed Cost (\$ (+/- 30%))	Component Lifespan (Years)	Purpose/Functionality
WiMax Subscriber Units	3	\$6,000	20	Each subscriber unit can communicate back to the WiMax base station for SCADA monitoring and control or remote relay to relay GOOSE messaging.
WiMax configuration and testing	1	\$23,000	-	The configuration and testing of the WiMax hardware
Installation Costs	-	\$128,000	-	Installation of capital components in the microgrid

**Table 30. Capital Cost of Proposed Generation Units**

Table displays the estimated costs and lifespan of the equipment associated with the generation units of the microgrid.

Proposed Generation Units				
Capital Component	Quantity	Installed Cost (\$ (+/- 30%))	Component Lifespan (Years)	Purpose/Functionality
0.175 MW Natural Gas Unit	1	227,500	20	Generation of electricity
0.02 MW PV System	1	48,000	30	Generation of electricity

The microgrid IT infrastructure will also require Cat-5e Ethernet for communication between distribution switches, generation switchgear, PV inverters, and network switches. The design uses Cat-5e cabling, including RJ-45 connectors at \$0.61 per cable.<sup>34</sup> The total installation cost of cabling is approximately \$5.65 per foot for Cat-5e cables.<sup>35</sup> The Project Team will use the existing cabling infrastructure to install the communications cables, thereby avoiding the high costs of trenching the proposed lines. The estimated total cost for the microgrid IT infrastructure is around \$8,000.<sup>36</sup>

In addition to the microgrid IT infrastructure, the microgrid will need new distribution lines in order to connect the DERs to the microgrid supported facilities. The Project Team has determined the approximate cost of building these new lines is \$12,300 for an overhead installation or \$135,000 for underground installation.<sup>37</sup>

<sup>34</sup> Commercially available RJ-45 connectors, \$0.30 per connector.

<sup>35</sup> Installation costs for Cat5e: \$5.45/ft. Component cost for Cat5e: \$0.14/ft (commercially available).

<sup>36</sup> The Project Team estimated ~1,400 feet of Cat5e will be necessary.

<sup>37</sup> The Project Team has determined that approximately 250 feet of new line is required at the cost of \$60/ft for overhead installation and \$540/ft for underground installation according to Travers Dennis at Con Ed.

#### 4.4.2 Initial Planning and Design Cost

The initial planning and design of the microgrid includes four preparation activities and total to approximately \$350,000.

1. The first set of activities are the design considerations and simulation analysis which will cost approximately \$250,000 to complete.
2. The second activity focuses on the financial aspects of the project including project valuation and investment planning which will cost approximately \$50,000.
3. The third activity focuses on the legal aspects of the project including an assessment of regulatory issues and legal viability which will cost approximately \$25,000.
4. The fourth activity focuses on the development of contractual relationships with key partners will cost approximately \$25,000.

A breakout of the initial planning and design costs are illustrated in Table 31 below.

**Table 31. Initial Planning and Design Cost**

Table displays estimates and descriptions for engineering, legal, and financing costs involved in initial planning and design of the microgrid.

Initial Planning and Design Costs (\$) <sup>38</sup>	What cost components are included in this figure?
\$250,000	Design considerations and simulation analysis
\$50,000	Project valuation and investment planning
\$25,000	Assessment of regulatory, legal, and financial viability
\$25,000	Development of contractual relationships
<b>\$350,000</b>	<b>Total Planning and Design Costs</b>

#### 4.4.3 Operations and Maintenance Cost

The proposed DERs will incur fixed operation and maintenance costs, including fixed annual service contracts.

Annual service for the proposed natural gas unit will cost approximately \$18,500.<sup>39</sup> The microgrid owner will also incur \$400 per year in total costs for annual fixed system service agreements for the solar PV array and backup generators.<sup>40</sup>

The DER assets will also incur variable O&M costs that fluctuate based on output. These include fuel and maintenance costs outside of scheduled annual servicing. First, the natural gas generator will require capital for fuel, consumable chemicals, and other operating expenses. The average

<sup>38</sup> Estimates developed by Booz Allen Project Team and industry experts.

<sup>39</sup> Natural Gas Generator O&M: \$0.014/kWh. (Siemens Estimate).

<sup>40</sup> Solar PV array (\$20/kW per year), \$4.60/kW per year for backup diesel generators (Electric Power Research Institute, "Costs of Utility Distributed Generators, 1-10 MW").

price of natural gas is \$5.08/Mcf, which translates to an average fuel cost of \$47/MWh for the natural gas unit.

The solar PV array will not require fuel to operate, and it should not require service outside of the normally scheduled down-time. Normally scheduled down-time should cost approximately \$20/kW per year.<sup>41</sup>

Annual service for all non-DER microgrid components will cost approximately \$70,000 per year.<sup>42</sup>

Table 32 outlines all fixed operations and maintenance (O&M) costs associated with normal operation of the DERs.

**Table 32. Fixed Operating and Maintenance Cost**

Table displays estimated values and descriptions of the fixed O&M costs associated with operating and maintaining the microgrid's DERs.

Fixed O&M Costs (\$/year)	What cost components are included in this figure?
~ 18,500	Natural system Service Agreement – Annual costs of maintenance and servicing of unit
~ \$400	Solar PV System Service Agreements – Annual costs of maintenance and servicing of unit
\$70,000	Non-DER Microgrid Components Service Agreement - Annual costs of maintenance and servicing of components

#### 4.4.4 Distributed Energy Resource Replenishing Fuel Time

The natural gas unit will have a continuous supply of fuel unless the pipeline is damaged or destroyed. The natural gas generator can operate continuously given properly functioning gas pipelines, therefore there is effectively no maximum operating duration for the natural gas generator in island mode. DERs such as diesel generators have limited tank sizes and have clear maximum operating times in island mode.

The solar PV array does not require fuel for operation, but its output depends on weather and time of day. Table 33 shows the fuel consumption and operating duration for all of the microgrid DERs.

<sup>41</sup> NREL (projects \$0/kWh variable maintenance costs): [http://www.nrel.gov/analysis/tech\\_lcoe\\_re\\_cost\\_est.html](http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html).

<sup>42</sup> O&M for non-DER microgrid components: \$70,000/year (Siemens).

**Table 33. Maximum Fuel Operating Time for Distributed Energy Resource**

Table displays the potential maximum operating times in Islanded Mode for each DER. The corresponding fuel consumption for each DER is also detailed.

Distributed Energy Resource	Location	Energy Source	Maximum Operating Time in Islanded Mode without Replenishing Fuel (hours)	Fuel Consumption During this Period	
				Quantity	Unit
DER1 – Natural Gas Unit	Near the Seward Senior Center	Natural Gas	N/A	N/A	Mcf
DER2 - Solar PV Array	Near the Seward Senior Center	Sunlight	N/A	N/A	N/A

## 4.5 Costs to Maintain Service during a Power Outage (Sub Task 4.5)

### 4.5.1 Backup Generation Cost during a Power Outage

All microgrid generation assets will serve as backup generation in the event of an extended power outage. The natural gas generator will be the most reliable and productive of the DERs, providing a maximum of 0.175 MW to the microgrid at any given time. Because the natural gas generator will use natural gas via pipeline as fuel, disruptions to its fuel source are unlikely. The natural gas generator can generate a maximum of 4.2 MWh per day, using approximately 38.8 Mcf (39.9 MMBTU) of natural gas. The natural gas generator will not require startup or connection costs in order to run during island mode and should not incur any daily variable costs other than fuel.

The solar array will be available for backup generation during a power outage, but its production is too inconsistent for it to qualify as a true backup generator. Extreme weather is responsible for many emergency outages in New York State, and such weather will greatly reduce the output of the solar panels. However, when high state-wide electricity demand on the most irradiated days of summer causes outages, the solar panels will be at their most productive and could provide up to 0.02 MW of load support to the Florida microgrid. Table 34 shows all of the costs associated with operating the DERs during a power outage, including fuel and variable O&M costs.



**Table 34. Cost of Generation during a Power Outage**

Table lists each generation unit and its respective energy source. Additionally, nameplate capacity, expected power outage operating capacity, and daily average production of power (in MWh) is detailed. Lastly quantity and units of daily fuel and operating costs (both one-time and ongoing) are described.

Location	Distributed Energy Resource	Energy Source	Nameplate Capacity (MW)	Expected Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/ Day)	Fuel Consumption per Day		One-Time Operating Costs (\$)	Ongoing Operating Costs per day – Fuel and variable O&M
						Quantity	Unit		
Near the Seward Senior Center	DER1 – Natural Gas Unit	Natural Gas	0.175	100%	4.2	38.8	Mcf	N/A	250 <sup>43</sup>
Near the Seward Senior Center	DER2 - Solar PV Array	Sunlight	0.02	14% <sup>44</sup>	0.067 <sup>45</sup>	N/A	N/A	N/A	1.10 <sup>46</sup>

<sup>43</sup> = Daily fuel cost during an outage (Mcf/day) + (Yearly O&M/365).

<sup>44</sup> NREL PV Watts Calculator.

<sup>45</sup> This output assumes that the PV array is still operational after an emergency event. In the case that the PV array is damaged, the microgrid will use the natural gas unit as the key source of emergency power.

<sup>46</sup> = Yearly O&M/365.

#### 4.5.2 Cost to Maintain Service during a Power Outage

There are no costs associated with switching the microgrid to island mode during a power outage other than the operational costs already accounted for Table 34. Please refer to Table 34 for one-time and ongoing costs of microgrid generation per day. The proposed microgrid has the capacity to support all the connected facilities, which means even those facilities with backup generators will not have to rely on or pay for on-site backup power. Facilities not connected to the microgrid will experience power outages and may need emergency services depending on the severity of the emergency event. Any other cost incurred during a wide spread power outage will be related to the emergency power (i.e. portable generators) rather than electricity generation costs.

### **4.6 Services Supported by the Microgrid (Sub Task 4.6)**

Most of the facilities to be connected to the microgrid are public facilities that serve the community of Florida (such as the Florida village clerk office, police department, fire department and public library). For estimates of the population served by each critical facility, see Table 35.

Backup power supplied by the microgrid should provide 100% of each facility's electricity demand during outage situations. However, if backup power from the microgrid is not available, the critical services provided by these facilities will be severely hampered. Some critical services do not require electricity (e.g. driving a police car to the scene of a crime), while others are completely dependent on a stable power supply (e.g. some municipal buildings or local water sanitizing operations). Based on the portfolio of services that each facility provides and the electricity dependency of each service, Table 35 provides an estimate of how effectively each facility can perform its normal services without electricity.

**Table 35. Critical Services Supported**

Table details critical services supported by the microgrid during an outage. The table also shows the percentage of services lost for each facility when backup power is not available during an outage.

Facility Name	Population Served by This Facility	Percentage Loss in Service During a Power Outage <sup>47</sup>	
		When Backup Power is Available	When Backup Power is Not Available
Florida Village Clerk	2,900	0%	> 75%
Police Department	2,900	0%	> 50%
Seward Senior Center	~ 40	0%	> 75%
Fire and Rescue Department	2,900	0%	> 50%
Public Library	2,900	0%	> 75%
Load Cluster 1	~ 15	0%	> 50%
Load Cluster 2	~ 15	0%	> 75%

## 4.7 Industrial Economics Benefit-Cost Analysis Report

As follows is a direct cost-benefit analysis deliverable from Industrial Economics. IEc was hired by NYSERDA to conduct a benefit-cost analysis of each feasibility study. The benefit-cost analysis of the Florida microgrid was delivered to the Project Team on February 24, 2016.

### 4.7.1 Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the Village of Florida has proposed development of a microgrid that would serve seven facilities within the Village, including:

- The Florida Village Clerk
- The Police Department and the Fire and Rescue Department
- The Seward Senior Center and the Public Library
- Two load clusters, one that includes two residential buildings, and another which supports four commercial buildings

The microgrid would be powered by two new distributed energy resources: a 0.175 MW natural gas-fired unit, and a 0.02 MW PV array; both would be installed near the Seward Senior Center. The town anticipates that the natural gas unit and PV system would produce electricity for the grid during periods of normal operation. The system as designed would have sufficient generating capacity to meet average demand for electricity from the seven facilities during a major outage. Project consultants also indicate that the system would have the capability of providing black start support to the grid.

<sup>47</sup> Booz Allen estimated % loss based on energy demands and services provided for Emergency Services, Municipal Services, Health Services, and Education Services based on previous research by NIH and CDC (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1497795/>; <http://www.ncbi.nlm.nih.gov/pubmed/15898487>; <http://emergency.cdc.gov/disasters/poweroutage/needtoknow.asp>).

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

#### 4.7.2 Methodology and Assumptions

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

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

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

The BCA model is structured to analyze a project’s costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.<sup>48</sup> It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system’s equipment. Once a project’s cumulative benefits and costs have been adjusted to present values, the model calculates both the project’s net benefits and the ratio of project benefits to project costs. The model also calculates the project’s internal rate of return, which indicates the discount rate at which the project’s costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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<sup>48</sup> The seven percent discount rate is consistent with the U.S. Office of Management and Budget’s current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the NYPSC’s 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 using a three percent discount rate, to value CO<sub>2</sub> emissions. As the NYPSC notes, “The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects.” The model also uses EPA’s temporal projections of social damage values for SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>2.5</sub>, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.<sup>49</sup>

#### 4.7.3 Results

Table 36 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 25.6 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

**Table 36. BCA Results (Assuming 7 Percent Discount Rate)**

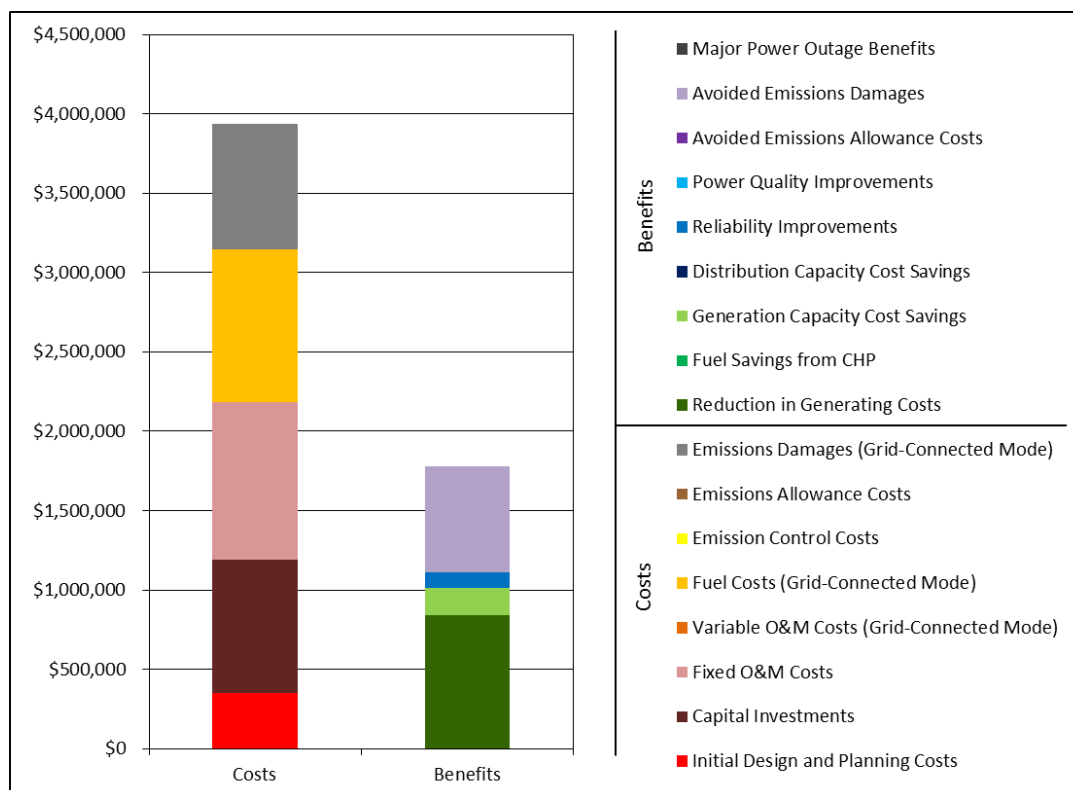
Economic Measure	Expected Duration of Major Power Outages	
	Scenario 1: 0 Days/Year	Scenario 2: 25.6 Days/Year
Net Benefits - Present Value	-\$2,160,000	\$2,690
Benefit-Cost Ratio	0.5	1.0
Internal Rate of Return	NA	7.6%

<sup>49</sup> The New York State Department of Public Service (DPS) requires utilities delivering electricity in New York State to collect and regularly submit information regarding electric service interruptions. The reporting system specifies 10 cause categories: major storms; tree contacts; overloads; operating errors; equipment failures; accidents; prearranged interruptions; customers equipment; lightning; and unknown (there are an additional seven cause codes used exclusively for Consolidated Edison’s underground network system). Reliability metrics can be calculated in two ways: including all outages, which indicates the actual experience of a utility’s customers; and excluding outages caused by major storms, which is more indicative of the frequency and duration of outages within the utility’s control. In estimating the reliability benefits of a microgrid, the BCA employs metrics that exclude outages caused by major storms. The BCA classifies outages caused by major storms or other events beyond a utility’s control as “major power outages,” and evaluates the benefits of avoiding such outages separately.

**Scenario 1**

Figure 8 and Table 37 present the detailed results of the Scenario 1 analysis.

**Figure 8. Present Value Results, Scenario 1**  
**(No Major Power Outages; 7 Percent Discount Rate)**



**Table 37. Detailed BCA Results, Scenario 1**  
**(No Major Power Outages; 7 Percent Discount Rate)**

Cost or Benefit Category	Present Value Over 20 Years (2014\$)	Annualized Value (2014\$)
<b>Costs</b>		
Initial Design and Planning	\$350,000	\$30,900
Capital Investments	\$839,000	\$72,500
Fixed O&M	\$998,000	\$88,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$959,000	\$84,600
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$792,000	\$51,700
<b>Total Costs</b>	<b>\$3,940,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$838,000	\$74,000
Fuel Savings from CHP	\$0	\$0
Generation Capacity Cost Savings	\$173,000	\$15,300
Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$97,800	\$8,630
Power Quality Improvements	\$0	\$0
Avoided Emissions Allowance Costs	\$450	\$40
Avoided Emissions Damages	\$669,000	\$43,700
Major Power Outage Benefits	\$0	\$0
<b>Total Benefits</b>	<b>\$1,780,000</b>	
<b>Net Benefits</b>	<b>-\$2,160,000</b>	
<b>Benefit/Cost Ratio</b>	<b>0.5</b>	
<b>Internal Rate of Return</b>	<b>NA</b>	

### ***Fixed Costs***

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately \$350,000. The present value of the project's capital costs is estimated at approximately \$0.8 million, including costs associated with installing a microgrid control system; equipment for the substation that would be used to manage the microgrid; the IT infrastructure (communication cabling) for the microgrid; and the new 0.175 MW natural gas unit and the 0.02 MW photovoltaic array. Operation and maintenance (O&M) of the entire system would be provided under fixed price service agreements, at an estimated annual cost of \$88,000. The present value of these O&M costs over a 20-year operating period is approximately \$1.0 million.

### ***Variable Costs***

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the proposed gas-fired generator. To characterize these costs, the BCA relies



on estimates of fuel consumption provided by the Project Team and projections of fuel costs from New York's State Energy Plan (SEP), adjusted to reflect recent market prices.<sup>50</sup> The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately \$1.0 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. In this case, the damages attributable to emissions from the new natural gas generator are estimated at approximately \$52,000 annually. The majority of these damages are attributable to the emission of CO<sub>2</sub>. Over a 20-year operating period, the present value of emissions damages is estimated at approximately \$0.8 million.

### ***Avoided Costs***

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. In the case of the Village of Florida's proposed microgrid, the primary 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 \$0.8 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. The reduction in demand for electricity from bulk energy suppliers would also avoid emissions of CO<sub>2</sub>, SO<sub>2</sub>, and NO<sub>x</sub>, yielding emissions allowance cost savings with a present value of approximately \$450 and avoided emissions damages with a present value of approximately \$0.7 million.<sup>51</sup>

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.<sup>52</sup> Based on standard capacity factors for solar and natural gas generators, the Project Team estimates the project's impact on demand for generating capacity to be approximately 0.15 MW per year (the team estimates no impact on distribution capacity).

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<sup>50</sup> The model adjusts the State Energy Plan's natural gas and diesel price projections using fuel-specific multipliers calculated based on the average commercial natural gas price in New York State in October 2015 (the most recent month for which data were available) and the average West Texas Intermediate price of crude oil in 2015, as reported by the Energy Information Administration. The model applies the same price multiplier in each year of the analysis.

<sup>51</sup> Following the NYPSC guidance for benefit-cost analysis, the model values emissions of CO<sub>2</sub> using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.] Because emissions of SO<sub>2</sub> and NO<sub>x</sub> from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

<sup>52</sup> 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.

Based on this figure, the BCA estimates the present value of the project's generating capacity benefits to be approximately \$0.2 million over a 20-year operating period.

The Project Team has indicated that the proposed microgrid would be designed to provide 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 market for black start support is highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing this service.

### ***Reliability Benefits***

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately \$9,000 per year, with a present value of approximately \$98,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:<sup>53</sup>

- System Average Interruption Frequency Index – 1.08 events per year.
- Customer Average Interruption Duration Index – 97.2 minutes.<sup>54</sup>

The estimate takes into account the number of small and large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the Project Team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.<sup>55</sup> It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

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<sup>53</sup> [www.icecalculator.com](http://www.icecalculator.com).

<sup>54</sup> The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Orange and Rockland.

<sup>55</sup> <http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1>.

## Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.5; i.e., the estimate of project benefits is slightly less than half 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.<sup>56,57</sup>

As noted above, the Village of Florida’s microgrid project would serve a number of residential, commercial, and critical service facilities, including fire and police services. The project’s consultants indicate that at present, none of the facilities are currently equipped with backup generators. All the facilities could maintain service by bringing in portable generators; Table 38 lists the team’s estimate of the associated costs. In the absence of backup power – i.e., if the backup generator failed and no replacement was available – all the facilities would experience between 50 and 100 percent loss in service capabilities (see Table 38).

**Table 38. Backup Power Costs and Level of Service, Scenario 2**

Facility Name	Cost of Maintaining Service with Portable Generator (\$/DAY)	Percent Loss in Service when Backup Generation is Not Available
Florida Village Clerk	\$352	75%
Police Department	\$176	50%
Seward Senior Center	\$214	75%
Fire and Rescue Department	\$1,119	50%
Public Library	\$675	75%

<sup>56</sup> The methodology used to estimate the value of lost services was developed by the Federal Emergency Management Agency (FEMA) for use in administering its Hazard Mitigation Grant Program. See: FEMA Benefit-Cost Analysis Re-Engineering (BCAR): Development of Standard Economic Values, Version 4.0. May 2011.

<sup>57</sup> As with the analysis of reliability benefits, the analysis of major power outage benefits assumes that development of a microgrid would insulate the facilities the project would serve from all outages. The distribution network within the microgrid is unlikely to be wholly invulnerable to service interruptions. All else equal, this will lead the BCA to overstate the benefits the project would provide.

Facility Name	Cost of Maintaining Service with Portable Generator (\$/DAY)	Percent Loss in Service when Backup Generation is Not Available
Load Cluster 1 (Residential Buildings)	\$176	50%
Load Cluster 2 (Commercial Buildings)	\$451	50%

The information provided above serves as a baseline for evaluating the benefits of developing a microgrid. In addition, the assessment of Scenario 2 also assumes that in all cases, the supply of fuel necessary to operate backup generators would be maintained indefinitely, and that at each facility there is a 15 percent chance that the backup generator would fail.

The economic consequences of a major power outage also depend on the services the facilities of interest provide. The analysis varies by facility, as described below:

- For fire services, the analysis calculates the impact of an outage on property losses, lives lost, and injuries suffered due to fires, due to an anticipated increase in response time. The methodology assumes that the population normally served by the non-functioning fire station would rely on the next-closest provider able to serve this population. In Florida's case, this would result in a 50 percent increase in response time.
- For police services, the analysis calculates the impact of a loss in service using standard FEMA values for the costs of crime, the baseline incidence of crime per capita, and the impact of changes in service effectiveness on crime rates.
- For residential facilities, the analysis assumes that the residents being served would be left without power; the impact is valued as a social welfare loss.
- For the Seward Senior Center, the value of service is approximately \$2,400 per day. This figure is based on an estimate of the facility's capacity (40 residents) and state data on the average rate for adult day health care in the Kingston area (approximately \$60/patient/day).<sup>58</sup>
- For the remaining facilities, the value of service was calculated using the U.S. Department of Energy's ICE Calculator.<sup>59</sup> For the Village Clerk the value of service is approximately \$6,400 per day, based on 12 hours of microgrid demand per day during an outage. The value of service calculated for the Public Library is based on 16 hours of microgrid demand, and is estimated at about \$7,600 per day. Lastly, for Load Cluster 2 (commercial buildings), the value of service is approximately \$28,500 per day during an outage, based on 12 hours of microgrid demand.

Based on these values, the analysis estimates that in the absence of a microgrid, the average cost of an outage for all facilities is approximately \$7,500 per day.

<sup>58</sup> <https://www.genworth.com/corporate/about-genworth/industry-expertise/cost-of-care.html>.

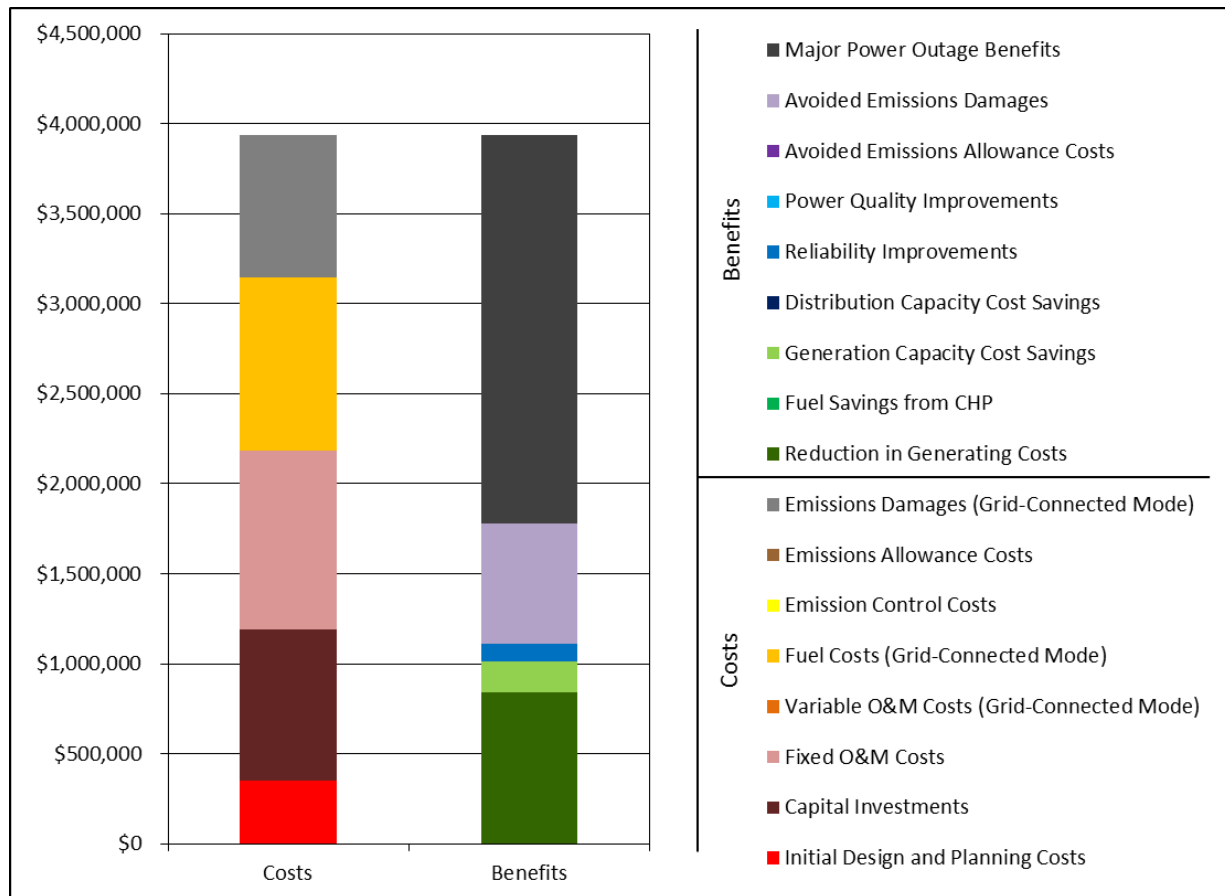
<sup>59</sup> <http://icecalculator.com/>.

### Summary

Figure 9 and Table 39 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 25.6 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 9. Present Value Results, Scenario 2**

**(Major Power Outages Averaging 25.6 Days/Year; 7 Percent Discount Rate)**



**Table 39. Detailed BCA Results, Scenario 2****(Major Power Outages Averaging 25.6 Days/Year; 7 Percent Discount Rate)**

Cost or Benefit Category	Present Value Over 20 Years (2014\$)	Annualized Value (2014\$)
<b>Costs</b>		
Initial Design and Planning	\$350,000	\$30,900
Capital Investments	\$839,000	\$72,500
Fixed O&M	\$998,000	\$88,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$959,000	\$84,600
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$792,000	\$51,700
<b>Total Costs</b>	<b>\$3,940,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$838,000	\$74,000
Fuel Savings from CHP	\$0	\$0
Generation Capacity Cost Savings	\$173,000	\$15,300
Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$97,800	\$8,630
Power Quality Improvements	\$0	\$0
Avoided Emissions Allowance Costs	\$450	\$40
Avoided Emissions Damages	\$669,000	\$43,700
Major Power Outage Benefits	\$2,160,000	\$192,000
<b>Total Benefits</b>	<b>\$3,940,000</b>	
<b>Net Benefits</b>	<b>\$2,690</b>	
<b>Benefit/Cost Ratio</b>	<b>1.0</b>	
<b>Internal Rate of Return</b>	<b>7.6%</b>	

The Project Team assumed an electricity sales price of \$0.085 per kWh in Florida. This is the supply cost for O&R, the average amount spent by O&R to import electricity into their distribution system. On a long term, fixed volume PPA, the Project Team believes this to be the most accurate pricing model. Industrial Economics modeled the LBMP for the local NYISO zone to price electricity sales. The LBMP is effectively the average spot market price, peaking on summer afternoons and dropping to nearly zero in low demand hours. While the LBMP would be an appropriate price for intermittent and unreliable grid sales, the proposal herein supports reliable, continuous electricity injections into the O&R grid. In Florida, the Hudson Valley LBMP is \$37.00 per MWh<sup>60</sup>, or \$0.037 per kWh, a more than 56% reduction in price from the supply cost. The benefits allowed for capacity cost reductions do not bring the electricity prices to parity. This has a predictable influence on the economics of the projects and is the driving force behind the divergent cost benefit analyses developed by the Project Team and by IEC. The Project Team is unaware of any community microgrid business model or generation set that is financially self-sufficient at the LBMP.

<sup>60</sup> Average according to IEC cost-benefit model.

## 5. Summary and Conclusions

### 5.1 Lessons Learned and Areas for Improvement

The lessons learned from the Florida microgrid feasibility study are divided into two parts. The first part in Section 5.1.1 highlights Florida-specific issues to be addressed moving forward. The second part in Sections 5.1.2 and 5.1.3 addresses statewide issues, replicability, and the perspectives of many stakeholder groups. These lessons learned may be generalized and applied across the State and NY Prize communities.

#### 5.1.1 Florida Lessons Learned

Through the Florida microgrid feasibility study, the Project Team learned site-specific lessons applicable to other communities in its portfolio and around the state.

Though Florida has natural gas and the proposed microgrid does not require significant new infrastructure, the overall project size is too small to pencil out. From a total load and cost perspective it is the smallest project within the Project Team portfolio. Small loads are very challenging to overcome given the high capital and operating costs associated with full microgrid control. The only mitigating factor that might allow full microgrids in very small load areas is exceptionally high power costs. While Florida's electricity costs are relatively high, they would need to be a multiple higher to drive sufficient revenue to support the project.

Florida, like many other communities, is constrained by its relatively low density: desired critical loads are often in distant locations and the adjacency found in urban or dense suburban areas is lacking. Such conditions require more control infrastructure, more intermediate load pickup, and the feeders are more likely to have downstream loads, rendering economic islanding impossible. Each of these conditions adds costs or strips revenue opportunities. The Florida proposal focuses on a small section of a single feeder as the alternative options to connect additional critical facilities would have required extensive modifications to the electrical system. This small footprint includes a handful of pickup loads, about which the Project Team knows very little. It is also simply a very small footprint with minimal overall loads; this reduces revenue opportunities and negatively impacts project economics.

In comparison to working with a municipal utility, working with the investor-owned O&R was a more time-intensive process. As a utility with a large footprint, customer base, and transmission and distribution network, O&R has many issues to manage that require its attention, among which microgrids and NY Prize were just one. However, O&R was receptive to the possibility of infrastructure ownership and microgrid operation, and the Project Team appreciates the exceptionally open dialogue. O&R was critical and very involved in the system's design in Florida and played a key part in ensuring a technically feasible microgrid. A NY Prize Phase II award would require more extensive conversations with O&R about their role in a future microgrid on the proposed footprint and how a microgrid might utilize existing infrastructure most efficiently.



### 5.1.2 Statewide Replicability and Lessons Learned

Through the process of developing deliverables for multiple communities over several months, the Team has discovered and considered new questions surrounding microgrid development. These questions address technical viability, financial structures, policy considerations, and other constraints that could inhibit the development or expansion of microgrids in New York State.

*Technical.* The existing electrical and natural gas infrastructure in a community is the chief determinant of what is possible. Florida has sufficient natural gas availability to support natural gas-fired generation within the microgrid and a useful electrical layout. While it would be more advantageous to have several desired facilities on the end of a feeder and not at a midpoint, there is no requirement to connect multiple feeders and the area in which the facilities are situated is relatively confined. Nearby generation that appears sufficient and connectable, such as diesel backup, is also at the mercy of the electrical infrastructure, and unfavorable feeder structures can quickly render otherwise exceptional generation useless to the microgrid.

Lastly, the availability of natural gas infrastructure is a major contributor to positive project feasibility. In communities without natural gas, generation is typically limited to solar PV and the tie in of existing diesel backup generation, given the high costs of storage and biomass and the larger footprints required for wind. Given the intermittency of solar, and the low capacity factor in New York State (approximately 15%), solar installations of a few hundred kW do not provide reliable generation for an islanded microgrid. In contrast, natural gas-fired generation provides a high reliability baseload, is relatively clean and efficient, and allows for cogenerated thermal sales if there is a proximate off-taker. Florida does not have a proximate thermal off-taker and, therefore, there is no CHP proposed.

*Financial.* Across the portfolio of communities managed by the Project Team, natural gas availability and thermal off-takers are the leading elements of financially viable projects. Simply, natural gas generation is more cost efficient and provides highly reliable revenue streams through electricity sales, consistency which is unavailable to a PV driven system. Given the currently high cost of battery storage options, it is difficult to make a compelling case for a small solar PV-battery system as a reliable baseload option

Project financial structures are also important to consider. Revenue from these projects is driven almost exclusively by the sale of electricity and, if available, thermal energy; however, the microgrid control components may require a million dollars or more of capital investment. Ownership structures that separate cost drivers from the revenue streams may be difficult propositions, as the microgrid controls owners would have little opportunity to recoup their investment. This is especially true for privately owned microgrids in locations with reliable power supplies where islanding would be infrequent. In these cases, municipal ownership of the generation and infrastructure would be the most effective. The exception is if the entire microgrid can be developed “behind the meter.” While it remains to be seen if utilities will allow this to transpire, a fully behind-the-meter solution in an area with moderate to high electricity prices would likely be a more advantageous financial proposition for connected facilities, as well

as for generation and controls owners. Moreover, ancillary services have the potential to provide positive revenue for community microgrids; however, they are hard to qualify for because they require high levels of reserve capacity for most programs, and the payments are somewhat small relative to the electricity that could be generated and sold with an at-capacity generator.

Project size is a final determinant of viability. Small projects with only a few hundred kW of generation simple to not have the revenue streams to support the installation and operating costs of an advanced, MCS and SCADA controlled microgrid. While the Project Team has not identified a bright-line at which projects tend to be viable, those under 500 kW of continuous generation will struggle to cover even variable costs. While fuel costs and generator O&M are commensurate with capital costs and generator size, and therefore revenue, microgrid system maintenance costs are fixed at approximately \$70,000 and capital costs at \$450,000. While these can be absorbed into a large project, they simply cannot be supported with small microgrids.

*Policy.* State policy does not currently address microgrids in a cohesive or holistic manner, nor have utility programs adequately recognized microgrid operations in their policies. DR is a potentially lucrative revenue stream in New York; however, current policies do not address microgrid DR participation. For instance, interpretations of the existing NYISO DR programs suggest that microgrids could take payments for islanding in times of high demand on the macrogrid. This scenario, while advantageous from a load shedding perspective, would also remove the microgrid connected generation simultaneously, leaving the macrogrid in a net-neutral position vis-a-vis the microgrid. While the nature of DR payments in such situations is not clear, the Project Team suggests explicit guidance from the NYPSC and the various utilities regarding their respective policies. Due to this lack of clarity, DR revenue has generally been excluded from the Project Team's revenue analysis.

Lastly, local community involvement is an important contributor to microgrid design success. Though even the most robust community engagement may not overcome highly unfavorable infrastructure, it is nonetheless imperative for steady forward progress.

*Scalability.* Scalability is governed by three factors. The structure of the electrical infrastructure, defined in the technical lessons learned section above, is a key factor to expansion of the microgrid. At some point of expansion, it becomes necessary to link multiple feeders, and having proximate feeders of the same voltage and connected to desirable facilities is an important criteria. The lack of voltage congruence was a key consideration in the Florida proposal. Second, widespread AMI infrastructure makes expansion far less complicated and allows for the selective disconnect of facilities that are not microgrid participants. Florida's microgrid is not an AMI remote disconnect based design; however, the utility of AMI is evident in other projects in the Project Team's portfolio. Lastly, the larger the microgrid grows, the more switches and controls are need to be installed, connected, and maintained for smooth islanding and grid-reconnect processes. In the aggregate, such infrastructure is costly and does not provide many direct returns. Utilities are also likely to push back if the microgrid grows to occupy significant portions of their infrastructure. To that end, the Project Team has worked diligently with the

local utilities to find acceptable footprints that meet the goals of NYSERDA and respect the operational concerns of the utilities.

### 5.1.3 Stakeholder Lessons Learned

*Developers.* Some of the NY Prize project proposals may require the Phase III award to achieve positive economics, and many will remain in the red even with the grant. At this time there is no incentive for developers to participate in the build-out or operation of proposed microgrids that demonstrate negative returns. The potential for developer involvement is highest in communities with relatively high electricity prices and the presence of thermal off-takers; these conditions drive project profitability. Moreover, many of the municipalities are interested in part or full ownership of the projects, but either do not have available funds or lose the project economics without the available tax credits and incentives. In these situations, there may be opportunities for developers to leverage the tax benefits through design-build-own-operate arrangements.

*Utilities.* The Project Team often experienced problems with information flow. The Project Team would request information about feeders, switches, and other infrastructure from the utilities to inform the best possible microgrid design. However, the utilities were often guarded about providing the full data request in the absence of a design proposal, leading to something of a catch-22 in that neither party was able to adequately answer the request of the other without the desired information. These holdups were incrementally resolved to the satisfaction of both the Project Team and the utilities, but gathering data required significantly more time and dialogue than expected. The utilities may have been unprepared for the volume and detail of data requests from the Project Team, and the expected detail of the overall feasibility study may not have been fully communicated to each party.

Investor-owned-utilities in the Project Team's portfolio, including O&R in Florida, were uniformly against allowing a third party operational control of utility-owned infrastructure. This view is understandable, however it engenders a particularly difficult situation if the utility does not support the microgrid development. O&R, on the other hand, has indicated a willingness to discuss ownership and operational scenarios in which it retains a strong role; it's neither necessary nor sufficient for a successful microgrid installation, but it reduces many of the operational concerns. In other situations, the microgrid will generally be forced to construct duplicate infrastructure, with is both prohibitively expensive and against the spirit of the NY Prize. In general, utilities which support the integration of their infrastructure to the extent technically possible allow for more expansive microgrid possibilities.

*Academics.* Academic considerations in microgrid development may center around three areas. First, research into a relatively small grid systems with multiple generators (some spinning, some inverter-based), temporally and spatially variable loads, and multidirectional power flows may inform better designs and more efficient placement of generation and controls relative to loads. The second is optimizing financial structures for collections of distributed energy resources and control infrastructure. To-date, most microgrids in the United States have been campus-style developments in which the grid serves a single institution and can be easily segregated from the

macrogrid. Community microgrids consisting of multi-party owned facilities and generation are a new concept, and literature on how best to own and operate such developments is not yet robust. Lastly, and related to financial structures, is the idea of how a “grid of grids” would be managed and structured to provide optimal operational support and the right mix of incentives to encourage customer and utility buy-in.

*Communities.* Engaged communities are important, but so too are realistic expectations of what a microgrid might include. Many communities expected dozens of facilities, or entire towns, to be included in the microgrid without understanding the limitations of the electrical and gas systems, the utility’s operation requirements, or simple cost feasibility. While the Project Team worked with each community to scope out and incrementally refine the facilities for inclusion, there is still much work to be done communicating the infrastructural realities of microgrid development. Setting expectations ahead of future microgrid initiatives will help communities begin with more concise and actionable goals for their community microgrids.

*NYSERDA.* NYSERDA awarded 83 Phase I feasibility studies, providing a wide canvas for jumpstarting microgrid development in the state but also placing administrative burdens on the utilities and on NYSERDA itself. As NYSERDA is aware, the timelines for receiving information from utilities were significantly delayed compared to what was originally intended, and this has impacted the ability of the Project Team to provide deliverables to NYSERDA on the original schedule. As mentioned in the Utilities Lessons Learned above, better communication between the State and the utilities may have preemptively alleviated this bottleneck.

Second, microgrid control infrastructure is expensive, and distributed energy resources require some scale to become revenue positive enough to subsidize the controls. Therefore, many NY Prize project proposals are not financially feasible without the NY Prize and myriad other rebate and incentive programs. In practical terms, this means that, while the NY Prize will create a body of knowledge around the development of community microgrids that did not previously exist, it is unlikely to spur unbridled growth of community microgrids in the State without policy changes. This is especially true in regions with relatively low electricity costs and as well as power supply and reliability problems. Additionally, many communities that require improvements to the grid for reliability and resiliency and are lower income communities, which creates the added challenge of making them harder to pencil out financially as the community cannot afford to pay extra to ensure reliability. The projects with the least advantageous financials are often those needed most by the community. This gap is not easily bridged without further subsidization from the State.

## **5.2 Benefits Analysis**

This section describes the benefits to stakeholders associated with the project. The microgrid will provide more resilient energy service, lower peaking emissions, ensure critical and important facilities remain operational during grid outages, and support the goals of New York’s REV.

### 5.2.1 Environmental Benefits

New York State's normal energy portfolio is very clean, with primary energy sources being hydropower and nuclear. Therefore, having a microgrid powered by a natural gas-fired reciprocating generator will increase the overall emissions per kWh. However, the natural gas generator is cleaner than many peaking assets, which come online when statewide demand is high. In particular, microgrid generation will offset diesel backup generators in many locations, reducing diesel fuel burn and overall emissions. The proposed microgrid also offers a platform for expanding renewable generation in the future. The microgrid's generation assets will not exceed current New York State emissions limits for generators of their size and will not need to purchase emissions permits to operate.

### 5.2.2 Benefits to the Village of Florida

Critical and important facilities in Florida will receive resilient backup power from the proposed generation assets, ensuring they are available in outage situations and reducing the need for further investments in backup generation. The electricity generated with the solar PV arrays and the natural gas-fired reciprocating generator will also offset higher-emission peaking assets during peak demand events. The Project Team met by phone with the community on February 26, 2016 to provide a summary of the project analysis and a recommended approach for a path forward.

### 5.2.3 Benefits to Residents in and around Florida

Residents of Florida and the surrounding community stand to gain from access to a broad range of critical services anytime the microgrid is forced into islanded operation by an outage on the grid. Even if they are not formally connected to the microgrid, all residents of Florida and nearby surrounding communities will have access to important services in the event of an outage. In the future, the microgrid could be expanded to connect more facilities.

### 5.2.4 Benefits to New York State

New York State will benefit from the continued localization of energy resources, reducing load and congestion on the grid. Moreover, the expansion of distributed energy resources will further the goals of REV and provide a more resilient overall grid. A successful implementation of the Florida microgrid will provide a proof of concept for the ownership and operation of a hybrid microgrid with local utility support. In addition, the lessons learned described in Section 5.1 are widely applicable to the further development of REV and future NY Prize efforts into Phase II and III.

## 5.3 Conclusion and Recommendations

The Project Team has concluded the proposed Florida microgrid is technically feasible and financially infeasible absent significant subsidies. Previous sections have detailed the capabilities of the microgrid, its primary technical design, the commercial, financial, and legal viability of the project, and the costs and benefits of the microgrid. The microgrid meets all of the NYSERDA required capabilities and most of its preferred capabilities.

The proposed Florida microgrid is replicable and scalable, and it provides a proof of concept for a natural gas-driven microgrid in a small community. If successful, it will be a source of new operational information gleaned in operating a true community microgrid within the context of investor-owned utility infrastructure and control systems. While the Project Team expects hiccups, there is potential value for O&R as a distributed system platform operator if a critical mass of microgrids can be established within their footprint.

This microgrid project will also help accelerate New York State's transition from traditional utility models to newer and smarter distributed technologies, and it will help achieve the REV goals of creating an overall more resilient grid, reducing load and congestion, expanding distributed energy resources, reducing GHG emissions, and constructing more renewable resources. It will also encourage citizens within the community to invest and get involved in local energy generation and distribution and will foster greater awareness of these issues.

Finally, the project will demonstrate the widely distributed benefits of microgrids paired with DERs. The utility will see improved grid performance, the community will reap the positive benefits of living in and around the microgrid, and industrial customers will benefit from the value of avoided outages. For these reasons, the Project Team recommends this project be considered for continued participation in the NYSERDA New York Prize Community Microgrid Competition.

#### *Path Ahead*

Beyond a fully integrated microgrid, there are several paths forward in Florida to improve energy resilience and reduce costs. The first approach should always be energy efficiency, and Florida has taken concrete steps to affect change. In 2010, Florida renewed the Village Clerk, Seward Senior Center, and other village buildings for energy saving LED lights, new insulation, and efficient windows. Three school buildings upgraded to automatic LED lighting systems also to improve EE. In 2015, Florida was working on a new solar project with SolarCity at Golden Hill Elementary School, aiming for \$3,000 electricity saving per month.

The Project Team estimates the reduction potential for the facilities in the footprint to be approximately 8.5 kW. Facilities should seek to qualify for existing O&R and NYSERDA EE incentive programs to help finance the upgrades. The microgrid project will target existing O&R and NYSERDA programs to encourage EE upgrades at facilities. Applicable EE programs are outlined in Section 2.2.14.

In addition, and as the solar project at the school demonstrates, standalone solar in New York State is often an attractive investment. High potential sites may be built out with third party solar developers at little or no capital cost to residents while providing steady, long term reductions in electricity prices and increases in renewable penetration. The 20 kW array proposed for the Florida microgrid may fit within the scope of a financeable standalone solar. If implemented, it would enhance Florida's energy resilience and incrementally benefit the O&R distribution system. In addition, the proposed natural gas reciprocating engine is a standalone positive value

proposition. A new continuous duty gas generator would provide positive operating cash flow for the owner and could serve as a backup source for one or more facilities. While this would not be a fully integrated microgrid, it would provide a generation base from which to build the microgrid in the future if the appetite to do so materializes.

## Appendix

Metering data for typical 24-hour load profiles were simulated with the monthly data provided by O&R. They are included in this feasibility study to show which facilities have the highest and lowest load demands at different times of the day. Analyzing these load demand curves has allowed the team to develop a better overall understanding of the generation capacity needed to sustain the microgrid.

**REDACTED PER NDA WITH O&R**