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Town of Somers Microgrid Feasibility Study

Microgrid Project Results and Final Written Documentation

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Abstract

Together with the Town of Somers (Somers), 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 is technically feasible, though not without challenges. The commercial and financial viability of the project have been analyzed and detailed in this document. The Somers microgrid project faces the challenge of high capital costs, but it calls for a novel mix of new technologies the State may choose to incentivize. Two new 300 kilowatt (kW) solar photovoltaic (PV) arrays, 12 megawatt hours (MWh) of battery storage, and a 15 kW biogas system will provide reliable, low-emission electricity to customers while providing a proof of concept for a community microgrid in 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 resources (DERs), energy resilience, clean energy, DER, Somers

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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
DC	Direct Current
DER	Distributed Energy Resources
DNP3	Distributed Network Protocol
DR	Demand Response
DSP	Distributed System Platform
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
$MMTCO_2e$	Million Metric Tons CO_2 Equivalent
$MTCO_2e$	Metric Tons CO_2 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

NYSEG	New York State Electric and Gas Corporation
NYSERDA	New York State Energy Research and Development Authority
O&M	Operation and Maintenance
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
QF	Qualifying Facility
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
SPV	Special Purpose Vehicle
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 Town of Somers. 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 Town can improve energy resilience with intentional and emergency island mode capabilities and comply with the greater New York REV (Reforming the Energy Vision) program by constructing 600 kW of clean energy generation capability and 12 MWh of storage. The study concludes the technical design is feasible, however it is financially infeasible as a standalone project.

The Somers microgrid project will tie together five critical facilities (per NYSERDA's definition) and three groups of residential and commercial facilities into a community microgrid. Table ES-1 lists all the facilities under consideration for the microgrid concept at this time, and Figure ES- 1 shows their locations in the Town of Somers.

Table ES- 1. Prospective Microgrid Facilities

Table lists the facilities in the Town of Somers's proposed microgrid, including their classifications as public, health, or school. The table also denotes critical and important facilities.

Map	Property	Address	Classification
F1	**Heritage Hills Sewage Treatment Plant**	8 Heritage Hills Dr	Infrastructure*
F2	**Somers Fire Station**	270 Rt. 202	Public*
F3	**Somers Pharmacy and Surgical, Somers Eye Clinic, and a retail store**	336 Rt. 202	Commercial/Health*
F4	**Town Government Office and Elephant Hotel**	335 Rt. 202	Public*
F5	**Mt. Kisco Medical Group**	342 Rt. 202	Health*
F6	**Heritage Residential Units**	1-5 Heritage Hills Dr	Residential**
F7	**Load Cluster 1**	263-265 Rt. 202	Residential/Commercial**
F8	**Load Cluster 2**	179-346 Rt. 202	Residential/Commercial**
		* Critical Facility **Important Facility	

In order to meet the energy needs of these critical and important facilities, the microgrid system will incorporate the following existing and proposed generation assets outlined in Table ES-2, below.

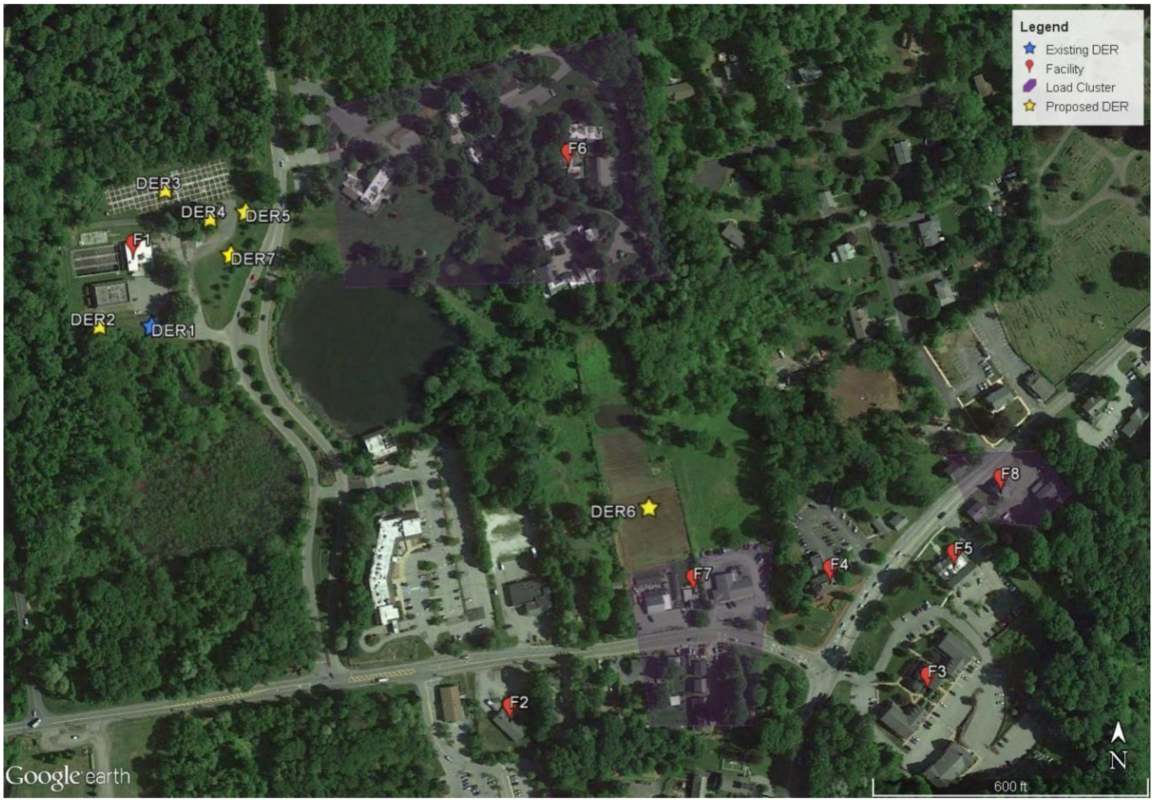
Table ES-2. Somers Generation Assets

Table lists the DERs that will be included in the Somers microgrid, including their address, fuel source, and nameplate capacity. The table also provides their label for Figure ES-1.

Name on Map	Description	Fuel	Capacity (kW)	Address
DER1	**Existing backup generator**	Diesel	500	8 Heritage Hills Dr
DER2	**New anaerobic digester and gas generator system**	Solid waste	15	8 Heritage Hills Dr
DER3	**New carport solar PV array**	Sunlight	300	8 Heritage Hills Dr
DER4	**New zinc air battery unit**	N/A	1 megawatt (MW)/4 MWh	8 Heritage Hills Dr
DER5	**New zinc air battery unit**	N/A	1 MW/4 MWh	8 Heritage Hills Dr
DER6	**New ground-mount solar PV array**	Sunlight	300	~263 Rt. 202
DER7	**New zinc air battery unit**	N/A	1 MW/4 MWh	8 Heritage Hills Dr

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 Somers microgrid. Existing DERs are marked as blue stars and new/proposed DERs are marked as yellow stars. Facilities are marked as red points.



The proposed DERs will typically have adequate capacity to supply all of the microgrid facilities in Table ES- 1 with electricity in island mode. When the solar arrays are operating close to their maximum production points, the microgrid's generation capacity will approach 615 kW, with spinning baseload generation coming only from diesel backup when in island mode. Aggregate demand from microgrid facilities averaged 267 kW and never exceeded 593 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 Town of Somers. With the addition of these generation assets, the Town could experience reduced emissions during peak demand events and could benefit from a more resilient and redundant energy supply to critical services.

The proposed DERs will generate revenues from electricity sales and ancillary services. In addition, the sewage treatment plant will realize savings on tipping fees[1] avoided. Annual revenues will not exceed the annual costs of production and the high cost of the infrastructure relative to the size of generation will prevent the project from independently achieving commercial viability. With funding from NYSERDA and additional operating subsidies, the community microgrid in the Town of Somers is feasible and will help maintain critical services to the community and extend resilient electrical service to a low and moderate income community.

The microgrid will incur initial capital costs of $4.9 million as well as yearly operation, maintenance, and fuel costs totaling $130,000 per year. Overall revenue streams from the project are estimated at $120,000 per year and will be captured primarily through the sale of electricity during grid-connected mode and frequency regulation payments. The proposed microgrid's commercial feasibility depends on NY Prize Phase III funding and additional operating subsidies. On an annual basis, costs will exceed revenues, and when capital expenditures are included, the project does not cover its total costs in the absence of NY Prize Phase III grant money.

The Somers microgrid concept, with new reliable and renewable generation, storage, and the integration of existing energy resources, provides the Town with an energy resilience solution that is technically sound. The ability to island five critical facilities (per NYSERDA's definition), and three groups of residential and commercial facilities is a significant addition to the resilience of the Town in times of emergency and extended grid outages.

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[1] These are the payments made by sewage treatment plants and other to remove municipal solid waste offsite. These are conservatively estimated at $60 per ton. http://www.cleanenergyprojects.com/Landfill-Tipping-Fees-in-USA-2013.html.

1. Introduction

Somers is seeking to develop a community microgrid to improve energy service resilience, accommodate DERs and reduce greenhouse gas (GHG) emissions. Working with the Town of Somers and New York State Electric and Gas Corporation (NYSEG), a team from Booz Allen Hamilton (hereafter Booz Allen or the Project Team) designed a preliminary microgrid concept that will connect five critical facilities and three groups of residential facilities with six new DERs and one existing backup generator. The design proposes two new 300 kW solar PV arrays, a 15 kW anaerobic digester / biogas generator, and three new 1 MW / 4 MWh storage units. The design also incorporates an existing 500 kW diesel generator at the sewage treatment plant to provide support during islanded operation. 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.

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

- Many critical services in Somers do not have backup generation. These facilities are therefore vulnerable to prolonged interruptions or outages in grid-supplied power.
- Extreme weather events and seasonal weather changes cause energy price volatility, and consumers are seldom able to respond to these price signals. There are no clear incentives to shift load or self-generate in response to price changes.
- Electricity service in the region has occasionally been interrupted by extreme weather events such as winter storms, rainstorms, and heatwaves. A microgrid could provide needed resiliency to critical services in the Town.
- 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 DER technologies, increasing the viability of the proposed reciprocating generator and making energy from the solar arrays available even in grid outage scenarios.

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

Somers faces several challenges that could be resolved with a community microgrid as outlined in the Executive Summary above. The absence of natural gas infrastructure in Somers prevented the use of reliable, low emission DERs such as combined heat and power (CHP) units and fuel cells. The design instead relies on storage units, solar PV arrays, and limited load management to maintain continuous power supply in island mode. Although expensive, these DERs will make the energy supply in Somers more resilient and will lessen the strain on the local electricity network by reducing the need for power imports during peak demand events.

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

The NYSERDA statement of work (SOW) 66642 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 Somers microgrid will meet these criteria.

Capability	Required/ Preferred	Microgrid will meet (Y/N)
Serves more than one, physically separated critical facilities	Required	Y
Primary generation source not totally diesel fueled	Required	Y
Provides on-site power in both grid-connected and islanded mode	Required	Y
Intentional islanding	Required	Y[2]
Seamless and automatic grid separation/restoration	Required	Y
Meets state and utility interconnection standards	Required	Y
Capable of 24/7 operation	Required	Y
Operator capable of two-way communication and control with local utility	Required	Y
Load following while maintaining the voltage and frequency when running in parallel to grid	Required	Y
Load following and maintaining system voltage when islanded	Required	Y
Diverse customer mix (residential, commercial, industrial)	Required	Y
Resiliency to wind, rain, and snow storms	Required	Y
Provide black-start capability	Required	Y
Energy efficiency (EE) upgrades	Required	Y
Cyber secure and resilient to cyber intrusion/disruption	Required	Y
Microgrid logic controllers	Preferred*	Y
Smart grid technologies	Preferred*	Y
Smart meters	Preferred	N
Distribution automation	Preferred*	Y
Energy storage	Preferred	Y
Active network control system	Preferred*	Y
Demand response (DR)	Preferred	Y[3]
Clean power sources integrated	Preferred	Y
Optimal power flow (OPF) (economic dispatch of generators)	Preferred	Y
Storage optimization	Preferred	Y
PV observability, controllability, and forecasting	Preferred	Y
Coordination of protection settings	Preferred	Y
Selling energy and ancillary services	Preferred	Y
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.

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[2] 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 will not be feasible for economic purposes.

[3] The microgrid could participate in DR programs by discharging the battery storage units, but will not intentionally enter island mode unless there is a forecasted disturbance or outage.

2.2.1 Serving Multiple, Physically Separated Critical Facilities

Somers and the Booz Allen team have identified five facilities and three groups of residential and commercial units that will be connected to the microgrid. All five connected facilities will provide NYSERDA-defined critical services to the community in the case of an outage. See Table ES-1 for a full list of prospective facilities to be tied into the microgrid.

The proposed microgrid footprint occupies approximately 75 acres in Somers. Loads will be interconnected via the existing medium voltage (13.2 kilovolt (kV)) NYSEG power lines along Heritage Hills Drive, US Route 100, and US Route 202. Distributed microgrid equipment and control software will communicate over NYSEG'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 to accommodate future expansion and technologies.

2.2.2 Limited Use of Diesel Fueled Generators

Solar and storage energy are the primary energy source for the Somers microgrid. Combined with 12 MWh of battery storage, solar energy will provide relatively reliable energy throughout the year. However, in a long-term outage scenario the lack of natural gas infrastructure in Somers will limit the supply of energy to battery charge, available sun light, output from the biogas generator, and stockpiled diesel fuel. The diesel generator will only come on-line when the batteries have exhausted their charge and the solar arrays are not producing electricity. When the diesel generator comes on-line, it will operate continuously, charging the batteries when its production exceeds microgrid demand. When aggregate demand exceeds the generator's capacity, the batteries will discharge enough current to meet demand. It is important to note the microgrid control system (MCS) will deploy solar energy whenever it is available, which should minimize use of the diesel generator.

The Project Team expects the diesel generator will likely need to operate for up to 22 hours in order for the microgrid to provide seven days of continuous energy. The generator will therefore be equipped with a 1500 gallon storage tank.

2.2.3 Local Power in both Grid-Connected and Islanded Mode

The microgrid will provide on-site power in both grid-connected and islanded mode. In island mode, the MCS will optimize charge and discharge of battery storage units to maintain stable and reliable power flow. The control system is capable of shedding the Heritage Hills Residential Units in real time. Load shedding is crucial to the successful operation of the Somers microgrid, as the supply of energy in island mode is limited by battery charge and availability of sun light. In grid-connected mode, the microgrid will optimize the use of available assets to reduce energy costs when possible and export to the larger NYSEG grid when economic and technical conditions align.

The solar arrays will stay online throughout the year, selling energy to NYSEG under a long-term power purchase agreement (PPA). The battery storage units may engage in some degree of energy arbitrage, frequency regulation, or peak shifting on a daily basis, but must maintain a high level of charge to prepare for unexpected emergency outages. The backup diesel generator will come on-line in island mode as necessary to meet microgrid load.

2.2.4 Intentional Islanding

The microgrid will intentionally switch to island mode when doing so will result 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.

Upon a command from the system operator, 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 will open the incoming utility line breaker. After completing the transition to island mode, the MCS must maintain system voltage and frequency between acceptable limits and adjust output from the battery storage units to match aggregate load.

Because the Somers microgrid is located in the middle of a feeder line, it will disconnect downstream non-microgrid loads when it operates in island mode. The microgrid therefore will not switch to island mode to participate in DR programs or to beat high electricity prices during peak demand events.

2.2.5 Resynchronization to NYSEG Power

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

The microgrid design requires a new automated switch along US Route 100 to serve as the point of common coupling (PCC) between the microgrid and NYSEG’s system. The control system will trigger the opening or closing of this breaker, as appropriate, during system transitions.

2.2.6 Standardized Interconnection

The microgrid design complies with New York Public Service Commission (NYPSC) interconnection standards. Table 2 outlines the most significant state interconnection standards that apply to this microgrid project. Customers that wish to connect DERs to NYSEG’s system must follow the same New York State Standard Interconnection Requirements identified in Table 2.

Table 2. New York State Interconnection Standards

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
Common	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
Synchronous Generators	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: • Solid grounding • High- or low-resistance grounding • High- or low-reactance grounding • Ground fault neutralizer grounding
Induction Generators	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, NYPSC	

2.2.7 24/7 Operation Capability

The project concept envisions solar energy as the microgrid's main generation source. Three 4 MWh battery storage units will considerably enhance the reliability of the microgrid's energy supply, and a 500 kW diesel generator will come on-line as necessary in island mode. The proposed DERs should be capable of supporting at least seven days of continuous load from the microgrid's critical facilities, and may even be able to energize the Heritage Hills Residential Units at times by bringing the diesel generator on-line. The diesel generator will be equipped with a 1500 gallon tank, which will support around 21.4 hours of continuous operation and augment the DERs ability to ensure service over a seven day outage.

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 Somers. The new automation solution proposed in this report will serve as a protocol converter to send and receive all data available to the operator over NYSEG's WAN using industry standard protocols such as DNP3, OPC, Modbus, 61850, and ICCP (IEC 60870-6).

2.2.9 Voltage and Frequency Synchronism When Connected to the Grid

Microgrid controllers will automatically synchronize the frequency and voltage of all DER-generated power, which will include rotating 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 its comparatively higher electrical and mechanical inertia filters out most fast dynamics. In contrast, the microgrid will be quite sensitive to fluctuations in load or generator output. It is therefore crucial to constantly monitor and regulate DER output, especially from the battery storage units, against aggregate load in real time.

2.2.10 Load Following and Frequency and Voltage Stability When Islanded

The microgrid's control scheme in island mode is quite similar in operations to that of the larger transmission system. The system maintains frequency by controlling discharge from the battery storage units and regulates voltage by controlling reactive power availability. To the degree that flexible loads are available, the MCS can curtail facility load. A new automated isolation switch will allow the MCS to disconnect the Heritage Hills Residential units in real time.

If generation and discharge 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 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.

2.2.11 Diverse Customer Mix

Connected facilities have different effects on power quality and stability based on load size and economic sector. A microgrid with too many industrial and/or digital electronics-based loads may be less reliable because these loads can negatively affect power quality and stability. The Somers microgrid will connect five facilities and three groups of residential and commercial units. No individual facility will have a significant negative impact on local power quality. The approximate load breakdown by sector for the Somers microgrid is as follows:[4]

- Sewage treatment plant – 41% of load
- Pharmacy and Surgical – 22% of load

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[4] Estimated based on each facility's typical monthly electricity consumption from 2014.

- Heritage Hills Residential Units – 18% of load
- Municipal Facilities – 5% of load
- Mount Kisco Medical Group – 6% of load
- Load Clusters 1 and 2 – 8% of load

The microgrid is capable of shedding the Heritage Hills Residential Units, which represent approximately 18% of aggregate load by consumption.

Together the sewage treatment plant, Somers Pharmacy and Surgical, and the Heritage Hills Residential Units use around 63% of the microgrid's electricity. Targeted energy efficiency upgrades at these facilities could significantly reduce each facility's (and therefore the microgrid's) average electricity demand (see Section 2.214 for more details).

2.2.12 Resiliency to Weather Conditions

Somers is exposed to the normal range of weather conditions that affects the Northeastern United States. Extreme weather events include, but are not limited to, torrential rain, snow, and wind that could cause falling objects and debris to disrupt electric service and damage equipment and lives. 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. At minimum, the new biogas generator will be enclosed inside a container on the sewage treatment plant's property.

However, severe weather events will significantly reduce the microgrid's energy generation potential. The Project Team estimates the solar arrays will produce 9 MWh during the worst week of the year, but several continuous days of rain or cloudy weather could strain the microgrid's limited energy resources.

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 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 Somers 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.

2.2.13 Black Start Capability

The proposed battery storage units and diesel generator will be equipped with black-start capabilities. If the Somers grid unexpectedly loses power, the microgrid control system will initiate island mode by orchestrating the predefined black start sequence. The storage units will ramp up to 60 Hz and prepare to supply the microgrid loads. The MCS will bring the biogas generator on-line and synchronize its output. After the storage units have established a stable power supply, the MCS will synchronize output from the solar arrays and bring them on-line. The diesel generator will only come on-line when the battery storage units have exhausted their charges. It will require an auxiliary source of direct current (DC) power to start multiple times in case of failure.

2.2.14 Energy Efficiency Upgrades

EE is critical to the overall microgrid concept. There is significant potential for EE upgrades in Somers—the Project Team was unable to confirm any EE upgrades that have been implemented in microgrid facilities.

The Project Team estimates the reduction potential for the five included facilities and three load groups to be approximately 20 kW. The project will leverage existing NYSEG EE programs to reduce load at existing facilities and will seek to qualify for NYSERDA funded EE programs.

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.

Because the logic controllers (IEDs) will be located at or near loads, the distributed equipment will take the IT system to the “edge” of the network, where it may be more vulnerable to hackers. A practical tool to prevent unauthorized access into the IT network is a program called sticky media access control (MAC). Every network attached device has a media access control MAC interface that is unique to it and will never change. The sticky MAC program will monitor the unique address of the device and its designated network port, and 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 IED is to provide monitoring and control capabilities of the object being controlled. The Project Team believes this is a required capability.

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, ICCP (IEC 60870-6) and more as required. The Project Team believes this is a required capability for the proposed microgrid.

2.2.18 Smart Meters

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

2.2.19 Distribution Automation

The automation solution outlined in this study for Somers's microgrid 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).

2.2.20 Energy Storage

The Somers microgrid includes three zinc air battery units, each rated at 1 MW/4 MWh. The MCS will optimize these storage resources for peak shifting, energy arbitrage, and possibly sale of ancillary services to the New York Independent System Operator (NYISO). By "stacking" different uses of energy storage (i.e., microgrid resiliency, frequency regulation, and PV integration), microgrid owners may be able to increase the returns from these expensive units.[5]

2.2.21 Active Network Control System

The MCS will continuously monitor and control the microgrid in both grid-connected and islanded modes. 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 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 site's fiber optics backbone partitioned using gigabit Ethernet switches.

2.2.22 Demand Response

The Somers microgrid will not intentionally switch to island mode to participate in DR programs because doing so would disconnect downstream NYSEG customers. The microgrid's participation in DR programs will therefore likely be limited to curtailing flexible loads and discharging available energy from the battery storage units. These units should reliably have at least 1 MWh of energy available for DR programs, so microgrid owners may be able to bid capacity into the required response programs (CA$HBACK plus).[6] However, participation in NYSEG DR programs is not as lucrative as participation in the NYISO frequency regulation market.

2.2.23 Clean Power Sources Integration

Solar coupled with battery storage will provide the microgrid with zero emission electricity throughout the year. Battery storage systems will enhance the reliability of the energy supply and will allow the microgrid to operate in islanded mode for multiple days. In the future it may be possible to expand the footprint or generation assets to include additional clean power sources.

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[5] Lazard's Levelized Cost of Storage Analysis, Version 1.0.

[6] 1 MWh is the approximate minimum energy total that will be required to participate in NYSEG's programs.

At that time, the Project Team will consider biomass, expanded solar, and expanded battery storage. More detailed methods to capture and convert energy by electric generators or inverters will be explored at a later time.

2.2.24 Optimal Power Flow

The proposed community microgrid has an average load of approximately 267 kW and a peak load of 593 kW. Because of the intermittent nature of solar energy production, NYSEG may negotiate a variable fee for microgrid-produced power. If so, the battery storage units will allow the microgrid to sell power to NYSEG at premium prices and store power when prices are low. The Project Team has assumed that solar energy will be valued at NYSEG's average local supply price because the ownership model may not qualify the system for net metering. If possible, the MCS will fully utilize the optimum output of generation sources at the lowest cost in a unique approach that includes maintenance, energy cost, and market prices as part of security constrained optimal power flow (SCOPF).

2.2.25 Storage Optimization

The storage systems 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 these systems. Possible uses for storage include reducing peak demand, participating in NYISO ancillary service 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 inverters will usually operate at their maximum power point (MPP) because there is no associated operation and maintenance (O&M) cost. In some rare situations, the solar arrays might have to reduce their output to help regulate frequency of local power flow or follow facility electricity demand in island mode. 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 depends on weather and time of day.

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.

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 islanded mode, which may complicate the necessary protection strategy. In later phases of this study, the microgrid designer will perform protection studies that account for possible bidirectional power flows and low fault current detection which can occur when the microgrid is operating in island mode.

2.2.28 Selling Energy and Ancillary Services

It is unclear whether the microgrid will be permitted to back-feed power through Somers's main substation into the broader NYSEG transmission system. The battery storage units may allow the microgrid to selectively sell energy at high prices. If allowed, the microgrid will sell energy from the solar arrays to NYSEG, the Project Team has assumed that electricity from the solar arrays will be valued at NYSEG's average local supply price.

Most lucrative NYISO ancillary service markets, such as the frequency regulation market, require participants to bid at least 1 MW of capacity. The microgrid's generation assets have an aggregate capacity of 4.115 MW, and average aggregate load in 2014 was 267 kW. Participation in these ancillary service markets is easily possible, but it is important the storage units maintain a certain level of charge to remain prepared for an unpredicted emergency outage. Other ancillary service markets, such as spinning and non-spinning reserves, do not provide competitive payments to relatively small scale generators. However, by selectively selling reserves when prices are high, participation in these programs may be economically viable.

2.2.29 Data Logging Features

The microgrid control center includes a Historian Database to maintain real-time data logs. The Historian Database displays historical trends in system conditions and process variables, and can also be used to predict future events such as system peaks with its built-in statistical analytics tool.

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 sale of energy to NYSEG in grid-connected mode and sale of energy directly to microgrid facilities in island mode. Investors will receive revenue from electricity sales to NYSEG and possibly from participation in ancillary service programs. However, it is unlikely this revenue will recover the project's capital costs without extra incentives or grants. 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 one of this feasibility study's main objectives. The Project Team has engaged with all involved parties to understand their specific needs and constraints. Additional detail about costs and benefits by stakeholder group can be found in Section 3.2.3.

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 town 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 Somers microgrid design includes two 300 kW solar PV arrays, a 500 kW diesel backup generator, a 3 MW/ 12 MWh battery storage system, and a 15 kW anaerobic digester and gas generator system. This section will describe the benefits and costs of the proposed resources and discuss how they will meet the microgrid's objectives in greater detail.

2.3.1 Existing Generation Assets

The Somers microgrid will incorporate the existing diesel generator at the Heritage Hills Sewage Treatment Plant. This asset will only come online in island mode when the battery units have exhausted their charge and the solar PV arrays are not producing sufficient electricity to meet microgrid demand. When it comes online, the generator will operate at full or nearly full capacity, charging the battery storage units when aggregate demand is below the generator's output. The generator will be outfitted with grid paralleling switchgear and controllers to regulate and synchronize its output.

2.3.2 Proposed Generation Assets

The microgrid design includes four new generation assets: two 300 kW solar PV arrays, a battery storage system consisting of three 1 MW/4 MWh battery storage units, and a net 15 kW anaerobic digester and gas generator (shown in Table 3). One of the solar arrays, all three battery storage units, and the anaerobic digester system will be located at the sewage treatment plant—the 300 kW solar PV array will be mounted above the storage tanks to the northeast of the building, the battery units will be placed on the grass north of the building, and the anaerobic digester system will be placed on the grass south of the building. Each battery system needs enough space for four 40 foot shipping containers.

Table 3. Proposed Generation Assets

Table shows the rating, fuel, and address for proposed generation assets.

Name	Technology	Rating (kW)	Fuel	Address
DER2	New anaerobic digester and gas generator system	15	Solid waste	8 Heritage Hills Dr.
DER3	New carport solar PV array	300	Sunlight	8 Heritage Hills Dr.
DER4	New zinc air unit	1 MW/4 MWh	N/A	8 Heritage Hills Dr.
DER5	New zinc air unit	1 MW/4 MWh	N/A	8 Heritage Hills Dr.
DER6	New ground-mount solar PV array	300	Sunlight	263 Rt. 202
DER7	New zinc air unit	1 MW/4 MWh	N/A	8 Heritage Hills Dr.

2.3.3 Generation Asset Adequacy, Resiliency, and Characteristics

The proposed design provides Somers with multiple additional energy resources. In grid-connected mode, the microgrid's solar arrays will sell electricity to NYSEG at the utility's average local supply price. In islanded mode, the solar arrays will charge the battery storage units and export excess energy to connected facilities if the storage units are fully charged. When the solar arrays are not producing electricity, the battery storage units will discharge available power to energize microgrid facilities.

One of the NYSERDA-defined required microgrid capabilities is to provide continuous power for seven days. The microgrid's average weekly electricity consumption is approximately 45 MWh. By shedding the Heritage Hills Residential Units, the Somers microgrid can reduce this weekly consumption to around 37 MWh. Assuming their charge has been maintained, the battery storage units can provide 12 MWh of electricity over the course of a week. The Project Team estimates the solar arrays can produce approximately 17 MWh per week under normal operating conditions and that the biogas generator can produce an additional 2.5 MWh per week—combined with the battery storage units, this level of production would require around 5.5 MWh of energy from the diesel generator (11 hours of continuous operation) to reach the seven day requirement.[7] Alternatively, if the microgrid operator wished to maintain power to the Heritage Hills Residential Units, the microgrid would require approximately 13.5 MWh of energy from the diesel generator (27 hours of continuous operation).

However, many outages are caused by extreme weather events that would also diminish output from the solar PV arrays. The Project Team estimates that during worst week of a given year the solar arrays could produce approximately 9 MWh. Combined with the battery storage units and output from the anaerobic digester system, this gives the microgrid around 23.5 MWh of energy supply. Under these conditions, the microgrid would require around 13.5 MWh (27 hours of continuous operation) from the diesel generator to power core microgrid loads or 21.5 MWh (43 hours of continuous operation) to power the entire microgrid for seven days. The existing diesel storage tank (550 gallons) will need to be expanded to hold approximately 1,500 gallons in order to accommodate this fuel capacity.[8]

After the battery storage units have been depleted, the MCS will always seek to replenish charge by deploying energy from the solar PV arrays. However, if the solar arrays are not producing sufficient electricity, the 500 kW diesel generator will come on-line and operate continuously until it exhausts its fuel supply, output from the solar arrays increases, or power returns to the larger grid. When aggregate microgrid demand is less than 500 kW, the generator will charge the battery storage units. When aggregate demand exceeds 500 kW, the battery storage units will discharge the necessary power to maintain power flow through the microgrid coverage area.

The proposed assets will be safe from a range of severe weather events. The anaerobic digester system will be placed inside an enclosure on the sewage treatment plant's land, and the battery storage units will be similarly enclosed. However, as discussed above, weather may significantly diminish the output from the solar PV arrays.

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 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,

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[7] Estimates of solar energy production derived from PV SYST software.

[8] Assuming 70 gallons per MWh, a 1500 gallon tank will allow the diesel generator to operate for around 21.4 hours.

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 Somers 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.

The battery storage units will normally maintain system stability in island mode. The diesel generator may also maintain system stability when it operates. The battery storage units and diesel generator can provide:

- Automatic load following capability – the DERs will be able to respond to frequency fluctuations within cycles, allowing the microgrid to balance demand and supply in island mode.
- Black-start capability – the diesel backup generator will have auxiliary power (batteries) for black starts and can establish island mode grid frequency. After the storage units or diesel generator have established stable power flow, the main microgrid controller will synchronize the solar arrays to match the target frequency and phase and bring them online.
- Conformance with New York State Interconnection Standards.[9]

2.4 Load Characterization (Sub Task 2.2)

The Project Team sized proposed DERs according to electricity demand data from Somers's load points. The load characterizations below describe the electrical loads served by the microgrid.[10] Descriptions of the load sizes to be served by the microgrid along with redundancy opportunities to account for downtime are included below.

2.4.1 Electrical Load

The Project Team evaluated five primary electrical loads and three load clusters for the Somers microgrid. For aggregate weekly, monthly, and yearly energy consumption data as well as average and peak power demand, see Table 5. For a cumulative 24 hour load profile, see Figure 2. Typical 24-hour load profiles for each facility can be found in the Appendix.

Somers's proposed community microgrid will incorporate the local sewage treatment plant, several municipal buildings, a health facility, and three groups of residential loads. All included facilities are connected to the primary NYSEG feeder in Somers (Golden Bridge 420).

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[9] 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*.

[10] Estimated loads are based on monthly metering data from the facility's account numbers via NYSEG's on-line metering portal wherever possible. The Project Team simulated load data for the following facilities: the Heritage Hills Sewage Treatment Plant, Somers Pharmacy and Surgical, Mount Kisco Medical Group, Heritage Hills Residential Units, and both load clusters.

Table 4. Town of Somers List of Prospective Microgrid Facilities

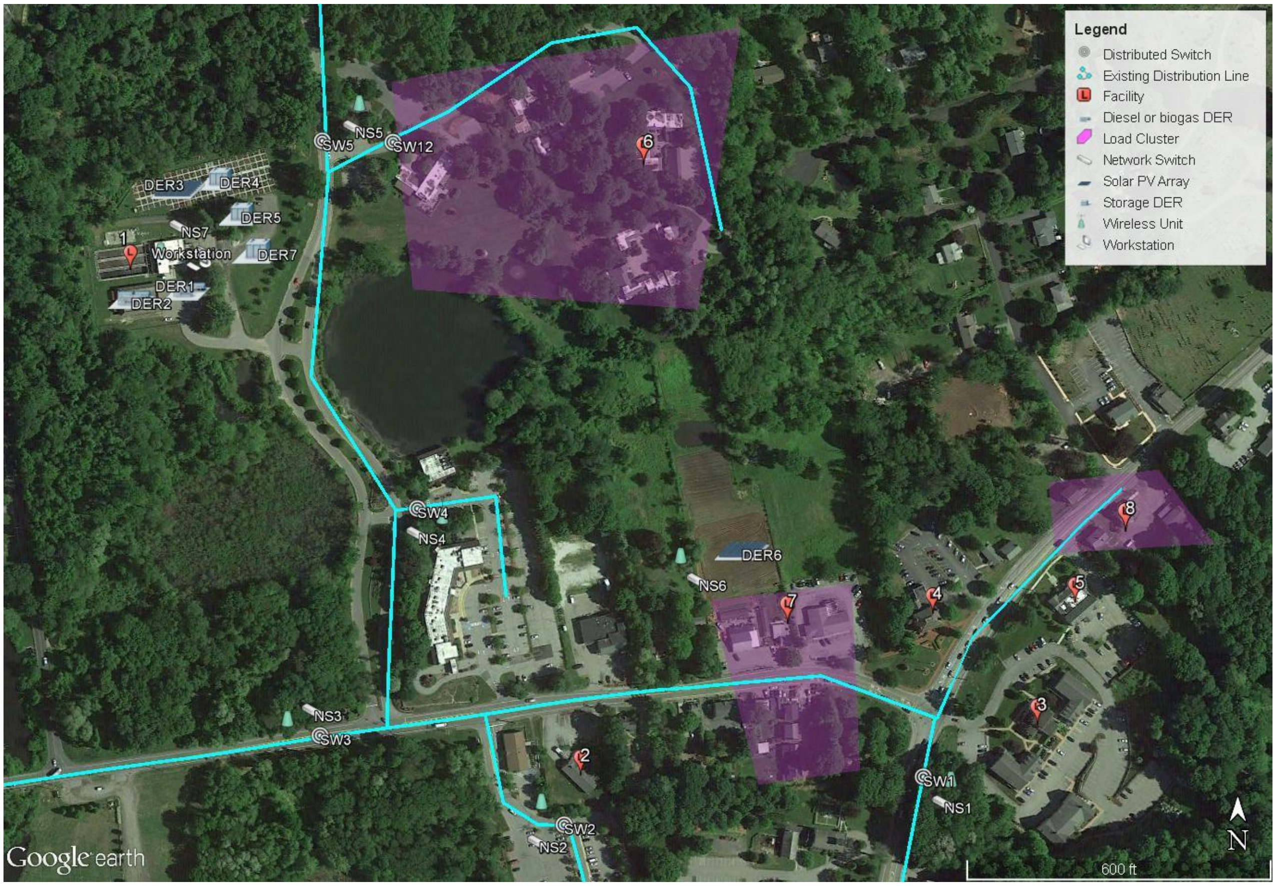
Table lists potential microgrid facilities, including their addresses and classifications.

	Property	Address	Classification
1	**Heritage Hills Sewage Treatment Plant**	8 Heritage Hills Dr	Infrastructure
2	**Somers Fire Station**	270 Rt. 202	Public
3	**Somers Pharmacy and Surgical, Somers Eye Clinic, and a retail store**	336 Rt. 202	Commercial/Health
4	**Town Government Office and Elephant Hotel**	335 Rt. 202	Public
5	**Mt. Kisco Medical Group**	342 Rt. 202	Health
6	**Heritage Hills Residential Units**	1-5 Heritage Hills Dr	Residential
7	**Load Cluster 1**	263-265 Rt. 202	Residential/Commercial
8	**Load Cluster 2**	179-346 Rt. 202	Residential/Commercial

The design includes six new automated isolation switches and switchgear for every generation asset. The proposed loads are all on the same feeder, so the design does not require construction of new electric distribution lines. Figure 1 provides an illustration of the proposed microgrid design and layout, including loads, switches, existing electrical infrastructure, and proposed electrical infrastructure.

Figure 1. Somers Equipment Layout

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



NYSEG provided the Project Team with twelve months of metering data for the Town Government Office and Fire Station (January through December 2014), summarized in Table 5. The Project Team estimated other facility loads based on facility type, size, and approximate number of customers served. In 2014 the estimated aggregate peak load was 593 kW, and the average was 267 kW.

Because battery storage units are the microgrid’s main energy source, conserving power in long-term outages is key to maintaining the power supply. The microgrid is therefore capable of shedding the Heritage Hills Residential Units in island mode when necessary. Table 5 includes cumulative load estimates for full service and post-load shedding scenarios.

Table 5. Somers's 2014 Microgrid Load Points

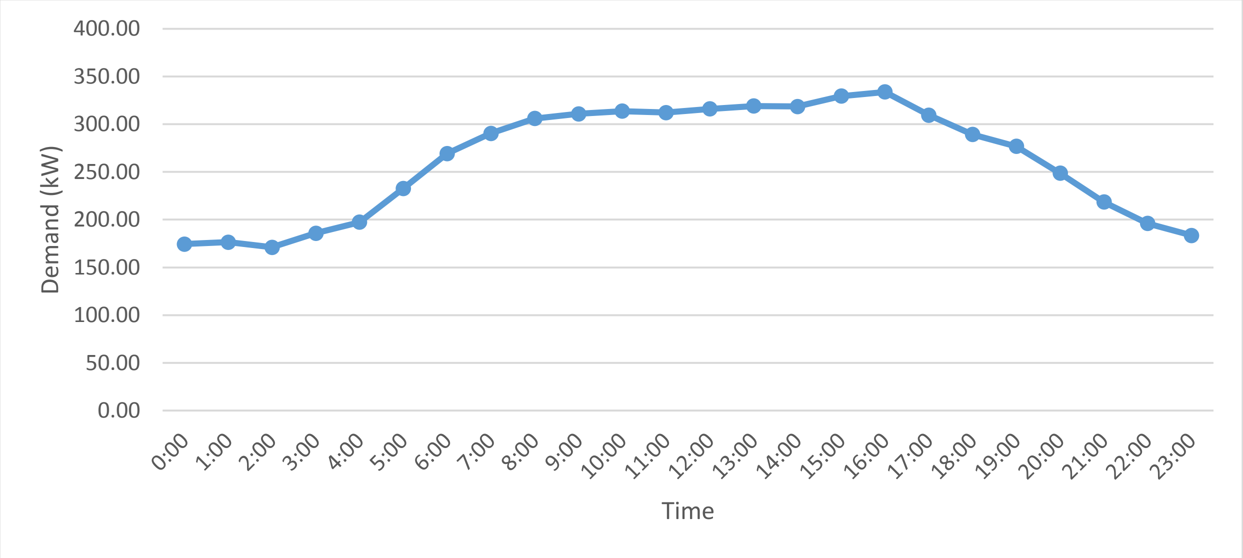
Table shows the microgrid electric demand in kW and electric consumption in kilowatt hour (kWh) for "full microgrid" and "post-load shedding" situations. Thermal consumption was deemed irrelevant because there is no natural gas infrastructure in Somers.

Scenarios	Electric Demand (kW)		Electric Consumption (kWh)		
	2014 Peak	2014 Average	2014 Annual	2014 Monthly Average	2014 Weekly Average
Microgrid Loads (Full)	593	267	2,343,778	195,315	45,422
Microgrid Loads (After load shedding)	462	218	1,915,278	159,607	36,832

Figure 2 provides a typical aggregate hourly load profile for Somers. Aggregate demand begins to increase before dawn, plateaus at around twice the night-time baseline throughout the day, and decreases back to the night-time baseline from 16:00 to 22:00.

Figure 2. Typical 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.



Although the output of the solar arrays 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 arrays are operating close to their name plate capacities, the microgrid's discharge capacity will approach 4.115 MW, with 500 kW from the diesel generator, 3 MW from the battery storage units, 600 kW from the solar PV arrays, and 15 kW from the anaerobic digester and gas generator system. Aggregate demand from microgrid facilities averaged 267 kW and never exceeded 593 kW in 2014.[11] The limiting factor on islanded operation will therefore be the total amount of energy stored in batteries rather than the peak discharge rate.

The Project Team expects some degree of natural load growth after construction of the microgrid. Because DERs 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 the threat of natural load growth by investing in EE upgrades or intelligent building energy management systems (BEMS) that respond to commands from the main microgrid controller. This is especially important in the Somers microgrid project, where there will be a finite supply of energy in islanded mode. Microgrid owners may also invest in additional supply-side resources such as small diesel generators or extra battery storage systems.

Because the design includes two solar arrays, each unit should have downtime available at various points throughout the year. However, the microgrid will need to rely on grid-supplied power and power from the diesel backup generator if the battery storage units are unavailable at any time.

2.4.2 Thermal Consumption

There is currently no natural gas infrastructure in Somers. Facilities and residential customers use electricity or fuel oil for thermal energy throughout the year. The absence of natural gas precluded the possibility of proposing a CHP unit, so the Project Team did not evaluate thermal consumption for the proposed facilities.

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 Parallel Mode

The microgrid will most often operate in grid-connected mode. In this mode, the proposed solar arrays will sell energy to NYSEG at the utility's average local supply price. The battery storage units will likely also participate in NYISO frequency regulation markets. The 15 kW gas generator (powered by gas from a new anaerobic digester at the sewage treatment plant) will stay online throughout the year, but will nearly always stay behind the meter to reduce its host facility's load. The microgrid design also includes one new diesel backup generator, but this

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[11] This number represents the highest aggregate monthly peak demand from 2014. Monthly peak demand was calculated by summing individual facilities' peak demand for the month. The final peak demand therefore assumes that facilities reached their individual monthly peak demands simultaneously, which is unlikely. The true peak demand was almost certainly less than 593 kW, but the Project Team was unable to obtain interval data for all included facilities.

DER will not come on-line in grid-connected mode. Refer to Table ES-2 for a complete list of microgrid DERs.

If the larger grid experiences an emergency 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 DERs. By injecting power into the larger grid, the microgrid may be able to balance frequency and voltage to avert an outage.[12] If the battery storage units and 15 kW gas generator have sufficient capacity to stabilize the larger grid system, they will immediately discharge the required power. However, the discharge from the storage units should not exceed a certain predetermined amount of power—as the microgrid's main source of energy in island mode, the battery units must always maintain a certain level of charge to prepare for emergencies.

2.5.2 Intentional Islanded Mode

The proposed energy management and control scheme will balance output from the solar arrays and battery discharge with microgrid demand to maintain adequate frequency, voltage, and power flow across the microgrid network in islanded mode. Islanded mode can be intentionally used during forecasted NYSEG grid outages or disturbances to maintain electricity supply for microgrid facilities—the system will manage the solar arrays, battery storage units, small gas generator, and diesel generator to match aggregate demand in real time. The battery storage units can provide real-time response to fluctuations in system frequency and voltage. Refer to the simplified one-line diagram in Figure 3 for a detailed device representation showing both existing and 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, the PCC, and the proposed utility infrastructure investment are also discussed below.

2.6.1 Electrical Infrastructure

The local utility, NYSEG, owns the existing electrical infrastructure in the Town of Somers. The Golden Bridge 420 line is the primary feeder in the area, and is the only feeder that supplies the microgrid coverage area with power. The proposed microgrid is located on the middle of the Golden Bridge 420 feeder, meaning new automated isolation switches will be necessary to disconnect downstream NYSEG customers. These customers will lose power when the microgrid operates in island mode, the microgrid will not switch to island mode in order to participate in demand response programs or beat high electricity prices. The proposed microgrid will not prevent outages throughout the larger grid, but will provide continuity of service to facilities within the footprint. Additionally, since the microgrid footprint includes public services (the fire

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[12] By averting a larger outage, the microgrid will provide value to the community of Somers as well as NYSEG. All involved parties therefore have incentive to support such a capability.

station) and infrastructure (sewage treatment plant), the full population of the Town of Somers (21,300 people) will benefit from the services of the microgrid in the event of an outage.

The PCC with the NYSEG system will be located along the Golden Bridge 420 feeder (SW1 in Figure 3). One new automated switch will disconnect the microgrid from this feeder at the PCC. Other isolation switches will disconnect downstream loads and provide the microgrid with load shedding capability. The existing switch that connects the 500 kW diesel generator to the sewage treatment plant must be upgraded to serve its function in the microgrid control scheme (SW6 in Figure 3).

All of the microgrid's generation assets (including the existing diesel generator) will require switchgear and controllers to communicate with the microgrid control system. See Figure 1 (Equipment Layout) for a map of proposed equipment and infrastructure. For a detailed outline of microgrid equipment, see the one-line diagram in Figure 3.

The following tables (Table 6 to Table 8) describe the microgrid components and are referenced throughout the rest of the document.

Table 6. Somers Distributed Switches Description

Table outlines distributed electrical switches with their names (on equipment layout), descriptions, and statuses.

Name	Description	New/Upgrade
SW1	Automatic switch for feeder isolation	New
SW2	Automatic switch for feeder isolation	New
SW3	Automatic switch for feeder isolation	New
SW4	Automatic switch for feeder isolation	New
SW5	Automatic switch for feeder isolation	New
SW6	OEM Diesel Generator Switch	Upgrade
SW7	OEM Biomass Generator Switch	New
SW8	OEM PV Inverter Switch	New
SW9	OEM Storage Inverter Switch	New
SW10	OEM Storage Inverter Switch	New
SW11	OEM PV Inverter Switch	New
SW12	Automatic switch for load shedding and Microgrid sequence control	New
SW13	OEM Storage Inverter Switch	New

Table 7. Somers's Network Switch Description

Table outlines all seven IT network switches with their descriptions, status as existing or proposed, and addresses.

Name	Description	Status	Address
NS1	Near Switch 1 for communication	Proposed	Refer to Eqp. Layout
NS2	Near Switch 2 for communication	Proposed	Refer to Eqp. Layout
NS3	Near Switch 3 for communication	Proposed	Refer to Eqp. Layout
NS4	Near Switch 4 for communication	Proposed	Refer to Eqp. Layout
NS5	Near Switches 5 and 12 for communication	Proposed	Refer to Eqp. Layout
NS6	Near DER 6 for communication	Proposed	Refer to Eqp. Layout
NS7	Near DER 1-5, DER 7, Supervisory Control and Data Acquisition (SCADA), and workstations for communication	Proposed	Refer to Eqp. Layout

Table 8. Somers's Server Description

Table describes the workstation and servers, their status as proposed, and their addresses. The Project Team has assumed that the servers will be placed inside the sewage treatment plant.

Name	Description	Status	Address
Workstation	Operator/Engineer workstation	Proposed	8 Heritage Hills Dr
Server1	Primary Energy Management System (EMS) and SCADA	Proposed	8 Heritage Hills Dr
Server2	Secondary EMS and SCADA	Proposed	8 Heritage Hills Dr

The NYSEG distribution system in Somers consists of medium voltage lines (13.2 kV). All branches off these medium voltage lines have their own transformers that step incoming power down to low voltage.

Figure 3. Somers One-Line Diagram

Figure displays a one-line diagram for Somers illustrating interconnections and lay-out.

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2.6.2 Points of Interconnection and Additional Investments in Utility Infrastructure

The proposed components and interconnection points for the Somers community microgrid are listed in Table 9. The PCC between the main grid and the microgrid will be located along the NYSEG Golden Bridge 420 feeder (SW1 in Figure 3). New automated circuit breakers and switches will be required to isolate the microgrid loads from the local NYSEG feeder and to segment loads during islanded operation.

The microgrid includes one new automated isolation switch that can disconnect the Heritage Hills Residential Units in island mode (Load 6 in Figure 3). Load shedding capability will help the MCS maintain system stability and conserve energy. This capability will be especially valuable in long-term outage situations.

The MCS will also have precise control over the discharge rate of battery storage units and output from the diesel backup generator. The battery storage units' immediate discharge capability will allow the MCS to provide voltage and frequency control within the millisecond response intervals required for maintaining a stable microgrid.

Table 3. List of Components

Table lists all the distribution devices/components included in the microgrid design.

Device	Quantity	Purpose/Functionality
Microgrid Control System Protocol Converter (Siemens SICAM PAS or equivalent)	1 Primary 1 Back-up	Protocol Converter responsible for operating the microgrid's field devices via protocol IEC-61850.
Automated, Pole Mount Circuit Breaker/Switches (Siemens 7SC80 relay or equivalent)	6	New relays/controllers at pole mounted distribution switches/breakers. These components will isolate the microgrid from the feeder and downstream loads, and enable load shedding in island mode. They include synchro-check capability.
Generation Controls (OEM CAT, Cummins, etc.) **Load Sharing (Basler or equivalent)**	2	OEM Generation controllers serve as the primary resource for coordinating generator ramp up/ramp down based on external commands and reaction to Microgrid load changes Basler distributed network controllers allow a primary generator to establish Microgrid frequency and supply initial load, while also managing load sharing between other spinning generators. Also manages paralleling sequence.
PV Inverter Controller (OEM Fronius or equivalent)	2	Controls PV output and sends live solar/power output data to SCADA and EMS for forecasting/decision making input.
Storage Inverter Controller (OEM Fronius or equivalent)	3	Controls battery storage input/output and sends live power data to SCADA and EMS for forecasting. Receives charge/discharge commands from SCADA Microgrid control.
Network Switch (RuggedCom or equivalent)	7	Located at IEDs and controllers for network connection, allowing remote monitoring and control.

All microgrid devices will 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. The device current draw (amperage used by each device) should not exceed 60% of the available power supply. When the normal AC voltage source is unavailable, the battery bank can provide DC power to devices for at least one week.

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. Currently, protection schemes are based on the assumption that power flows in one direction. Microgrid operations, particularly during island mode, 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 NYSEG grid. However, the microgrid is capable of exporting energy back to NYSEG.

2.6.4 Thermal Infrastructure

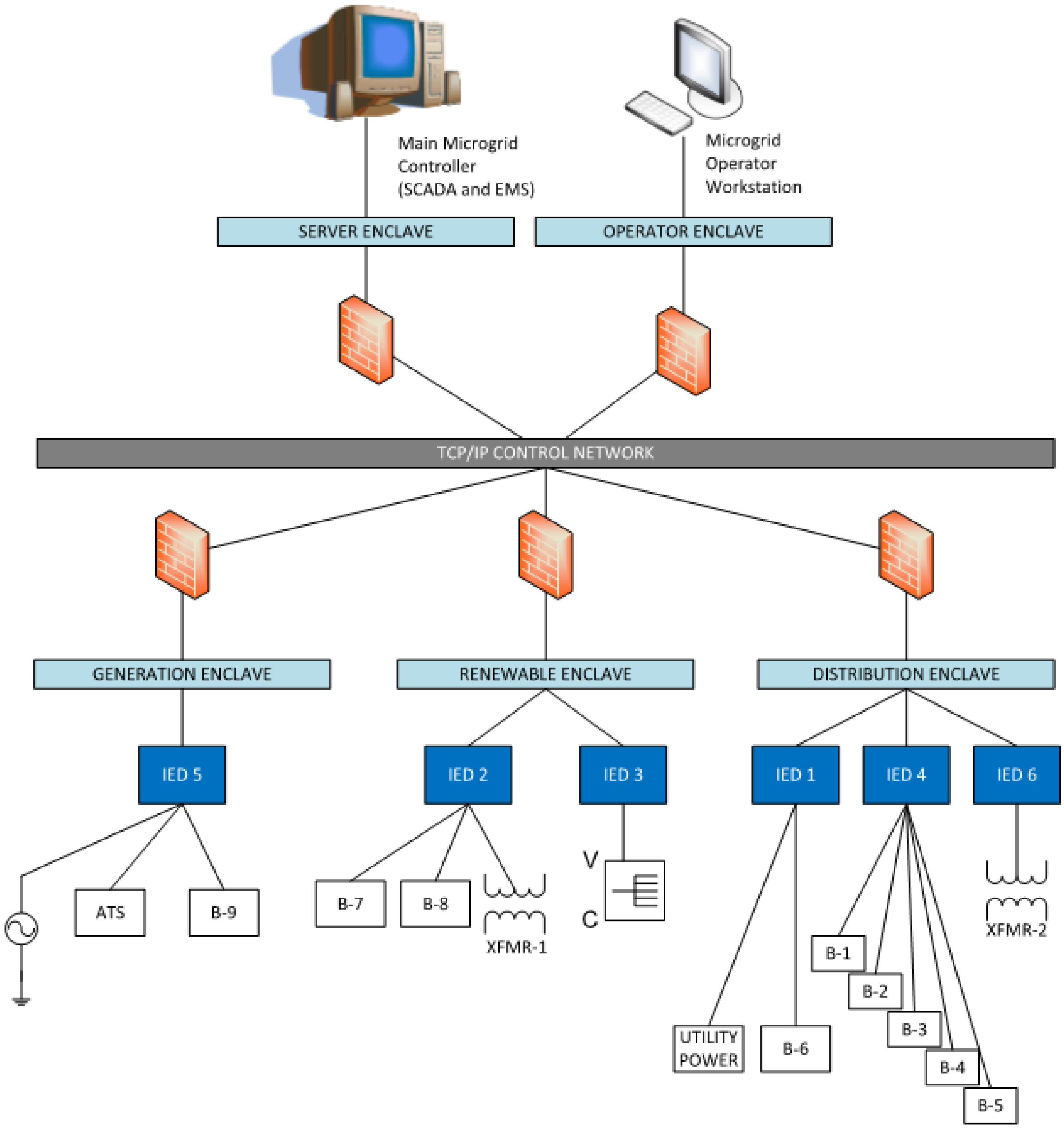
There is no natural gas infrastructure in Somers. Facilities and residential customers use electricity or fuel oil for thermal energy throughout the year.

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 4), hereafter collectively referred to as the main microgrid controller. Distributed IEDs 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 larger grid and will have the potential to export excess electricity to NYSEG. When controllers detect an outage or emergency disturbance on the larger 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 NYSEG grid (described in Section 2.7.7).

Figure 4. Diagram of Representative Microgrid Control System Hierarchy

The following network diagram illustrates a conceptual 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 Energy Management System (EMS) server and client workstation node.



2.7.1 Microgrid Supporting Computer Hardware, Software, and Control Components

The following is a preliminary list of hardware components needed for Somers'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 (EMS) and Supervisor Control and Data Acquisition (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 – The microgrid requires automated switches and breakers to isolate the microgrid from the local feeder and disconnect downstream loads. Other control elements at or near individual loads will allow the MCS to shed loads and conserve energy in islanded mode.
- Utility breakers and controls – These automatic controls will interface between the microgrid and the main NYSEG feeder (Golden Bridge 420).
- 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 Service Oriented Architecture (SOA) software that serves as the messaging and integration platform for the monitoring and control of distributed equipment. The SOA is vendor-agnostic—it 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:

- 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 when to shed the Heritage Hills Residential Units, integrating PV output into the energy portfolio (including high resolution solar forecasting), and controlling the charge/discharge of energy storage units. 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.
- Application servers (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 or equivalent relay) – The microprocessor based logic controllers, also referred to as IEDs, are located at or near loads and 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.
- PV Inverter Controller (OEM, Fronius, etc.) – These components will control output from the solar PV arrays and send data to the MCS for forecasting.
- Storage Inverter Controller (OEM, Fronius, etc.) – These components will control output from the battery storage units and convert DC to AC power before it reaches the microgrid.

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

2.7.2 Grid Parallel Mode Control

When the microgrid operates in grid-connected mode, every on-line DER will synchronize its voltage (magnitude and phase) and frequency with the voltage (magnitude and phase) and frequency of the electrically closest interconnection point with the main grid. After initial synchronization, the DER voltage phase will drift away from the main grid's voltage phase, which is caused by active and reactive power flow. The DER'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 battery storage units are capable of providing ancillary services to the NYSEG grid to enhance the reliability of the system. These services can include frequency regulation, spin/non-spin reserve, and voltage support. The microgrid control system may also use batteries for energy arbitrage, or purchasing electricity from the larger grid at low prices and selling it back at a higher price when demand is highest.

Please refer to the **Error! Reference source not found.** in the Appendix for the control scheme sequence of operations.

2.7.3 Energy Management in Grid Parallel Mode

The proposed microgrid will integrate software and hardware systems to ensure reliability and effective performance. Optimization of microgrid performance involves three distinct phases: measurement and decision, scheduling and optimization, and finally 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 prioritize loads, 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 battery discharge 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 switch will open automatically, disconnecting the microgrid from the larger grid. Any existing on-line generation will be disconnected 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 battery storage units’ black-start capabilities, the MCS will commence island mode operation.[13] If battery storage units are unavailable or have exhausted their charge, the diesel generator can initiate power flow through the microgrid. The battery storage unit or diesel generator will ramp up to 60 Hz and prepare to supply each of the microgrid loads in sequence. After power flow through the microgrid is stable, the main

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[13] Battery storage units can reliably perform black starts if they have sufficient charge. See http://www.irena.org/DocumentDownloads/Publications/IRENA_Battery_Storage_case_studies_2015.pdf.

microgrid controller will synchronize output from the solar arrays (voltage and frequency) and bring them on-line. In steady state, voltage amplitudes and frequencies will remain synchronized while voltage phases will drift apart.

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 NYSEG grid has an expected outage that could potentially affect transmission power to Somers substations.
- The NYSEG grid needs to perform network maintenance work, thereby isolating loads in the Somers 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 parallel the generation assets. The battery storage units or the diesel generator may set the system frequency. Once the available power sources are synchronized, the system is considered ready to implement islanded operation and will open the incoming utility line breaker.

Please refer to **Error! Reference source not found.** in the Appendix for the control scheme sequence of operation.

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 to ensure the microgrid is operating as expected and power flow is stable and reliable. The MCS will gather data on power flow, short circuit, voltage stability, and power system optimization using an N+1 (N components plus at least one independent backup component) contingency strategy to determine whether additional load can be added.[14] The N+1 strategy ensures extra generation is always online to handle the loss of the largest DER and assumes the on-line DER with the highest capacity could go off line unexpectedly at any time. It should be noted that low-priority loads may be disconnected in order to maintain the N+1 power assurance.

The microgrid must also be capable of handling any contingencies that may occur within the islanded system. These contingencies include, but are not limited to:

- Battery storage units exhaust available charge.
- Storage units or PV arrays trip off unexpectedly during microgrid operation.
- Switchgear fails to operate.
- Switchgear fails to report status.
- Loss of power from the diesel generator.

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[14] The microgrid control system only truly has control over the Heritage Hills Residential Units (Load 6) in the current design, but by installing intelligent Building Energy Management Systems or additional isolated switches, future operators of the microgrid can expand load shedding and demand side management capabilities.

- Loss of power from the solar arrays.

The MCS will optimize the microgrid's operation by managing generation assets and prioritizing loads according to operational requirements. Proposed DERs will provide stable, sustainable, and reliable power. The MCS will continuously balance generation and load in real-time, monitoring relevant variables (i.e., system frequency and voltage) and adjusting DER output as necessary. The main microgrid controller will first deploy energy from renewable generation assets and adjust output from the battery storage units to match remaining electricity demand. In the event that the battery storage units exhaust their charge in island mode, the diesel generator will come on-line. The microgrid design relies on the battery storage units to store and shift energy from the solar arrays.

The proposed battery storage units may be used for multiple purposes:

- Long-term storage: Long-term backup, to be used in conjunction with solar PV arrays and diesel generators to maintain power in a long-term outage.
- Ancillary services: Frequency regulation (enhances stability by providing an immediate response to a change in system frequency), spin/non-spin reserves (providing capacity to the NYISO), and voltage support (ensure reliable and continuous electricity flow across the grid).
- Shifting solar output: Storing excess generation from the solar PV arrays 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).
- Energy arbitrage: Similar to shifting solar output, but instead of storing excess generation from the solar arrays, the microgrid will purchase wholesale electricity from the NYISO when the Location Based Marginal Price (LBMP) is low and sell it back to the NYISO when the LBMP is high.
- Black starts: The units can start power flow through the microgrid in the event of an unplanned larger grid outage.

2.7.6 Black Start

The proposed battery storage units and diesel generator will be equipped with black start capabilities. If the Somers grid unexpectedly loses power, the main microgrid controller will initiate island mode by orchestrating the predefined black start sequence. The microgrid then begins the unintentional transition to island mode. A DC auxiliary support system is an essential part of the diesel generator's black start capabilities. The battery system must have 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 DERs are disconnected.

3. The main microgrid controller waits a pre-set amount of time (approximately 30 seconds) in case power returns to the NYSEG grid.
4. The main microgrid controller disconnects the entire current load (after estimating aggregate electricity demand).
5. The microgrid DERs are synchronized with each other (one of the battery storage units will usually provide reference voltage and frequency).
6. The main microgrid controller reconnects the microgrid loads based on the available generation and a predetermined load priority order.

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). If one of the battery storage units malfunctions or the diesel generator does not start as expected during a utility outage, the MCS is equipped with contingency algorithms to appropriately manage the situation. If possible, the main microgrid controller will still isolate the microgrid, but only critical loads will be energized.

The MCS will allow operators to designate certain DERs as unavailable for participation in the microgrid (e.g., if they require maintenance) so the DER dispatch and load shedding algorithms can accommodate a reduced available capacity.

Please refer to the **Error! Reference source not found.**in the Appendix for the control scheme sequence of operations.

2.7.7 Resynchronization to NYSEG Power

When power is restored to the larger grid, the main microgrid controller will coordinate a safe and orderly reconnection. The system will first wait a predefined, configurable time period to ensure power has been reliably restored and then will commence resynchronization with the NYSEG power supply. As a final check, the system operator will either receive an automated notification or directly contact NYSEG to confirm that power flow on the larger grid is on-line and stable.

While operating in island mode, the system will constantly monitor the status of the utility feeder at the PCC and determine when nominal frequency and voltage have been restored. When power is restored, the main microgrid controller will disconnect the solar arrays and synchronize output from the battery storage units with the utility service through the utility circuit breaker. Before the microgrid system starts paralleling with the utility, it will balance local generation and load so as not to exceed either minimum or maximum export limits or time durations set forth in the utility interconnection agreement. When microgrid power flow has been synchronized to the larger grid, the main microgrid controller will bring the solar arrays back on-line and stop discharge from the battery storage units. Depending on available charge, the batteries may need to charge for a significant period of time after reconnection to the larger grid.

Please refer to the Somers Microgrid Operation One-Line: Parallel Mode (from Islanded Mode) in the Appendix for the control scheme sequence of operations.

2.8 Information Technology and Telecommunications Infrastructure (Sub Task 2.6)

The existing IT and telecommunication infrastructure at Somers 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 sewage treatment plant, which is electrically served by the microgrid in islanded 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

Somers 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 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 (1) design and planning, and (2) continuous operations. Cyber security is especially important for the microgrid control system as it 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 the Operating System security teams.

For the planning stage, design considerations address cyber security by assigning roles to network-attached components on NYSEG's WAN thereby controlling data flow and access permissions over the integrated MCS and overarching IT architecture.[15] For example, the 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

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[15] Assumes the microgrid will utilize enterprise-level remote monitoring and control.

continuous monitoring and control of data flow. The firewall routes noncritical traffic such as 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" 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 network, where it is potentially more vulnerable to hackers. Sticky media access control (MAC) is an inexpensive and practical program that can help prevent unauthorized access and protect the NYSEG IT network. Every network attached device has a unique, unchanging 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.[16]

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 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 when 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 certain events (e.g., failed login attempts) are recorded. The security portion (software that resides on the control system servers) will be configured so 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.

The 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. Further considerations will be assessed during the next phase of the Prize initiative.

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[16] Sticky MAC is a common, widely effective IT security countermeasure. The Project Team does not foresee any difficulties integrating Sticky MAC into microgrid operations.

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, two significant items remain in order for Somers's microgrid to become a reality. First, generation assets and microgrid components must be available for maintenance at all times. The team is working with the included facilities to ensure they will allow a third party to service the generation assets and microgrid components located on their land. The Project Team expects these operational challenges to be resolved by the time of construction. Second, there is no natural gas infrastructure in Somers, which will make it difficult to meet the NYSERDA-defined required capability of providing continuous power for seven days. The design proposes large scale battery storage units that will work with solar PV arrays in order to meet this capability. However, the high cost of battery storage units discouraged a microgrid design wherein 100% of islanded energy comes from solar energy and battery storage—the design therefore includes a small diesel generator that will come on-line in long-term outages when the solar PV arrays are not producing power.

The microgrid design proposes multiple new automated switches to isolate the microgrid and, if necessary, shed the Heritage Hills Residential Units in island mode. Every connected DER will require switchgear and controllers to function properly in the microgrid control scheme. The design does not require additional cabling to connect separated facilities. Because the coverage area is located in the middle of the Golden Bridge 420 feeder, the microgrid cannot intentionally enter islanded mode without disconnecting downstream loads.

3. Assessment of Microgrid’s Commercial and Financial Feasibility (Task 3)

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

- Private investors will own the battery storage units and solar arrays, and the Project Team proposes NYSEG own the microgrid hardware and infrastructure. NYSEG may also elect to operate the microgrid on their system, however a third party operator such as Con Ed Solutions or Constellation could also operate the system under a long-term O&M contract. Although NYSEG has neither confirmed nor denied interest in owning and operating microgrid infrastructure, the Project Team views hybrid ownership as a simple, effective model that provides benefits to both NYSEG and the special purpose vehicle (SPV).
- The sewage treatment plant will own and operate the new biogas system and will retain ownership of the 500 kW diesel generator.
- Energy produced by the solar arrays will be valued at NYSEG’s average supply charge (the utility’s cost of electricity, minus transmission and distribution (T&D) charges). Energy produced by the biogas generator will be valued at the local retail industrial rate.
- The battery storage system will produce revenues from participation in the NYISO frequency regulation market. However, this market is relatively thin and prices are far from stable. For that reason, the Project Team has used conservative assumptions for estimating the value of frequency regulation.
- NYSEG, as the local expert in energy distribution and the current owner and operator of the Town’s distribution infrastructure, will operate the microgrid. NYSEG’s existing infrastructure is used extensively in the preliminary microgrid design, so operational engagement from the utility is vital to the project’s success.
- The current regulatory, legal, and policy environment will stay consistent. The proposal outlined in this report falls within the existing frameworks.

The microgrid design relies on the SPV to finance the construction of proposed solar arrays and battery storage units, while NYSEG will construct the required microgrid infrastructure and control components. The battery storage units must participate in ancillary service markets or DR programs in order to partially recover their high capital costs. However, after bidding 1 MW of capacity into the NYISO frequency regulation market and selling solar-generated power to NYSEG, the project’s revenues are insufficient to cover operating expenses and will not recover initial capital expenditures. NY Prize funding and additional subsidies will be necessary to make the Somers microgrid financially viable.

3.1 Commercial Viability – Customers (Sub Task 3.1)

The preliminary microgrid design includes five facilities and three groups of small residential and commercial loads (see Table ES-1 for a list of included facilities). Private investors, through the SPV, will own the proposed battery storage units and solar arrays and NYSEG will own the microgrid hardware components. The sewage treatment plant will own and operate the new biogas system and will retain ownership of the existing diesel generator. The solar arrays will stay online throughout the year, but their output will be intermittent.[17] Electricity generated by the solar arrays will be valued at NYSEG's supply charge. The biogas system will operate continuously behind the meter at the sewage treatment plant, selling electricity at the local industrial retail rate through a net metering program. The battery storage units can bid 1 MW of capacity into the NYISO frequency regulation market and may be able to gain additional savings by engaging in time-of-use (TOU) bill management and reducing peak demand charges. Batteries also provide non-cash values, such as deferral of transmission and distribution infrastructure upgrades and reduction of congestion costs, to the utility and larger electricity system. However, NYSEG has not indicated to the Project Team any specific investments that may be deferred by the proposed microgrid. By compensating SPV investors appropriately for these non-cash values, NYSEG and New York State have the capability to make the Somers microgrid a more attractive investment. Finally, DER owners will remit payment to NYSEG to support the costs of the control infrastructure.

Five of the connected facilities provide critical services (as defined by NYSERDA) to the Town during emergency situations. The project will affect several groups of stakeholders in the Somers 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

The Somers microgrid includes five critical facilities and three groups of small residential and commercial loads (see Table 10 for a list of direct microgrid customers). Although it is possible for the microgrid to sell power directly to the facilities, the current business model assumes the microgrid will sell solar power and potentially stored power to the NYSEG grid. As a result, the customers will continue to purchase electricity from NYSEG throughout the vast majority of the year. However, when there is an outage on the larger NYSEG system, the microgrid will switch to island mode and customers will receive electricity directly from the microgrid SPV via NYSEG infrastructure. The transition to islanded operation may be intentional or unintentional.

Although facilities outside the microgrid's footprint will not receive electricity from the microgrid's generation assets during emergency outages, they will benefit from the availability of critical and important services. In their day-to-day operations, each of the microgrid facilities serves the larger community. By providing critical services to the community, these facilities extend their reach beyond direct employees and residents in the event of emergencies.

Table 10 (below) identifies each of the direct microgrid customers. The full group of stakeholders that will benefit from the microgrid is discussed in Section 3.2.3.

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[17] The Project Team calculated a capacity factor of 14% using NREL PV Watts software.

Table 10. Microgrid Customers

Facilities that will be connected to the microgrid. All will purchase electricity from the microgrid in island mode, and will indirectly purchase electricity from the microgrid's DERs in grid-connected mode.

Property	Address	Classification	Critical Service	Back-up Generation
Heritage Hills Sewage Treatment Plant	8 Heritage Hills Dr	Infrastructure	Yes	Yes
Somers Fire Station	270 Rt. 202	Public	Yes	No
Somers Pharmacy and Surgical, Somers Eye Clinic, and a retail store	336 Rt. 202	Commercial/ Health	Yes	No
Town Government Office and Elephant Hotel	335 Rt. 202	Public	Yes	No
Mt. Kisco Medical Group	342 Rt. 202	Health	Yes	No
Heritage Hills Residential Units	1-5 Heritage Hills Dr	Residential	No	No
Load Cluster 1	263-265 Rt. 202	Residential/ Commercial	No	No
Load Cluster 2	179-346 Rt. 202	Residential/ Commercial	No	No

3.1.2 Benefits and Costs to Other Stakeholders

Stakeholders in the Somers microgrid extend beyond connected facilities to include SPV investors, existing generation asset owners, NYSEG, and residents of Somers and the surrounding communities.

The majority of benefits and costs to other stakeholders fall into the following categories:

- Supply of power during emergency outages
- Electricity generation in grid-connected mode
- Provision of ancillary services in grid-connected mode
- Cash Flows to owners from electricity and ancillary service sales
- Upfront capital investment and land requirements
- Expanded zero-emission energy generation

Details of each will be discussed in turn below.

Supply of power during emergency outages: The microgrid will supply power to five critical facilities as well as three residential and commercial load clusters. The critical facilities can provide shelter, sanitation, healthcare, and emergency services to residents of the Town in the event of a long-term grid outage.

Electricity generation in grid-connected mode: The solar PV arrays will stay online throughout the year. Integration with battery storage will reduce load for the larger NYSEG system during both peak demand events and normal periods of operation, possibly stabilizing electricity prices in the area and deferring the utility's future capacity investments. Although Somers is not considered a congestion point on the larger NYSEG and NYISO systems, peak load support from proposed generation assets may reduce congestion costs to NYISO, NYSEG, and their electricity customers. Finally, the sewage treatment plant will achieve significant savings by selling electricity from the proposed biogas generator through a net metering program with NYSEG.

Provision of ancillary services in grid-connected mode: The battery storage system can bid 1 MW of capacity into the NYISO frequency regulation market throughout the year. By continuously discharging or charging according to signals from the NYISO, the batteries will produce revenues for SPV owners and improve power stability on the larger grid.

Cash flows to DER owners: In a conservative base case, cash flows will be limited to energy sales to NYSEG and sale of ancillary services to the NYISO. The microgrid project will produce consistently negative operating cash flows unless battery storage units can engage in local TOU bill management and peak demand reduction or are compensated for non-cash values by the utility or state. The project's commercial viability will depend on NYSERDA NY Prize Phase III as well as funding and additional subsides.

Upfront capital investment and land requirements: The primary costs will be purchasing and installing necessary microgrid equipment and proposed generation assets. The sewage treatment plant has land available for the proposed DERs, but the solar arrays will prevent any alternative future use of the land space.

Expanded zero-emission energy generation: The proposed solar arrays will produce zero emission electricity throughout the year. They represent a significant local investment in renewable energy and will reduce GHG emissions in New York State. This provides benefits to residents of Somers, the local government, and the larger population of the state. The diesel generator will only come online in island mode when the battery units have exhausted their charges.

Although the biogas generator will emit GHGs from normal operation, it is considered a net-zero asset because its fuel would otherwise contribute GHGs to the atmosphere. Under normal conditions, wet organic waste in landfills is covered and compressed by material deposited above, creating an anaerobic environment. This environment allows anaerobic bacteria to thrive and digest organic waste, producing methane gas that is slowly released into the atmosphere. Methane is approximately 20 times more potent as a greenhouse gas than carbon dioxide—biogas generators are considered net-zero assets because they burn the methane gas that would otherwise escape into the atmosphere, converting it to energy and carbon dioxide.

3.1.3 Purchasing Relationship

In grid-connected mode, the SPV will sell electricity from the proposed solar PV arrays to NYSEG under a long-term PPA.[18] The biogas generator will nearly always stay behind the meter, reducing energy costs for the sewage treatment plant. The battery storage units may be

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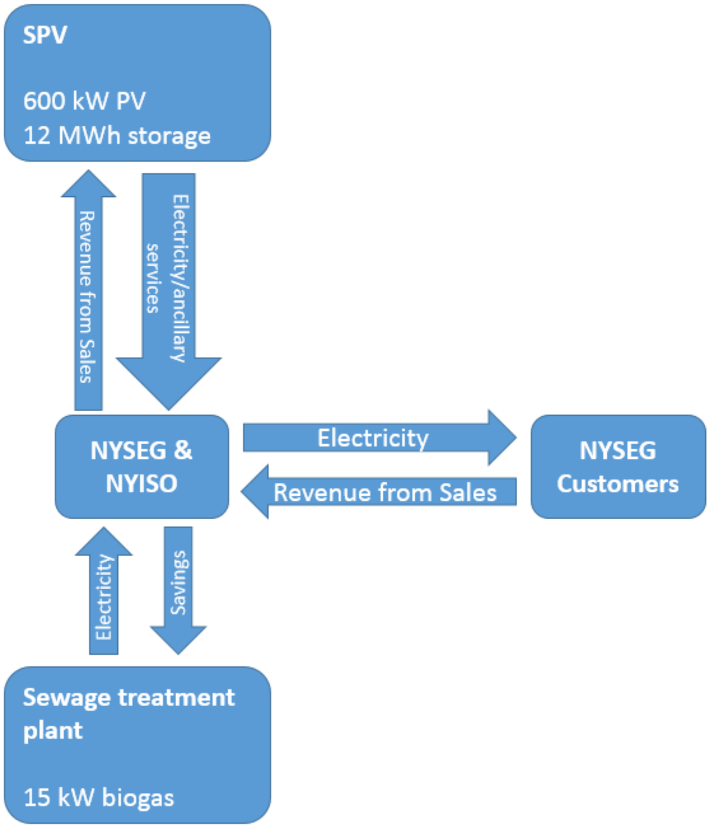
[18] The proposed solar arrays will not qualify for net metering because they will be owned by the SPV, which does not own a metered facility in the area.

used to smooth the output curve from the various solar arrays. Microgrid connected facilities will maintain their current electricity-purchaser relationship with NYSEG during grid-connected mode. In island mode, however, the facilities will be physically disconnected from the larger grid and directly supplied by the proposed generation assets. NYSEG will continue to bill microgrid facilities as normal, and proposed DERs will continue to sell electricity to NYSEG under the established long-term PPA. While it is possible for some facilities to individually net-meter, the financial implications of this arrangement would depend on the current tariffs for each facility. Further, the project team discovered through conversations with potential finance partners that the creditworthiness of a PPA to the local utility is in most cases advantageous as compared to purchase agreements with local users. 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 5 below for the purchasing relationships.

Figure 5. Purchasing Relationship

Value streams and purchasing relationships between the various entities during both grid-connected and island mode. The 500 kW diesel generator at the sewage treatment plant may come online in island mode to provide electricity to microgrid facilities.



3.1.4 Solicitation and Registration

The microgrid design team will work with the Town and utility to formalize agreements with the critical facilities identified. This outreach will include informal discussions and, ultimately, signed agreements of participation in the microgrid and fee structure determined by the NYPSC. Formal registration with the microgrid will be managed by programming the logic controllers to include or exclude facilities from islanded services based on their agreements with the utility. The Project Team views registration as an operational feature and not a legal requirement.

3.1.5 Energy Commodities

Proposed generation assets include two 300 kW solar PV arrays, a battery storage system including three battery storage units rated at 1 MW/4 MWh each, and a 15 kW anaerobic digester and biogas system. During normal operation, energy from the solar arrays will be sold to NYSEG and distributed on the NYSEG system as dictated by system needs. Conversely, if NYSEG wishes to prevent energy from flowing to the grid, the generation assets will be equipped with controls that have the necessary hardware and protection scheme to prevent back-feeding power into the system. The biogas generator will stay online behind the sewage treatment plant's meter, and its electricity will be valued at the local industrial retail rate through a net metering program.

The volume of electricity purchased from the solar arrays will depend on weather and insolation. The batteries can bid 1 MW of capacity into the NYISO frequency regulation market, and may be able to engage in some degree of TOU bill management and peak demand charge reduction at the sewage treatment plant. In order to engage in TOU bill management and peak demand charge reduction for all microgrid facilities, the microgrid would have to operate in island mode and funnel transactions with NYSEG through one meter. Because the microgrid is surrounded by downstream loads on the Golden Bridge 420 feeder, entering island mode would disconnect NYSEG customers that would otherwise have power. TOU bill management is therefore only possible at the sewage treatment plant, which will host the proposed storage units. However, it is difficult to precisely estimate the possible value from TOU bill management without specific operational data from the facility, so the Project Team did not include this value in the conservative base case analysis.

The battery storage units are capable of participation in demand response programs, but they must maintain a certain level of charge to prepare for unexpected grid outages and the NYISO frequency regulation market provides more lucrative payments for capacity. The batteries also provide several non-cash value streams to the utility and NYISO. Together these non-cash value streams can be worth as much as $610/kW-year.[19] The storage units can be used as an alternative to building new power plants to meet peak demand (resource adequacy), can be discharged downstream of congested corridors to minimize congestion costs during peak demand events (transmission congestion relief), and can delay, reduce, or remove the need for investments in the utility's transmission system (transmission deferral). The Project Team did not assume revenue from these non-cash value streams, but by appropriately compensating SPV investors, NYSEG and NYISO could make the Somers microgrid a more attractive investment.

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[19] NYSERDA estimates through the Rocky Mountain Institute, "The Economics of Battery Storage."

3.2 Commercial Viability – Value Proposition (Sub Task 3.2)

The microgrid will provide value to Somers, private investors, NYSEG, direct participants, and the larger State of New York. The new solar arrays will produce zero-emission energy in both normal and islanded operation, and the new battery storage units will firm the output curve and provide an energy bank for emergency outages. SPV members will receive stable revenues, though consistently negative operating cash flows, from operation of the proposed energy resources throughout the life of the project. Depending on the regulatory environment and the willingness of NYSEG and New York State to compensate the microgrid for non-cash value streams, SPV members may be able to realize additional cash flows that make the project a more attractive investment. The benefits, costs, and total value of the microgrid project are discussed in detail below.

3.2.1 Business Model

Table 11 below provides an overview of the Somers microgrid project, including an analysis of project strengths, weaknesses, opportunities, and threats (SWOT).

Table 11. Somers Microgrid SWOT Analysis

The strengths, weaknesses, opportunities, and threats (SWOT) associated with the Somers microgrid project.

Strengths	Weaknesses
• Full NYSEG participation in operation and ownership of the system hardware 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 • Allows for the use of existing transmission and distribution T&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) • Local generation will reduce congestion and the need for additional supply side resources during peak demand events, providing non-cash value to NYSEG throughout the year • Draws on NYSEG's expertise to facilitate daily operation of the microgrid (load aggregation, load following, voltage regulation, and other requirements) • Engages key critical facilities as well as local residents and businesses	• Selling electricity and ancillary services will not recover all initial investment costs. The commercial feasibility of the project therefore depends on funding from NYSERDA, NYSEG, or New York State • Separating significant capital costs from the revenues necessitates further agreement between revenue drivers (DERs) and control infrastructure owners (NYSEG). DER owners may balk at diverting revenue to non-revenue generating components • Uncertainty exists around the capital and operating cost of the anaerobic digester, as cost information is sparse for projects of this small scale
Opportunities	**Threats**
• Encourages teamwork between local government, private investors, and local investor owned utility. Because most communities are served by IOUs, this model could serve as a template for future projects • Demonstrates the feasibility of reducing load on the larger grid with DERs • Provides a proof point for utility operated microgrids in partnership with DER investor group • Provides data for NYSEG and NYSERDA on the benefits of using paired solar energy and battery storage systems. If successful, the paired solar/storage model could be applied to multiple towns throughout the state that do not have access to natural gas • The cost of battery storage is constantly decreasing, and by "stacking" different uses, SPV investors may soon be able to achieve a competitive levelized cost of storage[20]	• Changes in regulatory requirements could impact the proposed business model and stakeholder goals. • While currently lucrative, the frequency regulation market is thin. As more DERs across the state bid capacity into the market, the average price that NYISO pays for this ancillary service will likely decline, which would cause a drop in microgrid revenues

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** – First, SPV members will seek a long-term PPA, or some other form of long-term purchase agreement, with NYSEG to guarantee steady future revenue streams from electricity sales. As long as the agreement reliably guarantees fair compensation for

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[20] Lazard's Levelized Cost of Storage, Version 1.0.

generator output over the project lifespan, SPV members must be content with flexible compensation rates and a low amount of risk. Second, revenues from sale of electricity and ancillary services are projected to be insufficient to cover operating expenses. This weakness is partially offset by NY Prize Phase III funding, which is a requirement for project viability. Without further subsidization the project is unlikely to attract investor interest. Finally, revenue from ancillary service sales will likely decline in the future as more participants enter the frequency regulation market and prices decline. SPV members can partially mitigate this threat by switching use of the battery storage units to other services such as energy arbitrage or participation in demand response programs.

- **Organizational Competition** – This business model requires collaboration among groups of stakeholders that may have different motivations for participation in the microgrid project. NYSEG will construct and own non-revenue generating control and switchgear with an expectation of financial support from DER revenues. DER owners may be disinclined to support the non-revenue assets. Open communication and early agreement between NYSEG 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 NYSEG 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.

3.2.2 Replicability and Scalability

The Somers microgrid is a largely replicable and scalable model, and it is being designed with industry standard equipment and software that can be applied to diverse existing infrastructure. The proposed generation assets qualify for a significant total incentive payment—the NY Sun program will offset around 15% of the solar arrays’ capital cost, and the Federal investment tax credit (ITC) will offset an additional 30% of capital costs from the solar arrays. However, because operating revenues are relatively low and operating costs are high, the project’s commercial viability depends on NYSERDA NY Prize Phase III funding and additional subsidies, which will not be available to most community microgrid projects. This hinders the project’s replicability unless the NYPSC issues policy changes incentivizing microgrid development.

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, and microgrid control system, are widely available and could be repeated in any given location. All interconnections with the NYSEG grid are industry standard. While replicable, the project does include fairly unique elements. Both energy storage and anaerobic digesters exist on the distribution system today, however zinc-air batteries are still in early stages of commercial deployment. Further, anaerobic digesters are a fairly mature technology they are not typically deployed at the small scale contemplated in this report.

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 ownership that contracts the local utility to operate the DERs, coupled with utility 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 some degree of operational control over the generation assets 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.

Scalability. The Somers microgrid is scalable on the Golden Bridge 420 feeder. However, expansion to another feeder would require addition of new isolation switches, expanded generation, and additional power flow studies. It also assumes congruent line voltage, without which the linkage of different feeders would become more electrically complex.

Although the project is technically scalable, adding loads would require additional solar PV arrays and battery storage units. The high capital costs of adding more DERs that do not produce significant revenues will discourage expansion of the Somers microgrid.

3.2.3 Benefits, Costs and Value

The microgrid will provide widely distributed benefits, both direct and indirect, to a multitude of stakeholders. The SPV will receive stable revenues for the lifetime of the project, the sewage treatment plant will achieve savings on energy bills and tipping fees, the Town and citizens will benefit from a more resilient electricity system, and the community will reap the positive effects of living in and around the microgrid during times of emergency. These costs and benefits are described in Tables 12 through 17. Moreover, the local community will not bear any of the project's costs. However, without funding from NY Prize Phase III and additional subsidies, the cash flows generated by proposed DERs will not cover operating costs. This proposal involves a wide group of stakeholders—from local, non-customer residents to the State of New York—and provides value to all involved parties.

Tables 12 through 17 below provide an overview of the benefits and costs to members of the SPV, direct microgrid customers, citizens of Somers and surrounding municipalities, and the State of New York.

Table 12. Benefits, Costs, and Value Proposition to SPV

SPV shareholders will receive stable revenues from the microgrid project for the lifetime of the project.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
SPV	- Investors will receive annual revenues from sale of electricity and ancillary services - NY Sun incentive recovers ~15% of solar arrays' cost in the project's first year - Federal ITC recovers 30% of the cost of solar arrays - NY Prize Phase III funding may recover 50% of capital costs - Depending on the regulatory environment surrounding continuous operation in island mode, the microgrid may achieve some savings by deploying the batteries for effective TOU bill management and peak demand charge reduction. These savings would be remitted to the SPV as the owner of the battery storage units	- Initial capital outlay will be high because the SPV must purchase and install generation assets (including three expensive battery storage units) - Forecasted installed capital costs for the solar arrays and battery storage units are $1.59 MM and $2.5 MM, respectively - Ongoing maintenance of DERs - Payment to sewage treatment plant for use of backup diesel generator in emergencies - Financing costs associated with initial capital outlay will persist for many years	- Long-term purchase contracts make revenues from electricity sales low risk, however the high capital and operating costs cannot be recovered without significant subsidy

Table 13. Benefits, Costs, and Value Proposition to NYSEG

NYSEG will receive new revenues from the operation of the microgrid while bearing only a fraction of initial and ongoing costs.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
NYSEG	- The utility will continue to sell electricity to direct customers - NYSEG will maintain full control of distribution lines and new control infrastructure - Local generation reduces the amount of power that must be imported from the larger grid - By discharging batteries during peak demand events, NYSEG can flatten the output curve and may realize overall system savings - Improved reliability provided to customers within the microgrid footprint	- NYSEG will purchase electricity from the solar arrays at a price consistent with its existing electricity supply costs - NYSEG will bear the cost of installing and maintaining microgrid infrastructure	- The utility can serve as a market connector, realizing revenue from transmission and distribution and fees from the DERs - Improved grid resilience by integrating local generation assets with local distribution networks - NYSEG will have a new supply of electricity valued at their average supply charge but will marginally reduce their transmission and distribution costs in the immediate area

Table 14. Benefits, Costs, and Value Proposition to the Town of Somers

Somers will become a leader in achieving NY REV goals by providing a local market for DER-generated electricity and catalyzing investment in DER assets.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
Town of Somers	- Several municipal facilities will receive backup power from proposed DER assets—this will reduce the need for future investments in backup generation capabilities - The microgrid will provide a resilient and redundant energy supply to critical services - Reduced greenhouse gas emissions and progress towards state energy goals	- When the microgrid enters island mode due to a larger grid outage, customers will pay a slightly higher price for electricity than they would for electricity from the larger grid. This cost is offset by enhanced reliability and power quality	- Critical and important services will maintain power during outages, allowing the Somers microgrid to serve as a relief point for the local community - The microgrid project will serve as a catalyst for engaging customers in energy service opportunities and will inspire residential investment in DER assets, such as solar PV and battery storage, as citizens see benefits associated with avoiding peak demand hours and producing enough electricity to be independent from the larger grid - Generating electricity with the new solar PV array and firming the output curve with storage will provide reliable, zero-emission electricity and reduce greenhouse gas emissions

Table 15. Benefits, Costs, and Value Proposition to Connected Facilities

Connected facilities will benefit from a more resilient energy supply and may choose to invest in small DER assets of their own.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
Connected Facilities	- Resilient and redundant energy supply - Sewage treatment plant will achieve ~$20,000 in savings per year on electricity bills and tipping fees - Access to a local market for DERs makes investments in small DERs more attractive to connected facilities - Possible use of battery storage units would allow connected facilities to shift solar production to peak hours and realize more competitive returns	- Most connected facilities will bear no cost - Sewage treatment plant will bear capital, installation, and operation costs for biogas system	- Maintain operations during emergency outages and provide valuable critical services to the Somers community - Local market for excess energy makes investments in small DERs (such as solar panels) profitable for connected facilities

Table 16. Benefits, Costs, and Value Proposition to the Larger Community

Community will have access to critical services during grid outages.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
Community at Large	- Access to a wide range of critical and important services during grid outages - Reduced greenhouse gas emissions and progress towards state energy goals	- Because the larger community will not be connected to the microgrid, this stakeholder group will not bear any costs.	- Potential for reconnect in outage situations if generation assets are out-producing the demanded critical loads and the footprint of the microgrid is expanded - Future expansion of the microgrid could bring more facilities into the design—however, Somers will likely need to install advanced metering infrastructure (AMI) meters for this to be feasible

Table 17. Benefits, Costs, and Value Proposition to New York State

The microgrid provides a tangible example of a Town working towards a significant NY REV goal: to expand the privately-owned DER industry by providing a local, utility-owned power distribution platform.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
New York State	- Indirect benefits (such as outages averted, transmission upgrade deferral, congestion cost reduction, etc.) will demonstrate the benefits of microgrids paired with DER assets to citizens across the state and reduce load on the larger grid - Each microgrid accelerates NY state's transition from old macrogrid technology to newer, smarter, smaller technologies - Reduced greenhouse gas emissions and progress towards state energy goals - Meet NY Reforming the Energy Vision goals by encouraging zero emission DER construction and improving energy resiliency	- The State may need to compensate the project for the indirect benefits it provides in order to attract sufficient investor interest	- Successful construction and operation of a community microgrid will demonstrate the societal value of microgrid projects - Indirect benefits associated with microgrids will encourage and inspire citizens to strive for DER in their own communities - Success of 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

3.2.4 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 significantly expand renewable energy generation in Somers. The proposed microgrid supports the New York State Energy Plan by providing a power distribution platform for locally-owned DER assets.

By coordinating the microgrid as a local distributed system platform (DSP), the Somers 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 Town, 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. Eventually, as more microgrids arise in New York State, the proposed microgrid can integrate seamlessly into a larger "grid of grids" to promote energy markets, trading, and enhanced consumer choice for preferred power source.

3.3 Commercial Viability – Project Team (Sub Task 3.3)

The Project Team includes NYSEG, the Town of Somers government, Booz Allen Hamilton, Siemens AG, and Power Analytics. It may expand to include financiers 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 in communication with local stakeholders from the outset. Booz Allen and its Town partners have also communicated with each of the proposed facilities to gauge electricity demand and discuss other aspects of project development.

3.3.2 Project Team

The Somers microgrid project is a collaboration between the public sector, led by the Town of Somers, and the private sector, led by Booz Allen Hamilton with support from Power Analytics, Siemens, and NYSEG. Each of the private sector partners is well qualified in the energy and project management space, and Somers has strong interest in improving its energy reliability and expanding its clean energy generation capacity. Tables 18 and 19 provide details on the Project Team.

Table 18. Project Team

Background on Booz Allen Hamilton, Siemens AG, Power Analytics, and NYSEG.

Booz Allen Hamilton	**Headquarters: McLean, VA**	**Annual Revenue: $5.5 B**	**Employees: 22,700**
History and Product Portfolio: Booz Allen was founded in 1914 and 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 3rd party funded projects including energy efficiency, renewable energy, and smart grids.			
Siemens AG	**Headquarters: Munich, Germany;** **U.S. Headquarters: Washington, DC**	**Annual Revenue: €71.9 B**	**Employees: 343,000**
History and Product Portfolio: Siemens AG was founded in 1847 and today is 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.			
Power Analytics	**Headquarters: San Diego, CA**	**Annual Revenue: $10-15 MM**	**Employees: 50**
History and Product Portfolio: 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.			
NYSEG	**Headquarters: Orange, CT**	**Annual Revenue: $1.63 B**	**Employees: 7,000**
History and Product Portfolio: A subsidiary of AVANGRID, NYSEG is an electrical and gas company operating in New York State. NYSEG provides electric service to approximately 890,000 customers and gas service to approximately 262,000 customers across more than 40% of upstate New York. AVANGRID receives yearly operating revenues of approximately $1.63 billion and is headquartered in Orange, CT.			

Table 4. Project Team Roles and Responsibilities

Table outlines 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
NYSEG	NYSEG will work with the Project Team to develop the concept and provide input. They will further provide the financial support for the purchase of microgrid control systems and infrastructure.	NYSEG will provide a share of the initial capital outlay that corresponds to the microgrid control infrastructure.	NYSEG may provide the necessary domain expertise to operate and maintain the microgrid infrastructure. 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. Through the microgrid control system, the utility will have some degree of control over charge and discharge of batteries.
Town of Somers	The Town will serve as the main conduit to representatives of the critical and important facilities and other interests in the Town.	As the liaison, the Town will coordinate with all local and state parties as needed.	As the liaison, the Town 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 may 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	Power Analytics may 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
	software components and controls.		
Suppliers	There are no suppliers required during the 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, 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 required to ensure proper and efficient functioning of their components. The software provider will work in cooperation with NYSEG 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 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 ancillary services. NYSEG 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, NYSEG, 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 NYSEG and private investors, through the SPV.

Moody's Investor Service rates NYSEG at a Baa1 credit rating. According to the Moody's rating scale, "Obligations rated Baa are judged to be medium-grade and subject to moderate credit risk and as such may possess certain speculative characteristics." NYSEG is a subsidiary of AVANGRID, a U.S. based diversified energy and utility company. AVANGRID is an affiliate of the Spanish energy company Iberdrola and employs nearly 7,000 people across the United States. NYSEG provides electric service to approximately 879,000 customers and gas service to approximately 262,000 customers across more than 40% of upstate New York. AVANGRID receives yearly operating revenues of approximately $1.63 billion.

Given the high capital costs for large scale energy storage and the relatively low operating revenues from proposed DERs, outside investors will not have interest in the Somers microgrid project unless NYSEG, NYISO, or the state government compensates the SPV for the non-cash value of battery storage and subsidizes microgrid infrastructure.

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. Further, by incorporating the existing 500 kW diesel generator into the microgrid footprint, the project team was able to leverage an existing asset which will provide microgrid support in the event of an emergency.

Implementation of a vendor agnostic SOA framework will enable the microgrid to switch between grid-connected mode and island mode in real time, and it will allow future integration of BEMS using known open standards. The SOA framework will support a SCADA-based control center as well as a primary and secondary EMS. The SCADA-based control center allows remote monitoring & control of microgrid controllers from a single location; the EMS will be capable of detecting breaks in power lines, isolating problematic sections, and re-routing power. Working with automated switches distributed throughout the microgrid, the EMS will also be programmed with a black start sequence for sudden and unexpected disconnections of power from the larger grid. These technologies enhance power supply reliability in Somers by automating the transition to island mode based on real time, accurate data collected in the SCADA control center.

Because there is no natural gas infrastructure in Somers, the design relies on battery storage systems for energy resiliency. Solar PV arrays will provide significant zero-emission energy generation throughout the year, moving Somers and New York State closer to the renewable generation goals set forth in the state energy plan and the Renewable Portfolio Standards. If the battery units exhaust their charges in island mode, the microgrid is equipped with a diesel generator that will come on-line and provide supplemental power as necessary. The battery storage units will be capable of automatic load following (responding to load fluctuations within cycles, allowing the microgrid to maintain system voltage and frequency) and black starts. The batteries will also greatly reduce the need for diesel generation in emergency outage situations.

The Somers microgrid includes numerous components that have been previously used and validated. Solar PV and standby diesel generators are widely used technologies, with more than 6 gigawatts of solar PV installed in 2015 in the United States. The switch components are all industry standard and are widely used in utilities worldwide, and the IEDs, 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.[21] 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.[22]

The proposed battery storage units use an emerging zinc-air cell technology. Because it is so new, this technology has not accumulated much operational data. However, one manufacturer, Eos Energy Storage, projects that the battery will last 5,000 cycles at greater than 75% efficiency per discharge, and plans to sell the batteries at $160/kWh.[23] The batteries' uses include, but are not limited to, peak shaving, long term energy storage, and frequency regulation. The batteries will require inverters to synchronize their DC output with the AC electricity flowing through the larger grid and intelligent controls to synchronize with the microgrid control system.

A new anaerobic digester at the sewage treatment plant will capture methane gas from the degradation of solid waste products. This gas will be used to power a 15 kW generator, which will reduce the sewage treatment plant's load throughout the year.[24] Waste heat will be captured and used to dry waste products, allowing the generator system to achieve up to 90% efficiency.[25] It is important to note that, while the anaerobic digester would provide benefit to the project, there is significant uncertainty around the capital and operating cost of a unit of this small size. The project team is not aware of an example of an operating anaerobic digester this small, and thus cost estimates are based on proportional scale of costs for larger units. Additionally, the fixed operating costs of the digester could significantly hamper the financial performance of the unit as the costs cannot be spread over a large number of kWh generated. Finally, the design and construction of wastewater anaerobic digesters is currently a fully custom engagement, as the industry has not fully settled on standard designs, which serves to increase costs.

3.4.2 Operation

SPV investors will direct a portion of revenues to NYSEG, or a third party operator, to support the operation and maintenance of the microgrid. As the project's subject matter expert and owner of the distribution infrastructure, NYSEG will provide advice regarding the logistics of day-to-day operation or will coordinate closely with a third party operator for enhanced transparency. 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.

NYSEG 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, N+1 assurance, 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

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[21] Siemens case studies; available from http://w3.usa.siemens.com/smartgrid/us/en/microgrid/pages/microgrids.aspx.

[22] http://www.poweranalytics.com/company/pdf/M-12-GE-PPT-X-001-03%202012%20UCSD%20Virtual%20summit.pdf.

[23] Eos Aurora: http://www.eosenergystorage.com/products/.

[24] The Project Team sized the proposed biogas system based on a processing volume of 318 gallons per minute. Sizing information adapted from "Wastewater Treatment Plant Biogas for Spark-Ignited Engines", Cummins Power.

[25] Efficiency estimate adapted from "Wastewater Treatment Plant Biogas for Spark-Ignited Engines", Cummins Power.

operations dictate that to be the appropriate action. Interactions with the NYSEG power grid will be automatically governed by the microgrid controllers.

This analysis assumes NYSEG will purchase electricity from the solar PV arrays and distribute it across its grid. The facilities will continue to be billed for electricity via the regular NYSEG billing mechanism and cycle. Additional fees may be imposed upon microgrid participants as a percentage of their electricity cost. However, given the extremely limited amount of time forecasted in island operation and the commensurately limited time the customers will need to rely on the microgrid, the fee will be negligible or nonexistent.

The proposed biogas system will generate savings for the sewage treatment plant through a net metering program with NYSEG. The treatment plant will also retain ownership of the existing 500 kW diesel generator, and will be compensated by the SPV for the cost of operation during an emergency outage.

3.4.3 Barriers to Completion

The barriers to constructing and operating the microgrid are primarily financial. The lack of natural gas infrastructure forces the Somers microgrid to rely on large scale energy storage to achieve necessary resiliency. Although there have been significant advancements in battery technology in recent years, batteries still incur high capital costs and produce relatively little revenue. NYSERDA and the New York Battery and Energy Storage Technology Consortium (NY-BEST) have not developed incentive programs outside of Consolidated Edison service territory in New York City, so project owners will have to rely on cash flows from ancillary services, energy arbitrage, or DR programs in order to recoup investment costs. Assuming the SPV will sell electricity from the solar arrays to NYSEG at the current supply charge and will bid 1 MW of capacity into the NYISO frequency regulation market, the microgrid will produce negative operating cash flows from year to year. This means revenues will not cover operating costs and there will be no possibility of recovering capital expenditures.

3.4.4 Permitting

The Somers microgrid may require certain permits and permissions depending on the ultimate design choices. Local codes prohibit structural alterations, enlargements, or changes of any kind in the Business Historic Preservation District (B-HP), which includes the Town Government Office, Somers Pharmacy and Surgical, Fire Station, and Mount Kisco Medical Group. Even rooftop solar arrays may not be “harmonious and compatible with neighboring structures” under aesthetic design criteria in local code § 170-114. DERs may not be constructed at any of these facilities.

Proposed DERs are primarily located at the Heritage Hills Sewage Treatment Plant, which belongs to the Designated Residential Development Overlay District (DRD). Electric generation is not expressly listed as a permitted or special permit use in any district in Somers, so proposed DERs must be framed as a permitted use, an accessory use, a specially permitted use, or a variance. The aesthetic design criteria described above for the B-HP district do not apply to the DRD. The Project Team does not anticipate problems obtaining permits for proposed DERs at the sewage treatment plant under applicable local codes.[26] However, DER 6 (the 300 kW solar PV array located above Load Cluster 1) will belong to the Neighborhood Shopping District (NS), and as such is subject to the aesthetic design criteria listed for the B-HP district. The Somers planning board will therefore have the power to reject half of the proposed solar generation capacity, depending on their interpretation of the discussed aesthetic design criteria. Somers is not in any Environmental Protection Agency (EPA) Criteria Pollutant Non-Attainment zones.

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 NYSEG and sale of ancillary services to NYISO. These assets will require significant initial capital outlay as well as annual operation and maintenance costs. The microgrid project qualifies for the NY Sun incentive and the Federal ITC, which will partially offset the initial investment costs. 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 20. The revenues will sum to approximately $120,000 per year, while operation and maintenance for generation assets and microgrid infrastructure will cost around $130,000 per year. However, SPV members may be able to unlock other revenue streams by engaging in TOU bill management through the sewage treatment plant or obtaining appropriate subsidies for non-cash values from NYSERDA or NYSEG (see Table 21 for potential value streams). In the conservative base case, yearly cash flows will be negative and will not recover initial investment costs. The commercial viability of the Somers microgrid project is therefore dependent on Phase III NY Prize funding and operating subsidies.

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[26] Applicable local codes include Somers Code §170-17, Code §170-17.2, Code §170-114, and Code §170-15.2.

Table 20. Savings and Revenues

Expected revenues and savings directly associated with operation of the microgrid and its DER assets

Description of Savings and Revenues	Savings or Revenue	Relative Magnitude	Fixed or variable
Electricity sales from new solar PV arrays[27]	Revenue	~$60,000/yr	Variable
Revenues from frequency regulation services	Revenue	~$40,000/yr	Variable
Savings from biogas generator (net metering)[28]	Savings	~$10,000/yr	Variable
Savings from avoided tipping fees[29]	Savings	~$10,000/yr	Variable
Total Yearly Revenue and Savings		**~$120,000/yr**	Variable

The Project Team assumed the battery storage units can bid 1 MW into the New York frequency regulation market throughout the year. In 2015, the average payment per MW per service hour was $9.23. Assuming a conservative capacity factor, the battery units will be available for frequency regulation services for approximately 4,380 hours per year.[30] This translates to yearly revenues of approximately $40,000 per year, or a value of around $40.41 per kW per year. The Project Team has assumed the energy used for these frequency regulation services has a net-zero dollar value. This is a conservative assumption, as the battery will likely be required to charge (down regulate) when NYISO wholesale prices are low and discharge (up regulate) when NYISO wholesale prices are high.

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[27] The Booz Allen Team calculated NYSEG’s supply charge for electricity to be approximately $0.084/kWh in LOWER HUDSON VALLEY zone. This is the assumed price for grid-connected sales from the solar PV arrays.

[28] This estimate assumes a capacity factor of 90% (adapted from NREL: “A Technoeconomic Analysis of Biomethane Production from Biogas and Pipeline Delivery”) and an electricity rate of $0.106/kWh (electricitylocal.com).

[29] This estimate assumes ~163 tons per year of solid waste that would otherwise need to be removed, and estimated tipping fees of $60 per ton (http://www.cleanenergyprojects.com/Landfill-Tipping-Fees-in-USA-2013.html).

[30] Method adapted from Sandia National Laboratories, “Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide.”

Table 21. Possible Values from Batteries

Potential cash and non-cash value streams associated with battery storage units

Description of Savings and Revenues	Cash or non-cash	Relative Magnitude	Fixed or variable
TOU bill management[31]	Cash (savings)	~$17,000/yr	Variable
Peak demand charge reduction[32]	Cash (savings)	~$8,000/yr	Variable
Resource adequacy (use storage as an alternative to building new power plants to meet peak demand)[33]	Non-cash	~$10,000/yr	Fixed
Transmission congestion relief (use storage downstream of congested corridors to minimize congestion costs during peak demand events)[34]	Cash (savings)	~$1,000/yr	Variable
Utility transmission deferral (delay, reduce, or remove the need for utility investments in the transmission system)[35]	Non-cash	~$48,000/yr	Fixed
Total Potential Values		**~$84,000/yr**	Variable

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[31] Based on 95 kW available for TOU bill management (average net sewage treatment plant demand after biogas) and a value of $180/kW-year (Sandia National Labs through the Rocky Mountain Institute, "The Economics of Battery Energy Storage").

[32] Based on 95 kW available for demand charge reduction (average net sewage treatment plant demand) and a value of $90/kW-year (Sandia National Labs through the Rocky Mountain Institute, "The Economics of Battery Energy Storage").

[33] Based on 95 kW available for discharging during peak demand events (average net sewage treatment plant demand) and a value of $100/kW-year (NYSERDA through the Rocky Mountain Institute, "The Economics of Battery Energy Storage").

[34] Based on 95 kW available for discharging (average net sewage treatment plant demand) and a value of $10/kW-year (NYSERDA through the Rocky Mountain Institute, "The Economics of Battery Energy Storage").

[35] Based on 95 kW available for discharging (average net sewage treatment plant demand) and a value of $500/kW-year (NYSERDA through the Rocky Mountain Institute, "The Economics of Battery Energy Storage").

Table 22. Capital and Operating Costs

Expected costs from construction and operation of the microgrid.

Description of Costs	CapEx or OpEx	Relative Magnitude	Fixed or Variable
300 kW Solar PV array (carport)	Capital	$870,000	Fixed
300 kW Solar PV array (ground-mount)	Capital	$720,000	Fixed
12 MWh Battery storage[36]	Capital	$2,500,000	Fixed
15 kW Biogas system[37]	Capital	$85,000	Fixed
Distributed Equipment	Capital	$265,000	Fixed
Microgrid Control System	Capital	$450,000	Fixed
IT costs (wireless and cables)	Capital	$60,000	Fixed
Total CapEx		**$4.95 MM**	Fixed
Design considerations and simulation analysis	Planning and Design	$375,000	Fixed
Project valuation and investment planning	Planning and Design	$75,000	Fixed
Assessment of regulatory, legal, and financial viability	Planning and Design	$25,000	Fixed
Development of contractual relationships	Planning and Design	$25,000	Fixed
Total Planning and Design		**$0.5 MM**	Fixed
Battery Maintenance	Operating	$50,000/yr	Variable
Solar PV Maintenance	Operating	$11,000/yr	Variable
Biogas System O&M[38]	Operating	$2,000/yr	Variable
Microgrid Control O&M	Operating	$70,000	Fixed
Total OpEx		**$130,000/yr**	Variable

The proposed microgrid will qualify for two existing incentive programs: the NY Sun program and the Federal ITC for solar PV arrays, see Table 23 for details. NY Sun will cover around 15% of each solar array's capital cost, and the Federal ITC will recover an additional 30%. The Federal ITC also applies to battery storage units that charge at least 75% of their energy from renewable sources, but the Project Team does not expect that the proposed storage units will consistently meet this criterion. Other possible sources of incentive payments include

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[36] Capital estimate includes $160/kWh plus 30% for installation costs for a total of approximately $210/kWh. Zinc air battery storage is a new technology that is significantly cheaper than other storage technologies because half of the electrolyte (Oxygen) is free. Companies such as Fluidic Energy and Eos Energy Storage, both members of the New York Battery and Energy Storage Technology Consortium (NY BEST), have pioneered this technology in recent years with successful results.

[37] Capital estimate includes cost for anaerobic digester and generator ($5,600 per kW). Adapted from Energy & Environmental Economics: "Capital Cost Review of Power Generation Technologies."

[38] Operation cost estimate adapted from Energy & Environmental Economics: "Capital Cost Review of Power Generation Technologies."

NYSERDA Phase III NY Prize funding (up to $5 million with a 50% cost share burden on the project).

Table 23. Available Incentive Programs

State and utility 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 III	$2,475,000	Required
NYSERDA NY Prize Phase II	$500,000	Required
NY Sun	~$240,000	Required
Federal Solar ITC	~$480,000	Required

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 would supply most of the funding for project design and development, with the SPV providing capital for any costs that exceed available NYSERDA funding. The Project Team anticipates NYSERDA to supply 75% of the required funds for Phase II with the balance coming from a cost-share. This is based on the Phase II cost structure as described in NYSERDA RFP-3044. Somers and their Project Team would provide cash support or 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 (described below).

The SPV and NYSEG would also need to leverage Phase III funding from NYSERDA to complete the construction phase. Phase III NY Prize funding, would cover half of the capital cost of the project (estimated to be approximately $2.48 MM in total), and private and utility funding would represent the balance of the financing.

The Project Team assumes the sewage treatment plant will grant the physical space to site the DERs at no cost because they will be one of the primary beneficiaries of the proposed microgrid. Paired solar and storage systems also present valuable learning opportunities for students throughout the Town. The SPV will maintain ownership over all generation assets and NYSEG over the control infrastructure.

3.6 Legal Viability (Sub Task 3.6)

Like any infrastructure project that involves development of public and private land, the Somers 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 State code, however the process for constructing small DERs in New York is well established. The microgrid will comply with all rules governing the interconnection of generation assets to the grid, and given NYSEG's close participation in the project the Project Team does not envision any onerous requirements.

Local Regulation

All entities that require the use of public ways (i.e., for transmission or distribution facilities) must be granted permission by the presiding municipal authority in the form of a franchise or some lesser consent, depending on the scope of the usage. Towns in New York have specific statutory authority to grant franchises. As provided by N.Y. Vil. Law § 4-412, every Town Board of Trustees is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city.[39] "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.[40] As the distribution infrastructure already exists in Somers, new permissions for the running of lines should not be a concern. As outlined in Town zoning documents, a zoning permit is required for the modification in use of any property and this may apply to the accessory addition of distributed energy resources. Given the relatively small scale of the proposed generating assets and the municipal support for the project, the Project Team does not foresee this condition as prohibitive.

Air Quality

Diesel and biogas 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, how much electricity is delivered to the grid versus used onsite, and the date of construction. The specific details associated with the proposed biogas generator in Somers 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 (diesel generators)

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[39] N.Y. Vil. Law § 4-412.

[40] See, e.g., "Contract of April 7, 1887 between Hess et al. Commissioners & Consolidated Telegraph & Electrical Subway Co." (Con Tel and Electrical Subway Company Agreements 1886-1891.pdf).

- NSPS for Stationary Spark Ignition (SI) ICE: 40 CFR part 60 subpart JJJJ (natural gas and landfill gas-fired generators)

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.

New York state has enacted amendments to Environmental Conservation Law Articles 19 (Air Pollution Control) and 70 (Uniform Procedures) as well as New York State Department of Environmental Conservation (NYS DEC) amended regulations 6NYCRR Parts, per the 1990 Amendments to the Clean Air Act. With this demonstration of authority, NYS DEC received delegation of the Title V operating permit program from the 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) and
- 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 diesel unit.

3.7 Project Commercial and Financial Viability Conclusions

The proposed microgrid's commercial feasibility depends on NY Prize Phase III funding and additional subsidies from NYSERDA or NYSEG. Its design includes six new DERs: two 300 kW solar PV arrays, 12 MWh of battery storage, and a 15 kW anaerobic digester and biogas generator. The existing 500 kW diesel generator at the treatment plant will also be connected. The SPV will provide the capital required to purchase and install the batteries and solar arrays and will receive revenues from sale of electricity and ancillary services to NYSEG and NYISO throughout the lifespan of the DERs. Investors in the SPV will contribute funds to the daily operation and maintenance of the DERs, and NYSEG will leverage its local expertise to keep the microgrid components and control infrastructure running smoothly. The Project Team forecasts yearly revenues of approximately $120,000 and yearly operation and maintenance costs of approximately $130,000, plus capital expenditures of $4.95 million. The project will produce negative annual operating cash flows, and it will require subsidies to fully recover operating costs and initial investment costs.

The microgrid cannot enter island mode to participate in DR programs because doing so would disconnect downstream NYSEG customers. However, if prices in the frequency regulation market decline in future years, SPV owners may bid up to 1 MW of capacity into NYSEG DR Programs. The Project Team did not have sufficient data to accurately forecast savings from

TOU bill management, but by intelligently deploying the battery units behind the sewage treatment plant's meter, the SPV could realize significant revenue through energy savings and concomitant payments from the treatment plant. These savings are not included as part of the conservative base case, but could represent an important value stream to SPV investors. The value of savings through TOU bill management and peak demand charge reduction at the sewage treatment plant will be explored further in Phase II of the NY Prize competition.

In addition to revenues from electricity sales, the microgrid will provide indirect financial and non-financial benefits to Somers citizens, SPV shareholders, NYSEG, NYISO and the larger Westchester 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.

Permitting and regulatory challenges should be reasonably straightforward. The primary regulatory consideration will be the Clean Air Act permitting of the new biogas generator. The Project Team has assumed that the sewage treatment plant has obtained requisite permits for the existing 500 kW diesel generator. The SPV will also need to apply for a zoning permit through the Town of Somers's zoning process for the installation of the proposed DERs.

4. Cost Benefit Analysis

This section is made up of seven sections in addition to the introduction:

- ***Section 1*** analyzes the *facilities connected to the microgrid* and their energy needs.
- ***Section 2*** discusses the *attributes of existing and proposed distributed energy resources*, including factors such as nameplate capacity and expected annual energy production.
- ***Section 3*** analyzes *potential ancillary services sales and the value of deferring transmission capacity investments*.
- ***Section 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 5 and 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 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 Somers microgrid will include eight facilities from multiple rate classes and economic sectors. NYSERDA designates three primary rate classes based on type of facility and annual electricity consumption: residential, small commercial (less than 50 MWh per year), and large commercial (greater than 50 MWh per year). See Table 24 for basic statistics on each facility's energy usage. Five of the proposed microgrid facilities belong to the large commercial rate class rate class requiring approximately 1,842 MWh of electricity per year. One facility is a part of the small commercial rate class and consumes 32 MWh of electricity per year. An additional two facilities make up the residential rate class which collectively use 468 MWh. Additionally, the average aggregate demand in 2014 was 0.267 MW and rose as high as 0.593 MW.

There are five kinds of facilities: public, commercial, healthcare, residential and infrastructure. For simplicity, the commercial facilities have been accounted for in the healthcare and residential sectors. Facilities belonging to the public sector represent the largest projected electricity loads, comprising more than 5% of the microgrid's total annual electricity usage. The healthcare sector facilities make up about 28% of the total electricity usage. The residential facilities are approximately 26% microgrid's total annual electricity usage. The remaining infrastructure facility accounts for 41% of the annual electricity usage.

During a major power outage, the generation assets included in the microgrid design will be capable of meeting 100% of average aggregate facility energy usage, but may approach their generation limits if the facilities simultaneously reach peak energy use. In these situations, the backup diesel generator and zinc air batteries may need to come online to supply additional electricity. For information on each facility's average daily operation during a major power outage, see Table 24.

Table 24. Facility and Customer Detail Benefit[41]

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.

REDACTED PER NDA WITH NYSEG

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[41] Load data was provided to Booz Allen by NYSEG.

4.2 Characterization of Distributed Energy Resource (Sub Task 4.2)

The microgrid design incorporates distributed energy resources, including one existing diesel generator, two proposed solar PV arrays, one proposed biogas generator and three proposed zinc air batteries. The proposed solar PV arrays will produce an average of 0.084 MW of electricity throughout the year (including projected capacity factors), and the diesel generator at the Heritage Residential Units will provide up to 0.5 MW of backup generation capacity during emergencies.

Limited by weather conditions and the availability of sunlight, the combined solar PV arrays are expected to produce a total of 735 MWh per year (assuming a capacity factor of 14%).[42] 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 arrays will produce 2.02 MWh of electricity per day, which represents 31% of average daily electricity demand from microgrid-connected facilities. Maintenance costs for the solar arrays will be around $12,000 per year,[43] which means the marginal cost of producing solar electricity will be about 34/MWh.[44]

The proposed zinc air batteries will not generate any electricity but will be able to act as a backup source of electricity during emergency situations. Each battery unit is capable of providing up to 1 MW of load supports, well over 100% of the microgrid's average daily demand, for up to 4 hours. The existing backup diesel generator will be used only in islanded situations when the proposed solar arrays or zinc air batteries are not producing sufficient electricity to meet aggregate demand. The existing generator has a nameplate capacity of 0.5 MW. This 0.5 MW of backup generation capacity could be vital in emergency situations, or when the solar arrays go offline for maintenance. The Booz Allen team forecasts around 1.93 hours of larger grid outage based on NYSEG's CAIDI from 2013,[45] and therefore predicts that annual output from backup diesel generators will be insignificant. The 0.5 MW generator requires around 35.5 gallons of fuel per hour of operation.[46] In the event of a major power outage, the generator could produce up to 12 MWh/day—however, assuming that the solar PV arrays will require backup power during 60% of emergency outage hours,[47] this figure drops to 7.2 MWh/day. See Table 25 for a detailed list of all proposed and existing distributed energy resources in Somers.

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[42] Solar array capacity factor: 14% (NREL PV Watts Calculator).

[43] Annual fixed O&M cost: $20/kW per year (NREL, http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html).

[44] Capital cost: $2,400 – $2,700 (Siemens estimate for solar array), Variable cost: 20 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).

[45] Grid outage data from DPS 2013 Electric Reliability Performance Report (NYSEG average CAIDI).

[46] Backup Diesel Generator fuel consumption rate – 35.5 gallons/hour.

[47] The Booz Allen team forecasts a 60% level of operation from the backup generator based on historical loads and expected generator output. In 2014, the average load in Somers was 0.267 MW. Load is expected to exceed the solar PV arrays maximum output for approximately 60% of time spent in island mode. Solar output is unreliable, but it should provide significant support on the most irradiated days of the year when peak demand is highest.

Table 55. 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). “Normal operating conditions” assumes approximately 1.15 effective hours of operation per year for the diesel backup generator.

Distributed Energy Resource Name	Location	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 - Existing Diesel Generator	Heritage Residential Units and Heritage Recreation	Diesel	0.5	0.579	0.002	12	71 Gallons	9.86 MMBTUs
DER2 - Proposed Biogas Generator	Heritage Residential Units and Heritage Recreation	Biogas	0.015	118.26	0.324	0.36	12.2 Mcf	12.5 MMBTUs
DER3 - Proposed Carport Solar PV Array	Heritage Residential Units and Heritage Recreation	Sunlight	0.3	367.92	1.008	2.4[48]	N/A	N/A
DER4 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	1 MW/4 MWh	N/A	4.0	4.0	N/A	N/A
DER5 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	1 MW/4 MWh	N/A	4.0	4.0	N/A	N/A

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[48] Assumes 10 hours of production (daylight) at 80% of capacity.

Distributed Energy Resource Name	Location	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
DER6 - Proposed Solar PV Array	Somers Fire Station	Sunlight	0.3	367.92	1.008	2.4[49]	N/A	N/A
DER7 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	1 MW/4 MWh	N/A	4.0	4.0	N/A	N/A

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[49] 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.

The proposed solar arrays will be at their most productive on the most irradiated days of year when peak demand events are common, thus providing peak load support when it is most needed. The solar PV arrays will provide around 0.084 MW of load support on average over the course of a year. However, because its generation depends on weather conditions and time of day, the solar arrays are not a reliable source of peak load support.

The proposed zinc air batteries will also be able to provide peak load support. Each battery unit will have the ability to provide up to 1 MW of load support for 4 hours at full charge.

See Table 26 for the maximum generation capacities of the proposed and existing DERs.

Table 26. Distributed Energy Resource Peak Load Support

Table shows the available capacity and impact of the expected provision of peak load support from each DER. Existing generator was not included because it is not expected to generate electricity outside of emergency island mode situations (existing diesel generator).

Distributed Energy Resource Name	Location	Available Capacity (MW)	Does distributed energy resource currently provide peak load support?
DER2 - Proposed Biogas Generator	Heritage Residential Units and Heritage Recreation	Maximum of 0.015	No
DER3 - Proposed Carport Solar PV Array	Heritage Residential Units and Heritage Recreation	Maximum of 0.3	No
DER4 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	1.0	No
DER5 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	1.0	No
DER6 - Proposed Solar PV Array	Somers Fire Station	Maximum of 0.3	No
DER7 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	1.0	No

4.3.2 Deferral of Transmission/Distribution Requirements

NYSEG has a robust grid in Somers's region with little congestion, therefore the 0.094 MW of average local generation produced by the DERs will only marginally defer the need to invest in new or upgraded power lines. Although these power lines will last up to one hundred years if well maintained,[50] they can only transmit a limited amount of power. As demand for electricity in Somers increases, the lines might need to be supplemented to handle additional load.

The same is true for distribution capacity investments on a local, feeder-by-feeder basis. However, constructing DERs could actually increase the distribution capacity investment cost in certain cases (e.g., if the assets are placed in remote locations and thus expensive to connect to the local grid). Somers has ample capacity within the town, construction of DERs will not require a significant distribution capacity investment.

4.3.3 Ancillary Service

The proposed zinc air batteries in the Somers microgrid will participate in ancillary services markets. Each zinc air battery unit will bid 1 MW of capacity into the NYISO frequency regulation market throughout the year. By continuously discharging or charging according to signals from the NYISO, the batteries will produce revenues for owners and improve power stability on the larger grid.

4.3.4 Development of a Combined Heat and Power System

Due to lack of natural gas pipelines in the area and lack of steam off-takers within a technically feasible distance of the generation site, the Project Team decided to propose solar PV arrays and zinc air batteries instead of a CHP unit. Therefore, there is no proposed CHP unit for the Somers microgrid.

4.3.5 Environmental Regulation for Emission

The microgrid's generation assets will drive a net 309 $MTCO_2e$ (metric tons CO_2 equivalent) decrease in GHG emissions in Somers as compared to the New York State energy asset mix. The proposed generation assets will produce around 854 MWh of electricity per year. The backup diesel generators will emit approximately 1 $MTCO_2e$ per year, while the solar arrays will emit none. The current New York State energy asset mix would emit approximately 310 $MTCO_2e$ to produce the same amount of electricity[51]. The microgrid's generation assets will therefore result in a net decrease in emissions by 309 $MTCO_2e$.

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 $MMTCO_2e$ in 2014, and will begin decreasing in the near

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[50] Professor John Kassakian, MIT: http://engineering.mit.edu/ask/how-do-electricity-transmission-lines-withstand-lifetime-exposure-elements.

[51] 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 MTCO2e/MWh. Info from EPA (http://www3.epa.gov/statelocalclimate/documents/pdf/background_paper_3-31-2011.pdf).

future. The state sells an “allowance” for each ton of CO_2e emitted in excess of the limit at allowance auctions, but does not require assets under 25 MW to purchase allowances.

Table 27 catalogs the CO_2, SO_2, NO_x, and Particulate Matter (PM) emissions rates for the diesel generators.

Table 27. 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_2, SO_2, NO_x).

Distributed Energy Resource Name	Location	Emissions Type	Emissions Per MWh (Metric Tons/MWh)
DER1 – Existing Backup Diesel Generator	Heritage Residential Units and Heritage Recreation	CO_2	0.7196[52]
		SO_2	0.1911[53]
		NO_x	2.9074
		PM	0.2046
DER2 – Biogas Generator	Heritage Residential Units and Heritage Recreation	CO_2	0.508
		SO_2	9.09358E-07[54]
		NO_x	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 equipment at the substation and across the rest of the microgrid:

- 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 44 kV utility breaker at the substation as well as the smaller 13.2 kV distribution feeders.
- Automated breakers installed throughout Somers 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 $665,000 and $15,000 for the IT infrastructure. The Project Team estimates the 0.015 MW biogas generator, two 0.3 MW solar PV arrays and three zinc air battery units carry an installed cost of $60,000,

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[52] Diesel Generator Emissions rate: 0.72 MTCO2e/MWh (assuming 161 lb CO2e per MMBTU; EIA, http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11).

[53] Michigan Department of Environmental Quality; Environmental Science and Services Division. “Potential to Emit, Diesel Fired Generator Calculation Worksheet.”

[54] “Natural Gas-fired Reciprocating Engines” – EPA, http://www3.epa.gov/ttnchie1/ap42/ch03/final/c03s02.pdf.

$1.59 million and $2.5 million, respectively.[55] This brings the total installed capital cost to approximately $4.83 million, not including interconnection fees and site surveys. However, it is important to note that while anaerobic digesters do exist in commercial applications, they are typically of a much larger scale, and as such there is some uncertainty around the cost of a very small, 15 kW digester. Aside from the capital costs, the fixed costs of operating the unit may also significantly impact the cost effectiveness of this technology, and will need to be further studied. Additionally the estimated capital cost does not account for any financial incentives or tax credits that may lower the overall cost of the microgrid. See Tables 28 and 29 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 28 details capital cost of the distributed equipment including the microgrid control system and centralized generation controls that will allow the operator and electronic controllers to manage the entire microgrid.

Table 28. Distributed Equipment Capital Cost

Table displays the 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	1 Primary	$50,000 (total)	7 - 8	Control system responsible for operating the microgrid sequencing and data concentration under all operating modes.
(Siemens SICAM PAS or equivalent)	1 Back-up			
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)	6 new 6 upgrade	$150,000 $30,000	20	Upgraded breakers/switches at distribution load feeders to enable IED interface with and control by the microgrid.

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[55] Diesel Generator Capital Cost: $1,000/kW (Siemens Diesel estimate), Solar PV Capital Cost: $2,400 - $2,700/kw (Siemens Solar PV estimate).

Distributed Equipment Capital Costs				
Capital Component	**Quantity**	**Installed Cost ($) (+/- 30%)**	**Component Lifespan (Years)**	**Purpose/Functionality**
Generation Controls (OEM CAT, Cummins, etc.)	2	$8,000	20	New manual switch to de-energize existing lines preventing the microgrid from back feed at multiple places.
PV Inverter Controller (OEM Fronius, etc.)	2	$8,000	20	Controls PV output and sends data to SCADA for forecasting
Storage Inverter Controller (OEM Fronius or equivalent)	3	$12,000	20	Controls battery storage input/output and sends live power data to SCADA and EMS for forecasting. Receives charge/discharge commands from SCADA Microgrid 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.
WiMax Subscriber Units	7	$14,000	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	1	$62,000	-	Installation of capital components in the microgrid

Table 29. 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**
0.015 MW Biogas Generator	1	$60,000	20	Generation of electricity
0.3 MW Carport PV System	1	$870,000	30	Generation of electricity
0.3 MW PV System	1	$720,000	30	Generation of electricity
1 MW / 4 MWh Zinc air unit	1	$832,000	20	Storage of electricity
1 MW / 4 MWh Zinc air unit	1	$832,000	20	Storage of electricity
1 MW / 4 MWh Zinc air unit	1	$832,000	20	Storage of electricity

The microgrid IT infrastructure will also require Cat-5e Ethernet cables 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, [56] for distances under 100 meters. The total installation cost of cabling is approximately $5.65 per foot. [57] 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 $15,000. [58]

4.4.2 Initial Planning and Design Cost

The initial planning and design of the microgrid includes four preparation activities and total to approximately $0.5 million.

1. The first set of activities are the design considerations and simulation analysis which will cost approximately $375,000 to complete.
2. The second activity focuses on the financial aspects of the project including project valuation and investment planning which will cost approximately $75,000.
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 30 below.

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[56] Commercially available RJ-45 connectors, $0.30 per connector.

[57] Installation costs for Cat5e: $5.45/ft. Component cost for Cat5e: $0.14/ft (commercially available).

[58] The Project Team estimated ~2,500 feet of Cat5e will be necessary.

Table 30. 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 ($)[59]	Cost Components
$375,000	Design considerations and simulation analysis
$75,000	Project valuation and investment planning
$25,000	Assessment of regulatory, legal, and financial viability
$25,000	Development of contractual relationships
$500,000	**Total Planning and Design Costs**

4.4.3 Operations and Maintenance Cost

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

The microgrid owner will also incur $75,000 per year in total costs for annual fixed system service agreements for the zinc air unit. Additionally the total costs for annual fixed system service agreements for the solar PV arrays, biogas generator and backup diesel generator will be approximately $15,500 per year. [60]

The diesel fuel usage of the backup diesel generators is difficult to predict because they will be used only during some emergency outage situations. The average price of diesel fuel in New York State from 2013-2015 was $3.91 per gallon, which translates to an average fuel cost of approximately $25/MWh. The high price of diesel fuel, along with increased GHG emissions, discourages extended use of the diesel generators.

The solar PV arrays will not require fuel to operate, and should not require service outside of the normally scheduled downtime. Normally scheduled downtime should cost approximately $20/kW per year.[61]

Annual service for all non-DER microgrid components will cost approximately $70,000 per year.[62] Table 31 outlines all fixed operations and maintenance (O&M) costs associated with normal operation of the DERs.

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[59] Estimates developed by Booz Allen Project Team and independent consultant.

[60] $75,000 for zinc air battery unit ($25/kw per year), $12,000 for solar PV arrays ($20/kW per year) and $4.60/kW per year for backup diesel generators (Electric Power Research Institute, "Costs of Utility Distributed Generators, 1-10 MW").

[61] NREL (projects $0/kWh variable maintenance costs): http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html.

[62] O&M for non-DER microgrid components: $70,000/year (Siemens).

Table 31. 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)	Cost Components
~ $12,000 (total)	Solar PV System Service Agreement – Annual costs of maintenance and servicing of unit
~$2,300	Diesel Generator Service Agreement – Annual costs of maintenance and servicing of unit
~ $1,200	Biogas Generator Service Agreements – Annual costs of maintenance and servicing of unit
$75,000	Battery System Service Agreement – 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

At full operation, the proposed 0.5 MW diesel generator will require 35.5 gallons of diesel fuel per hour at full load. The proposed diesel generator has a 550 gallon diesel storage tank installed, so at a 100% level of output this generator can operate for 15.5 hours without replenishing its fuel supply. Cutting output to 50% increases the maximum operation time to 31 hours.

The biogas unit will have a continuous supply of fuel unless the production of biogas is impeded, therefore the biogas unit will be able to operate continuously. There is effectively no maximum operating duration for the biogas unit in island mode. DERs such as diesel generators have limited tank sizes and have clear maximum operating times in island mode.

The solar PV arrays do not require fuel for operation, but their output depends on weather and time of day.

The zinc air batteries does not require fuel for operation, but are limited by a maximum output of 1 MW for a total of 4 hours each. Table 32 shows the fuel consumption and operating times for all of the microgrid DERs.

Table 32. 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 - Existing Diesel Generator	Heritage Residential Units and Heritage Recreation	Diesel	15.5	550	Gallons
DER2 - Proposed Biogas Generator	Heritage Residential Units and Heritage Recreation	Biogas	N/A	N/A	Mcf
DER3 - Proposed Carport Solar PV Array	Heritage Residential Units and Heritage Recreation	Sunlight	N/A	N/A	N/A
DER4 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	4 (at 1 MW load)	N/A	N/A
DER5 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	4 (at 1 MW load)	N/A	N/A
DER6 - Proposed Solar PV Array	Somers Fire Station	Sunlight	N/A	N/A	N/A
DER7 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	4 (at 1 MW load)	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 generators in the event of an extended power outage. The solar arrays will be available for generation during a power outage, but their 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 0.0975 MW of load support to the Somers microgrid.

The zinc air batteries will be able to provide backup load support to the microgrid in the case of a grid wide outage. Each zinc air battery can provide up to 1 MW for 4 hours at full charge. This level of energy storage should provide sufficient power to the microgrid connected facilities during an outage.

The backup diesel generators will only come online when the solar arrays and zinc air batteries do not provide sufficient power to the islanded microgrid. Because the solar arrays and zinc air can produce 2.10 MW of power at full capacity and the microgrid's loads had an average power demand of 0.267 MW during 2014, the zinc air batteries and solar arrays should be capable of satisfying the microgrid's power demand in most situations. The diesel generator will only be necessary for about 60% of total outage time. At 60% operation the 0.2 MW diesel generator would produce an average of 7.2 MWh per day. The backup generator will require around 510 gallons of fuel per day at this level of generation. One-time startup costs or daily non-fuel maintenance costs for either of the diesel generators are not anticipated.

Table 33 shows all of the costs associated with operating the DERs during a power outage, including fuel and variable O&M costs.

Table 33. 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		
DER1 - Existing Diesel Generator	Heritage Residential Units and Heritage Recreation	Diesel	0.5	100%	12	340	Gallons	N/A	$2,997
DER2 - Proposed Biogas Generator	Heritage Residential Units and Heritage Recreation	Biogas	0.015	100%	0.36	12.5	MMBTUs	N/A	$21.29
DER3 - Proposed Carport Solar PV Array	Heritage Residential Units and Heritage Recreation	Sunlight	0.3	14%	1.008[63]	N/A	N/A	N/A	$16.50
DER4 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	1 MW 4 MWh	N/A	6.0	N/A	N/A	N/A	$68.50
DER5 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	1 MW 4 MWh	N/A	6.0	N/A	N/A	N/A	$68.50
DER6 - Proposed Solar PV Array	Somers Fire Station	Sunlight	0.3	14%	1.008[64]	N/A	N/A	N/A	$16.50
DER7 - Zinc air battery unit	Heritage Residential Units and Heritage Recreation	N/A	1 MW 4 MWh	N/A	6.0	N/A	N/A	N/A	$68.50

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[63] This output assumes that the PV array is still operational after an emergency event.

[64] This output assumes that the PV array is still operational after an emergency event.

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 33. Please refer to Table 33 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 municipally owned buildings or serve the entirety of the population in Somers (such as the Town Government Office and Fire Station). Others, like the Heritage Residential Units, serve a smaller population for most of the year. For estimates of the population served by each critical facility, see Table 34.

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. receiving a 911 call or local water sanitizing operations). Based on the portfolio of services that each facility provides and the electricity dependency of each service, Table 34 provides an estimate of how effectively each facility can perform its normal services without electricity.

Table 34. 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[65]	
		When Backup Power is Available	When Backup Power is Not Available
Heritage Hills Sewage Treatment Plant	~ 21,300	0%	100%
Somers Fire Station	~ 21,300	0%	> 50%
Somers Pharmacy and Surgical, Somers Eye Clinic, and a retail store	~ 21,300	0%	> 75%
Town Government Office and Elephant Hotel	~ 21,300	0%	> 50%
Mt. Kisco Medical Group	~ 21,300	0%	> 75%
Heritage Residential Units and Heritage Recreation	~ 35	0%	> 50%
Load Cluster 1	~ 45	0%	> 75%
Load Cluster 2	~ 16	0%	> 50%

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 Somers microgrid was delivered to the Project Team on March 23, 2016.

4.7.1 Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the Town of Somers has proposed development of a microgrid that would serve 19 facilities within the Town, including:

- Heritage Hills Sewage Treatment Plant
- Somers Fire Station
- A health related businesses complex that houses Somers Pharmacy and Surgical, Somers Eye Clinic, and a retail store
- The Elephant Hotel, a National Historic Landmark that serves as the community's Town Hall
- Mt. Kisco Medical Group

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[65] 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).

- Heritage Residential Units and Heritage Recreation, a community of eight residential/recreational units
- Two load clusters – the first a collection of six residences, two businesses, and one restaurant, and the second a collection of four residences

The microgrid would be powered by six new distributed energy resources: a 0.015 MW biogas generator, powered by anaerobic digestion; two 0.3 MW photovoltaic arrays; and three Eos Aurora battery units, each with a 1.0 MW output and 4.0 MWh of storage. The new biogas generator, the Eos Aurora battery units, and one of the proposed photovoltaic arrays would all be installed at Heritage Residential Units and Heritage Recreation; the remaining photovoltaic array would be installed at the Somers Fire Station. In addition, the microgrid would incorporate one currently installed 0.5 MW backup diesel generator, located at the Heritage Residential Units and Heritage Recreation. The Town anticipates that the biogas generator and the photovoltaic systems would produce electricity for the grid during periods of normal operation. The diesel generator and the Eos Aurora battery units would produce power only during an outage, when the microgrid would operate in islanded mode. The system as designed would have sufficient generating capacity to meet average demand for electricity from the 19 facilities during a major outage.

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

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

The BCA considers costs and benefits for 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.[67]

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[66] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's 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 CO2 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 SO2, NOx, and PM2.5, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

[67] 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.

4.7.3 Results

Table 35 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 1.5 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 35. BCA Results (Assuming 7 Percent Discount Rate)

Economic Measure	Expected Duration of Major Power Outages	
	Scenario 1: 0 Days/Year	Scenario 2: 1.5 Days/Year
Net Benefits - Present Value	-$2,640,000	$129,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-0.8%	7%

Scenario 1

Figure 6 and Table 36 present the detailed results of the Scenario 1 analysis.

Figure 6. Present Value Results, Scenario 1

(No Major Power Outages; 7 Percent Discount Rate)

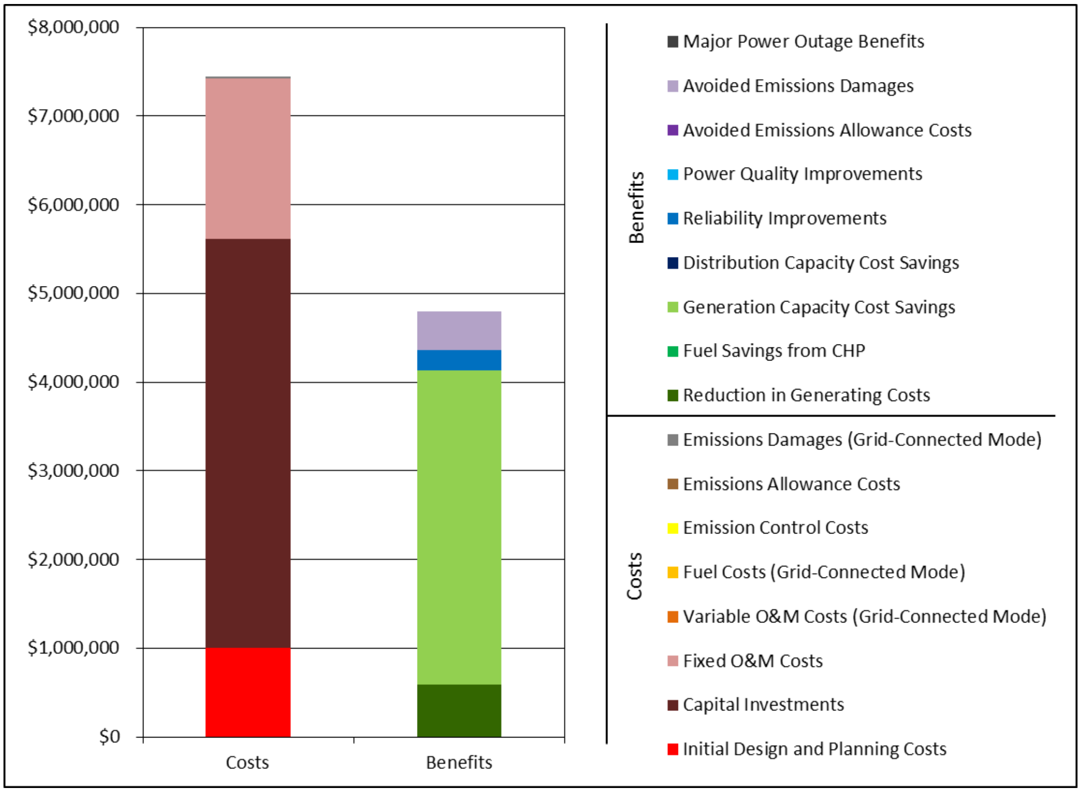

Table 36. Detailed BCA Results, Scenario 1

(No Major Power Outages; 7 Percent Discount Rate)

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,000,000	$88,200
Capital Investments	$4,610,000	$355,000
Fixed O&M	$1,810,000	$160,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$15,300	$1,000
Total Costs	**$7,440,000**	
Benefits		
Reduction in Generating Costs	$590,000	$52,100
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$3,540,000	$312,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$237,000	$20,900
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$290	$26
Avoided Emissions Damages	$430,000	$28,100
Major Power Outage Benefits	$0	$0
Total Benefits	**$4,800,000**	
Net Benefits	**-$2,640,000**	
Benefit/Cost Ratio	**0.6**	
Internal Rate of Return	**-0.8%**	

Fixed Costs

The BCA relies on information provided by the Project Team to estimate the fixed costs of developing the microgrid. The Project Team's best estimate of initial design and planning costs is approximately $1.0 million. The present value of the project's capital costs is estimated at approximately $4.6 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; the new 0.015 MW biogas generator; the two 0.3 MW photovoltaic arrays; and the three 1.0 MW Eos Aurora battery units. Operation and maintenance of the entire system would be provided under fixed price service agreements, at an estimated annual cost of $160,000. The present value of these O&M costs over a 20-year operating period is approximately $1.8 million.

Variable Costs

The anaerobic digester would produce the fuel required by the new biogas generator, eliminating the cost of fuel as a consideration in analyzing the project's variable costs. Thus, the analysis of variable costs focuses on the environmental damages associated with pollutant emissions from the generator, based on the operating scenario and emissions rates provided by the Project Team and the understanding that the generator would not be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the generator are estimated at approximately $1,000 annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $15,300.

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 Town of Somers' proposed microgrid, the BCA estimates a reduction in demand for electricity from bulk energy suppliers, with a resulting reduction in generating costs of approximately $0.6 million over a 20-year operating period; 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_2, SO_2, NO_x, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $290 and avoided emissions damages with a present value of approximately $430,000.[68]

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.[69] Based primarily on the capacity of the battery units, the Project Team estimates the project's impact on demand for generating capacity to be approximately 3.1 MW per year (the team estimates no impact on distribution capacity). On the basis of this figure, the BCA estimates the present value of the project's generating capacity benefits to be approximately $3.5 million over a 20-year operating period.[70]

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 $20,900 per year, with a present value of approximately $237,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption

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[68] Following the New York Public Service Commission's guidance for benefit cost analysis, the model values emissions of CO2 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 SO2 and NOx 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.

[69] 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.

[70] The estimate of generating capacity benefits assumes utilization of the batteries in grid-connected mode to produce power during periods of peak demand. If the batteries are used solely as a source of power during outages, the project's impact on generating capacity requirements – and any associated cost savings – would be negligible.

Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[71]

- System Average Interruption Frequency Index – 1.03 events per year
- Customer Average Interruption Duration Index – 118.2 minutes[72]

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.[73] 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.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.6; i.e., the estimate of project benefits is approximately 60 percent of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

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

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[71] www.icecalculator.com.

[72] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for New York State Electric & Gas.

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

that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[74,75]

As noted above, the Town of Somers' microgrid project would serve a number of residential, commercial, and critical service facilities, including fire and wastewater services. The project's consultants indicate that at present, only one facility, Heritage Residential Units and Heritage Recreation, is equipped with a backup generator; this unit can support the ordinary level of service at this facility. Operation of the unit costs approximately $1,300 per day. The remaining 18 facilities could maintain service by bringing in portable generators; Table 37 lists 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 a loss in service capabilities of between 50 and 100 percent (see Table 37).

Table 37. 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
Heritage Hills Sewage Treatment Plant	$2,111	100%
Somers Fire Station	$204	50%
Somers Pharmacy and Surgical, Somers Eye Clinic, and retail store	$1,398	75%
Town Government Office and Elephant Hotel	$4,079	50%
Mt. Kisco Medical Group	$835	75%
Load Cluster 1 (six residences, two businesses, one restaurant)	$865	75%
Load Cluster 2 (four residences)	$314	50%

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

- Heritage Residential Units and Heritage Recreation would rely on its existing backup generator, maintaining full service capabilities while the generator operates. If the backup generator fails, the Heritage complex would experience a 50 percent loss in service capabilities.
- The remaining facilities would rely on portable generators, experiencing no loss in service capabilities while the units are in operation. If the portable generators fail, the facilities would experience a loss in service capabilities of between 50 and 100 percent, as shown in Table 37.

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[74] 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.

[75] 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.

- In all cases, the supply of fuel necessary to operate backup generators would be maintained indefinitely.
- At each facility, there is a 15 percent chance that the backup generator would fail.

The 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 Somers' case, this would result in a 50 percent increase in average response time.
- 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 wastewater services, the methodology again assumes that the population usually served would be left without the service. The impact of the loss in service includes both the lost economic productivity due to a loss of commercial wastewater services, and the welfare loss from lost residential service.
- For the remaining facilities, the value of service is based on the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator:[76]
    - For the health related businesses complex (Somers Pharmacy and Surgical, Somers Eye Clinic, and the retail store), the value of service is estimated at approximately \$35,000 per day, assuming 12 hours of microgrid demand per day during an outage;
    - For the Government Office and Elephant Hotel, the value of service is estimated at approximately \$16,000 per day, using an assumed 12 hours of microgrid demand per day during an outage;
    - For Mt. Kisco Medical Group, the value of service is estimated at approximately \$29,000 per day, assuming 18 hours of microgrid demand per day during an outage; and
    - For the commercial facilities included in Load Cluster 1, the combined value of service is approximately \$19,000 per day, using an assumed 12 hours of microgrid demand per day during an outage.

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 \$163,000 per day.

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[76] http://icecalculator.com/.

Summary

Figure 7 and Table 38 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 1.5 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 7. Present Value Results, Scenario 2

(Major Power Outages Averaging 1.5 Days/Year; 7 Percent Discount Rate)

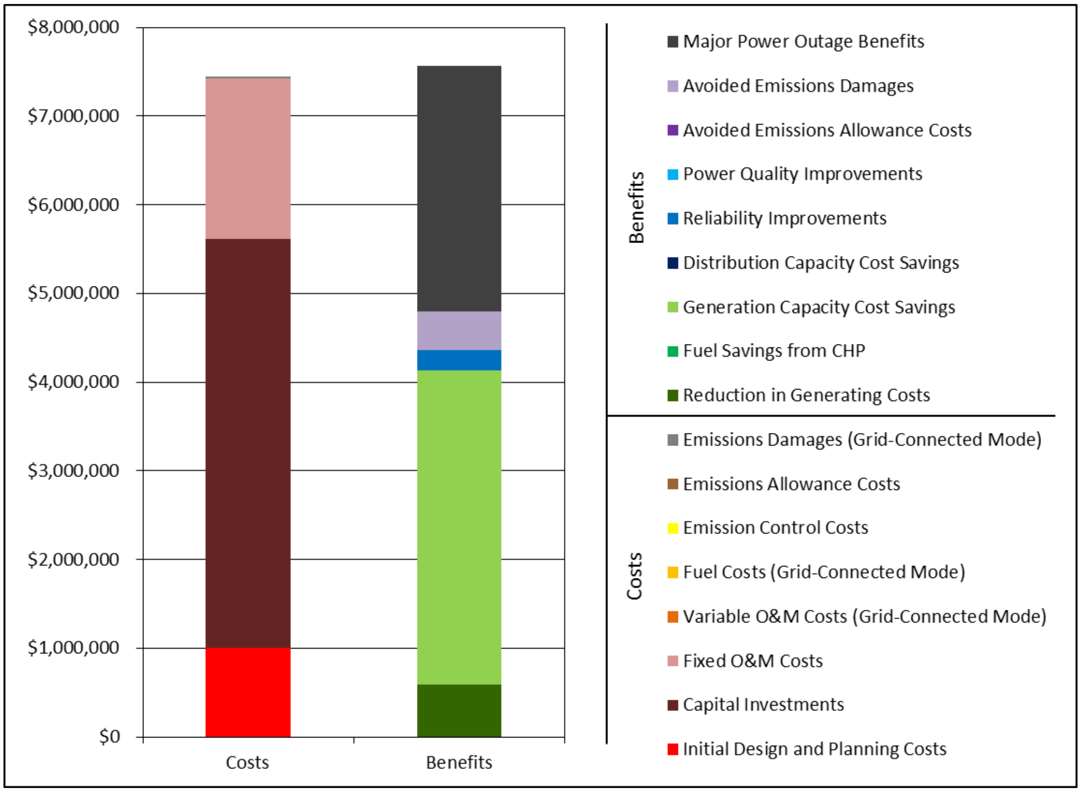

Table 38. Detailed BCA Results, Scenario 2

(Major Power Outages Averaging 1.5 Days/Year; 7 Percent Discount Rate)

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,000,000	$88,200
Capital Investments	$4,610,000	$355,000
Fixed O&M	$1,810,000	$160,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$0	$0
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$15,300	$1,000
Total Costs	**$7,440,000**	
Benefits		
Reduction in Generating Costs	$590,000	$52,100
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$3,540,000	$312,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$237,000	$20,900
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$290	$26
Avoided Emissions Damages	$430,000	$28,100
Major Power Outage Benefits	$2,770,000	$245,000
Total Benefits	**$7,570,000**	
Net Benefits	**$129,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.0%**	

The Project Team assumed an electricity sales price of $0.084 per kWh in Somers. This is the supply cost for NYSEG, the average amount spent by NYSEG 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 location-based marginal price (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 NYSEG grid. In Somers, the Dunwoodie LBMP is $39.16 per MWh[77], or $0.039 per kWh, a more than 53% 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.

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[77] Average according to IEc cost-benefit model.

5. Summary and Conclusions

5.1 Lessons Learned and Areas for Improvement

The lessons learned from the Somers microgrid feasibility study are divided into two parts. The first part in Section 5.1.1 highlights Somers-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 Somers Lessons Learned

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

The microgrid footprint in Somers occupies a single feeder connecting several, diverse facilities. In this respect, the footprint is attractive and requires limited controls and infrastructure to operate. There are two major hurdles in Somers, however, that negatively impact project feasibility. The first, as in other communities, is the lack of natural gas service in the footprint of the microgrid. Spinning, natural gas-fired generation is the most cost efficient and resilient source of microgrid power that the Project Team has identified and without it, the microgrid is forced to rely on intermittent solar PV or relatively expensive battery storage. While Somers has limited peak demand and thus lower on-site generation requirements, the economics of storage are difficult without significant incentives and exceptionally high electric prices. There are minimal storage incentives in Somers and the demand charges in the community do not support the viability of storage. The Project Team is aware of distribution level gas service in a neighboring area of Somers, but the cost to expand the natural gas infrastructure was deemed prohibitive for the scope of the proposed microgrid.

The second hurdle in Somers is the historic designation of the commercial core of the community. The microgrid centers on the intersection Route 100 and Route 202, and exterior alterations to the municipal and commercial microgrid facilities fronting Route 202 are subject to community approval. In practice, this severely restricts the installation of solar PV on facility roofs, over parking lots, or in adjacent open space. The Project Team was therefore forced to propose somewhat larger PV arrays off of the main street in locations that may be otherwise developed in the future. Somers was unique in that it is the only community in the Project Team's portfolio with such requirements, and moving forward, it will be difficult for the community to develop a microgrid on this footprint without dispensation for the installation of generation assets.

In comparison to working with a municipal utility, working with the investor-owned NYSEG was a more time-intensive process. As a utility with a large footprint, customer base, and transmission and distribution network, NYSEG has many issues to manage that require its attention, among which microgrids and NY Prize were just one. However, NYSEG was receptive to the possibility of placing microgrid along a substantial portion of a feeder, allowing for the inclusion of a diverse facility set in the proposal. The result is a technically feasible microgrid that meets NYSERDAs critical facility requirements. A NY Prize Phase II award would require more extensive conversations with NYSEG about their role in a future microgrid on the proposed footprint and how a microgrid might utilize existing infrastructure absent direct involvement of the utility.

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. All of the proposed loads in Somers are on a single feeder. The extent of critical and important facilities on this feeder is unusual, but significantly lessens the complexity and cost of the electrical infrastructure required.

Second, the availability of natural gas infrastructure is a major contributor to positive project feasibility. In Somers, which is without natural gas, generation is limited to solar PV, the tie in of existing diesel backup generation, and a small anaerobic digester, plus storage. Given the intermittency of solar, and the low capacity factor in New York State (approximately 15%), solar installations of a few hundred kW, as in Somers, 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 steam sales if there is a proximate off-taker.

Financial. Across the portfolio of communities managed by the Project Team, natural gas availability and steam 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, and offers steam sales as an added revenue stream that 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, steam; 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.

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.

The financial viability of many community microgrids would be significantly enhanced if the NYPSC were to include community microgrids as eligible for Qualifying Facility (QF) designation or, absent that change, if the NYPSC were to provide affirmatively lightened regulation[78] for primarily natural-gas fired projects. Qualifying Facilities must meet certain tests regarding generation type and size, distance, and number of users. A behind-the-meter microgrid would provide significantly stronger returns to investors, propel New York State in the direction of a "grid of grids," and provide more opportunities for load support and DR across the state. This solution would allow generation assets to load follow the facilities within the microgrid, selling power closer to retail rates to the associated facilities, which would result in greater revenues. Excess power may be sold to the utility when the locational-based marginal price (LBMP) is greater than the variable cost of production, and additional revenue may be generated through DR programs participation. While many microgrids may already be eligible for qualifying facility designation, uncertainty about any given project's regulatory disposition drives up costs. The Project Team believes energy costs in New York State, and the current condition of the electricity infrastructure in the State, are ripe for an economically efficient expansion of a system of microgrids. However, this remains an elusive proposition without clarifications in policy.

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. In Somers, support from the utility for this effort has been robust and the community has been helpfully engaged. In other communities, as in Somers, the Project Team has been in contact with administrators, elected officials, and non-governmental community representatives; this type of engagement is necessary to not only build support among prospective facilities but also to engage on ownership models, generation options, and other considerations that will directly affect the feasibility of the proposal. The engagement and commitment from the community is instrumental to the Project Team's ability to make recommendations that are acceptable and reasonable to the community.

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[78] CHP, hydro, PV, fuel cells, etc. are already qualifying generation for a QF. Standalone natural gas (turbine or recip.) provides reliable baseload power, and is largely more flexible than the currently included generation types, but is currently excluded. Many locations cannot leverage steam loads and may not have the space available for sufficient PV installations, thus limiting the effectiveness of the QF regulatory status.

In those communities that are more removed from the process it is difficult to make firm recommendations, and the Project Team runs the risk of suggesting solutions that are, for whatever reason, unpalatable to the community.

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. Second, widespread AMI infrastructure makes expansion far less complicated and allows for the selective disconnect of facilities that are not microgrid participants. Somers'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. Many of the NY Prize project proposals require the Phase III award to achieve positive economics, and several more 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 steam 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 NYSEG in Somers, 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. In such 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 DERs and control infrastructure. To-date, most microgrids in the United Stated 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. This is especially true in regions with relatively low electricity costs. 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. The Somers microgrid utilizes 100% renewable energy sources in normal operation, including solar PV, battery storage, and a solid waste-based anaerobic digester. Only in island mode when peak loads exceed available solar and battery power will the existing diesel units at the wastewater treatment plant come online. As these would come online in an outage at present, there is no net addition of fossil generation in the Somers microgrid proposal.

5.2.2 Benefits to the Town of Somers

Critical and important facilities in the Town of Somers 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 battery storage will also offset higher-emission peaking assets during peak demand events and local diesel backup requirements. The Project Team provided a summary briefing and path forward to the community by phone on March 10, 2016.

5.2.3 Benefits to Residents in and around Somers

Residents of Somers 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 Somers and nearby surrounding communities will have access to critical facilities and other important services in the event of an outage. In the future, the microgrid could be expanded to connect more facilities, including a soon-to-be-developed, centralized police barracks and local emergency facility on Rt. 100 approximately ¼ mile from the current microgrid footprint.

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 Somers 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 Somers microgrid is technically feasible but financially infeasible. The microgrid meets all of the NYSERDA required capabilities and most of its preferred capabilities.

The main barriers to completion will be obtaining funding for the project's capital costs and offsetting the annual loss that the microgrid will realize. NYSEG must also agree to the new interconnection and electrical distribution network because it will incorporate NYSEG lines and switches. The Heritage Hills Wastewater Treatment Plant will need to agree to host the anaerobic digester, the battery units, and the car-port PV over the settling pools. Existing and proposed generation assets and microgrid components must be available for maintenance at all times. The Team is still working with the facilities to ensure that they will allow a third party to service the generation assets and microgrid components located on their land. The Project Team expects these operational challenges to be resolved by the time of construction—these facilities have considerable incentive to support the project, as construction and interconnection will guarantee a reliable power supply and possibly provide DER owners with new sources of revenue.

The proposed Somers microgrid is replicable and scalable, and it provides a proof of concept for a renewables 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. 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 Somers, providing citizens with access to additional pharmacies, groceries, and public safety services in outage situations.

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 DER assets. The utility will see increased revenues and grid performance, the community will reap the positive benefits of living in and around the microgrid, and commercial customers will benefit from the value of avoided outages.

Path Ahead

Absent NY Prize Phase III, and additional support, the project will not be financially feasible. However, the Community and the utility may use the Feasibility Study as a basis for improving energy resilience and reliability in the community absent a full microgrid implementation. Expanded distributed energy resources within the footprint, even without smart controls and dedicated switches, will add more support for the grid and provide a positive value stream for the owner of the asset. If new assets are small and numerous enough, the net effect may be a footprint that has a wide mix of facilities that can remain online and functioning through an indefinite outage. The expansion of solar in the community need not be tied to a microgrid and if the specific roof orientation and size is advantageous, numerous firms will install PV arrays at no cost to the customer or facility. To be sure, Solarize has been successful in Somers and with somewhat more permissive historic designation regulations, it could expand even further. While this does not create a microgrid, it does stabilize, and often reduce, electricity bills. The expansion of solar, particularly when 3rd party owned and financed, offers a no-regrets option and should be looked upon favorably.

Beyond new DERs in the community, energy efficiency is the most cost effective way to bring down energy costs and in the event that a full microgrid is implemented in the future, decreases the required generation associated with it. NYSEG and NYSERDA have numerous programs available to customers, ranging from light-emitting diode (LED) upgrade rebates to full energy audits and thousands of dollars of support. These programs are not restricted to the microgrid footprint and a wide push across the community could materially reduce energy costs and increase the financial security and discretionary spending power of town residents. Within the microgrid footprint, the Project Team estimates approximately 25 kW of available efficiency savings, saving a potential $15,000/year in electricity costs. NYSEG and NSYERDA programs include:

- NYSEG Small Business Energy Efficiency Program: NYSEG offers energy assessments and incentive payments to business customers with less than 110 kW average demand per month. Incentive payments cover up to 70% of the cost of recommended equipment upgrades, which often include replacing light fixtures, installing occupancy sensors and dimmer switches, upgrading commercial refrigeration, etc. The various municipal, medical, and retail facilities may be eligible for this program.
- NYSEG Commercial and Industrial Rebate Program: NYSEG plans to re-launch this program. As of February 16, 2016, the utility had not provided updated information on the program. In its previous iteration, the program offered prescriptive rebates for specific, predetermined EE upgrades such as lighting and controls, natural gas furnaces,

HVAC and heat pumps, and HVAC chillers. The program also included a custom rebate option where customers could apply for site-specific rebates for a variety of retrofitting EE opportunities. Finally, the program offered free access to INVEST, a Microsoft Excel-based workbook that helped users calculate cost, savings, and ROI from various EE upgrades.

- NYSEG Multi-Family Energy Efficiency Program: This program provides incentives for residents and/or property owners in apartments or condominium complexes with 5-50 units. The program offers several incentives for EE upgrades in common areas and individual dwelling units. 10 residential facilities may be eligible for this program. Incentives are listed below:
    - Free installation of LED and CFL bulbs in common areas
    - Incentives totaling 70% of the cost of hardwired LED, fluorescent, and exist sign lighting upgrades in common areas
    - Free installation of water heater pipe wrap in buildings with electric water heaters
    - Free installation of CFLs and LEDs in up to six fixtures per dwelling unit
    - Free installation of smart power strips in dwelling units
    - Free installation of energy-efficient faucet aerators and showerheads in dwelling units
    - Incentives totaling 30% of the cost of fluorescent fixture upgrades in dwelling units
- NYSERDA Commercial Existing Facilities Program: This program offers facilities two options for participation. Under the pre-qualified path, NYSERDA will compensate participating facilities up to $60k for qualifying retrofits or EE upgrades (such as lighting, commercial refrigeration, HVAC, and gas equipment upgrades). Facilities can also apply for custom incentives under the performance-based path (if a facility wishes to participate in this path, it is crucial to involve NYSERDA early in the planning and development process). The various municipal and commercial buildings in Somers may qualify for this program.

Appendix

The Project Team obtained monthly metering data for the Town Government Office and Fire Station from NYSEG and estimated monthly data for other facilities. The following 24 hour load curves represent simulations based on facility type and estimated monthly load factor (ratio of peak to average demand). They are included in this feasibility study to show which facilities have 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 NYSEG