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Notice

Town of Clarkstown Microgrid Feasibility Study

Microgrid Project Results and Final Written Documentation

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Abstract

Together with the Town of Clarkstown (Clarkstown), 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 feasible, though not without challenges. The commercial and financial viability of the project are analyzed and detailed in this document. The Clarkstown microgrid project faces the challenge of high capital costs, but it benefits from an advantageous mix of generation and loads. A new 1.5 megawatt (MW) natural gas generator and a 100 kilowatt (kW) solar photovoltaic (PV) array in the East footprint, and a 1 MW natural gas generator and a 100kW solar PV array in the West footprint of the microgrid will provide reliable, low-emission electricity to customers while providing a proof of concept for a community microgrid in an investor-owned utility (IOU) territory. Many of the takeaways of the feasibility study may be generalized across the spectrum of NY Prize and community microgrids.

Keywords: NY Prize, NYSERDA, distributed energy resources, energy resilience, clean energy, DER, Clarkstown

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Acronyms and Abbreviations

AC	Alternating Current
AMI	Advanced Metering Infrastructure
ATS	Automatic Transfer Switch
BCA	Benefit Cost Analysis
BEMS	Building Energy Management Systems
BTU	British thermal unit
CAIDI	Customer Average Interruption Duration Index
CHP	Combined Heat and Power
DADRP	Day Ahead Demand Response Program
DC	Direct Current
DER	Distributed Energy Resources
DNP3	Distributed Network Protocol
DR	Demand Response
DSP	Distributed System Platform
EDRP	Emergency Demand Response Program
EE	Energy Efficiency
EMS	Energy Management System
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
Hz	Hertz
ICCP	Inter-Control Center Communications Protocol
IEc	Industrial Economics
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IOU	Investor-Owned Utility
ISM	Industrial Scientific and Medical
IT	Information Technology
ITC	Investment Tax Credit
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
LAN	Local Area Network
LBMP	Location-Based Marginal Price
LED	Light-Emitting Diode
Mcf	One Thousand Cubic Feet of Natural Gas
MCS	Microgrid Control System
MHz	Megahertz
MMBTU	One Million British thermal units
$MMTCO_2e$	Million Metric Tons CO_2 Equivalent
$MTCO_2e$	Metric Tons CO_2 Equivalent
MW	Megawatt
MWh	Megawatt-hour
NYISO	New York Independent System Operator

NYPA	New York Power Authority
NYPSC	New York Public Service Commission
NYS DEC	New York State Department of Environmental Conservation
NYSERDA	New York State Energy Research and Development Authority
O&M	Operation and Maintenance
OPC	Open Platform Communication or OLE (Object Link Embedded) Process Control
OPF	Optimal Power Flow
O&R	Orange and Rockland Utilities
PCC	Point of Common Coupling
PLC	Programmable Logic Controller
PPA	Power Purchase Agreement
PV	Photovoltaic
RAID	Redundant Array of Independent Disks
REV	Reforming the Energy Vision
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SCOPF	Security Constrained Optimal Power Flow
SOA	Service Oriented Architecture
SOW	Statement of Work
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 Clarkstown. 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 that the Town can improve energy resilience with intentional and emergency island mode capabilities, stabilize energy prices by relying on its own energy generation assets when statewide electricity demand is high, and comply with the greater New York REV (Reforming the Energy Vision) program by constructing 2.7 MW of clean energy generation capability. The study concludes that the technical design is feasible.

In Clarkstown, two groups of identified loads are physical adjacent but separated electrically due to the existing Orange and Rockland Utilities (O&R) distribution system. For this reason, the Project Team proposes a microgrid with two small footprints: the East footprint and the West footprint. They are physically separated but virtually connected. Four facilities and two load clusters compose the electrical loads of the proposed east footprint. Six facilities and one load cluster compose the electrical load of the proposed west footprint. 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 Clarkstown.

Table ES- 1. Prospective Microgrid Facilities

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

Name on Map	Property	Classification
East Footprint		
1	Town Hall	Public*
2	Fire Department	Public*
3	Police Department	Public*
4	Rockland County Courthouse	Public**
5	Load Cluster 1 (one grocery store, three restaurants, one retail store)	Commercial
6	Load Cluster 2 (eight retail stores, three restaurants)	Commercial
West Footprint		
7	Rockland County Sheriff's Department	Public*
8	Rockland County Corrections	Public*
9	Rockland County Highway Department	Public**
10	Rockland County Legislature	Public**
11	Animal Hospital of New City	Private**
12	Load Cluster 3 (eight residential buildings)	Residential
13	Office Building	Commercial
		* Critical ** Important

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

Figure ES-1 shows the proposed microgrid and the locations of facilities and DERs.

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

Table ES- 2. Existing and Proposed Generation Assets

Table describes proposed generation assets in the Clarkstown and the fuel source, capacity, and address of each system. Table also provides their label for Figure ES-1.

Label	Description	Fuel Source	Capacity (kW)	Address
East Footprint				
DER1	Existing Backup Diesel Generator	Diesel	400	1 South Main St.
DER2	Existing Backup Diesel Generator	Diesel	264	10 Maple Ave
DER3	Existing Backup Diesel Generator	Diesel	300	20 Maple Ave
DER4	Existing Backup Diesel Generator	Diesel	161	20 Maple Ave
DER5	Existing Backup Diesel Generator	Diesel	161	20 Maple Ave
DER6	Existing Backup Diesel Generator	Diesel	161	20 Maple Ave
DER7	Existing Backup Diesel Generator	Diesel	161	20 Maple Ave
DER8	New Natural Gas Generator	Natural Gas	1500	1 South Main St.
DER9	New Solar PV Array	Sunlight	100	1 South Main St.
West Footprint				
DER10	New Natural Gas Generator	Natural Gas	1000	11 New Hempstead Road
DER11	New Solar PV Array	Sunlight	100	11 New Hempstead Road

In the both east and west footprint, the proposed DERs should have adequate capacity to supply the microgrid loads shown in Table ES-2, above, during emergency outage conditions. When the solar arrays operate close to their nameplate capacities, the east footprint's generation capacity will approach 1.6 MW with a guaranteed 1.5 MW from the natural gas generator, while the west footprint's generation capacity will approach 1.1 MW with a guaranteed 1 MW from the natural gas generator. Aggregate demand from the east footprint facilities averaged 689 kW and never exceeded 1,311 kW in 2014. Aggregate demand from the west footprint loads averaged 507 kW and never exceeded 982 kW in 2014.[1] 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.

A hybrid ownership model is envisioned for the Clarkstown microgrid, wherein one special purpose vehicle (SPV) owns the two natural gas generators and the two solar PV arrays as well as the microgrid controls. The SPV will be supported by private investors. It is proposed at this time that O&R will own all new and upgraded distribution infrastructure as a means to retain control over their existing operations and their distribution infrastructure. The Project Team believes this hybrid model offers the greatest benefits and flexibility to the utility and customer base within the Town.

Given the capital expenditures, it is anticipated that the majority stake in the SPV for the natural gas generators and solar PV arrays will be owned by private investors. O&R will leverage its energy domain expertise to operate the microgrid and controls on a contract basis. Revenues streams from electricity sales will accrue to SPV investors and will cover variable generation costs. In Clarkstown, the proposed ownership model provides the greatest benefits to the utility and customer base within the Town, ensuring that revenues and costs are relatively in balance.

The microgrid will incur initial capital costs of $4.6 million as well as yearly operation, maintenance, and fuel costs totaling $1.2 million per year. Overall revenue streams from the project are estimated at $1.6 million per year and will be captured primarily through the sale of electricity during grid-connected mode. The proposed microgrid may qualify for two incentive programs in the Federal Investor Tax Credit (ITC) and NY Sun. The programs will each cover around 30% of the total solar PV capital cost. Other possible sources of incentive revenue include NYSERDA Phase III NY Prize funding.

The Clarkstown microgrid concept, with new reliable and clean generation, and the integration of existing energy resources, provides the Town with an energy resilience solution that is technically sound and, with the NY Prize, financially viable. The ability to island several critical facilities is a significant addition to the resilience of the Town in times of emergency and extended grid outages.

[1] 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 982 and 1,311 kW, but the Project Team was unable to obtain synchronized real-time load data for all included facilities.

1. Introduction

The Town of Clarkstown (Clarkstown) is seeking to develop a community microgrid to improve energy service resilience, accommodate distributed energy resources (DER), stabilize energy prices, and reduce greenhouse gas (GHG) emissions. Working with the Clarkstown and O&R, a team from Booz Allen Hamilton (hereafter Booz Allen or the Project Team) designed a preliminary microgrid concept that will connect ten facilities and three load clusters to the microgrid across two distinct footprints and will provide essential services to the community in grid outage situations. Four of these facilities, the Town Hall, Fire Department, Police Department, and the County Courthouse, are classified as critical facilities. Four proposed generators behind the Courthouse and the Country Legislature will produce electricity throughout the year and provide power to all facilities in island mode: a 1.5 MW natural gas generator and a 100 kW solar PV array in the East footprint, and a 1 MW natural gas generator and a 100kW solar PV array in the West footprint. Section 2 of this document describes the configuration further. In this document, the Project Team discusses the observations, findings, and recommendations from the entirety of the analysis. Within the document, Booz Allen also explores avenues for further development, discusses project results, and shares lessons learned regarding configuration, capabilities, environmental and economic benefits, and implementation scenarios.

2. Microgrid Capabilities and Technical Design and Configuration

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

2.1 Project Purpose and Need

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

Clarkstown was significantly impacted by Hurricane Sandy and participated in the New York Rising Community Reconstruction Program. As part of the program, the Town identified areas which are vulnerable to storm damage and formulated a plan to provide funding to address these issues, including adding backup generation to additional municipal facilities, encouraging residents to install alternatively fueled backup generation, and amending the zoning code to require backup generation for critical facilities. The Planning Department has been working to help the town attain their goals as a Climate Smart Community. Participation in these initiatives and the generated products will serve as the foundations of the Climate Action and Sustainability Plan, which will be included in the 2020 Comprehensive Plan Update. The Town also participated in a NYSERDA microgrid study that focused on Rockland County assets and town services.[2] The study found that a microgrid could be financially feasible in the area if the system participated in a demand response (DR) program, which is why the town joined the New York Independent System Operator (NYISO) Installed Capacity (ICAP) Special Case Resources (SCR) DR program through Demand Response Partners, Inc. in 2014. The Clarkstown Town Hall currently participates, and the Police Department plans to bid some capacity in the future. The microgrid could function as a virtual aggregator for the various facilities.

The Project Team estimates the microgrid's main DERs will generate an instantaneous average output of approximately 2.2 MW of electricity throughout the year.[3] Although Clarkstown is not currently considered a critical congestion point on the NY State grid, this generation capacity will reduce the amount of power that must be transmitted to the Town from the larger grid, which may result in lower congestion costs to O&R in the surrounding area. The project could serve as a model for the critical congestion points in the area, providing data on how distributed energy resources affect required transmission capacity for NYSERDA and the NYISO. Coupled with other distributed energy resource projects in the area or elsewhere, the aggregate reduction of load on the transmission system could be material.

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

The NYSERDA statement of work (SOW) 65096 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.

[2] NYSERDA, Microgrids For Critical Facility Resiliency in New York State Final Report Summary, December 2014, http://www.nyserda.ny.gov/-/media/Files/Publications/Research/Electic-Power-Delivery/Microgrids-for-Critical-Facility-NYS.pdf.

[3] Natural gas capacity factor: 85% (EPA; http://www3.epa.gov/chp/documents/faq.pdf), Solar PV capacity factor: 14% (NREL PV Watts Calculator).

Table 1. Microgrid Capabilities Matrix

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

Capability	Required/ Preferred	Microgrid will meet (Y/N)
Serves more than one physically separated critical facility	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[4]
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	N
Active network control system	Preferred*	Y
Demand response	Preferred	Y[5]
Clean power sources integrated	Preferred	Y
Optimal power flow (OPF) (economic dispatch of generators)	Preferred	Y
Storage optimization	Preferred	N
PV observability, controllability, and forecasting	Preferred	Y
Coordination of protection settings	Preferred	Y
Selling energy and ancillary services	Preferred	N[6]
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.

[4] While the system will be technically capable of intentional islanding, doing so would cut power flow to other customers on the included feeders and thus would not be feasible for economic purposes.
[5] The system is technically capable of providing DR, but it is unclear whether islanding the microgrid will qualify for DR programs (both load and generation assets will be taken off-line simultaneously).
[6] Microgrid has the capability to sell energy and ancillary services, but it may only sell energy in reality.

2.2.1 Serving Multiple, Physically Separated Critical Facilities

Clarkstown and the Booz Allen team have identified five critical facilities, four important facilities, and four additional facilities/load clusters to be tied into the microgrid. See Table 2 for a full list of prospective critical, important, and additional facilities to be tied into the microgrid.

Table 2. Town of Clarkstown Critical, Important, and Additional Facilities

Table lists microgrid loads, their addresses, and their classifications as critical, important, or additional.

Name of Facility / Load Cluster	Address	Classification (Critical, Important, Additional)
East Footprint		
Town Hall	10 Maple Ave.	Critical
Fire Department	15 Maple Ave.	Critical
Police Department	20 Maple Ave.	Critical
Rockland County Courthouse	1 South Main St.	Important
Load Cluster 1 (one grocery store, three restaurants, one retail store)	39-55 South Main St.	Additional
Load Cluster 2 (eight retail stores, three restaurants)	12-22 South Main St.	Additional
West Footprint		
Rockland County Sheriff's Department	55 New Hempstead Rd.	Critical
Rockland County Corrections	55 New Hempstead Rd.	Critical
Rockland County Highway Department	23 New Hempstead Rd.	Important
Rockland County Legislature	11 New Hempstead Rd.	Important
Animal Hospital of New City	22 New Hempstead Rd.	Important
Load Cluster 3 (eight residential buildings)	54-70 New Hempstead Rd.	Additional
Office Building	28 New Hempstead Rd.	Additional

The proposed west footprint occupies approximately 30 acres. The east footprint occupies approximately 15 acres. Facilities will communicate over O&R's WAN (using the existing IT fiber optic backbone). Utilizing TCP/IP network communication protocols that are compatible with 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 allow remote monitoring and control of distributed devices, regardless of manufacturer. The microgrid design is flexible and scalable in order to accommodate future expansion and technologies.

2.2.2 Limited Use of Diesel Fueled Generators

Natural gas-fired generators will serve as the primary energy sources. As a comparatively low-emission, high reliability fuel, natural gas is an ideal source of energy for the proposed community microgrid. Electricity from the two 100 kW solar PV arrays will supplement energy from the natural gas generators. The solar arrays will operate at maximum capacity during the summer and will offset some of the natural gas generators' emissions. The existing diesel backup generators provide additional generation redundancy and will only be used occasionally in island mode if the natural gas unit fails to operate.

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 islanded mode, the microgrid control system (MCS) will optimize on-site generation and automatically shed non-critical loads as needed to maintain stable and reliable power flow. In grid-connected mode, the microgrid will optimize the use of available assets to reduce energy costs when possible and export to the O&R grid when economic and technical conditions align.

The proposed natural gas generation assets will operate continuously in grid-connected mode, reducing local dependence on grid-supplied power. In island mode, the solar PV arrays will supplement the reciprocating generators' output to meet critical loads when they are producing. The MCS will bring existing backup diesel generators on-line as necessary in the east footprint to ensure a steady power supply.

2.2.4 Intentional Islanding

The microgrid will intentionally switch to island mode when doing so results in a more stable and reliable environment and prevent potential outage. 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. Since both east footprint and west footprint are not at the end of a feeder, intentional islanding means the downstream loads will not be connected to the grid and therefore experience an outage. Thus, the microgrid will only switch to island mode intentionally upon critical reliability situation and not for economical reason.

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

2.2.5 Resynchronization to O&R Power

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

An additional breaker at both the points of common coupling (PCCs) is required to connect the new microgrid generation. The control system will trigger the opening or closing of this breaker, as appropriate, during system transitions. See Section 2.7.7 for more information.

2.2.6 Standardized Interconnection

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

Table 3. New York State Interconnection Standards[7]

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
Inverters	Direct current (DC) generation can only be installed in parallel with the utility's system using a synchronous inverter
	Need for additional revenue metering or modifications to existing metering will be reviewed on a case-by-case basis and shall be consistent with metering requirements adopted by the NYPSC

[7] 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.

2.2.7 24/7 Operation Capability

The project concept envisions two natural gas-fired reciprocating generators as the main generation sources for the community microgrid footprint in Clarkstown. A six-inch 30-80 pound per square inch (psi) gas line at Rockland County Courthouse and a twelve-inch 30-80 psi gas line at Rockland County Legislature will support continuous operation of these generators.

The Project Team was unable to determine the storage capacity for the diesel backup generators in Clarkstown. The diesel generators will be unable to operate continuously because they are limited by the amount of diesel fuel on hand.

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 Clarkstown. 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 O&R's WAN using industry standard protocols such as DNP3 as well as OPC, Modbus, IEC 61850, 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 sensitive to fluctuations in load or generator output. It is therefore crucial to constantly monitor and regulate generator output against aggregate load in real time.

2.2.10 Load Following and Frequency and Voltage Stability When Islanded

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

In islanded mode, the MCS will maintain control of the generating units to maintain voltage and frequency.

2.2.11 Diverse Customer Mix

At present, the microgrid design includes ten facilities and three load clusters (see Table 4 for a list of included facilities). The customer mix includes residential, commercial, retail, public, private, and government buildings. These facilities and load clusters provide critical and important services to the Town of Clarkstown during outages. It may be possible for more facilities to be connected to the microgrid in the future. Table 4 lists all the facilities and load clusters currently being considered in the microgrid concept design, and Figure 2 shows them on a map.

Table 4. Town of Clarkstown List of Prospective Microgrid Facilities

Table lists properties, addresses, classifications, and number of load points for each facility/load cluster proposed for the Clarkstown microgrid.

	Property	Address	Classification
1	Town Hall	10 Maple Ave.	Public
2	Fire Department	15 Maple Ave.	Public
3	Police Department	20 Maple Ave.	Public
4	Rockland County Courthouse	1 South Main St.	Public
5	Load Cluster 1 (one grocery store, three restaurants, one retail store)	39-55 South Main St.	Commercial
6	Load Cluster 2 (eight retail stores, three restaurants)	12-22 South Main St.	Commercial
7	Rockland County Sheriff's Department	55 New Hempstead Rd.	Public
8	Rockland County Corrections	55 New Hempstead Rd.	Public
9	Rockland County Highway Department	23 New Hempstead Rd.	Public
10	Rockland County Legislature	11 New Hempstead Rd.	Public
11	Animal Hospital of New City	22 New Hempstead Rd.	Private
12	Load Cluster 3 (eight residential building)	54-70 New Hempstead Rd.	Residential
13	Office Building	28 New Hempstead Rd.	Commercial

Figure 2. Map of Microgrid Coverage Area

Figure provides a detailed map of the approximately 0.07 square mile coverage area for the east and west footprints illustrating where all thirteen facilities and DERs are located relative to each other and the main streets within Clarkstown.

2.2.12 Resiliency to Weather Conditions

Typical forces of nature affecting the Clarkstown include, but are not limited to, storms, heat in the summer, and animal damage to infrastructure. Clarkstown is subject to hurricanes and flooding, including recent prolonged power outages due to Hurricane Irene, Hurricane Lee, and Superstorm Sandy.

By implementing line fault notifications and deploying other sensors, microgrid owners can ensure the network is as resilient as possible to storms and other unforeseen forces of nature. The natural gas generators—the microgrid's main generation assets—will be protected from extreme weather by new enclosures or will be placed inside the existing Rockland County Legislature building and Rockland County Courthouse.

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

The distribution lines in Clarkstown 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 reciprocating generators will be equipped with black-start capabilities. If the Clarkstown grid unexpectedly loses power, the MCS will initiate island mode by orchestrating the predefined black-start sequence. The natural gas generators will require an auxiliary source of DC power to start multiple times in case of failure. They will ramp up to 60 Hz and prepare to supply the microgrid loads. After the generators are on-line and providing a stable power supply, the MCS will synchronize output from the solar arrays and bring them on-line.

2.2.14 Energy Efficiency Upgrades

Energy efficiency is critical to the overall microgrid concept. Clarkstown has been proactive in taking steps to reduce their total energy consumption. In 2015, Clarkstown bought 4,161 of its street lights from O&R for $690,000. This purchase was the first step in retrofitting the town's stock of high-pressure sodium lights with energy efficient light-emitting diodes (LEDs). The Town developed an ambitious Climate Action Plan to reduce GHG emissions by 10% by 2014. To date, they have exceeded their goal and reduced emissions by 20%.

The Town developed an ambitious Climate Action Plan to reduce GHG emissions by 10% by 2014, which they exceeded with a 20% reduction. Clarkstown has taken several steps to decrease energy use and improve EE within their community:

- In 2010, energy efficient street and traffic lights were installed as a part of New City Revitalization.
- In 2009, the Town initiated a pilot LED street light conversion program by installing LED pilot lights on Maple Avenue.
- In 2008, the Town leveraged NYSERDA funding to complete energy audits for municipal buildings, and they installed energy efficient lighting at the Parks and Recreation building.
- In 2007, the Town contracted an outside company to perform an energy audit of all Town-owned buildings.

Clarkstown has also adopted a Green Purchasing Policy to make the purchasing of environmentally sound products a priority, from green cleaning products to ENERGY STAR certified office equipment.

2.2.15 Cyber Security

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

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.

Assuming the logical controllers, or 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), used to monitor the unique address of the device and its designated network port. If the device is ever disconnected, the program will disable that port and prevent an unauthorized device from entering the IT system.

2.2.16 Use of Microgrid Logic Controllers

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

2.2.17 Smart Grid Technologies

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

2.2.18 Smart Meters

The Town of Clarkstown does not have smart meters installed throughout its coverage area. While ideal, smart meters are not required for the Clarkstown microgrid because the control sequence is performed at the feeder and facility level.

2.2.19 Distribution Automation

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

2.2.20 Energy Storage

The Project Team's analysis of battery storage technologies found their cost to be prohibitively high. Despite this, the MCS will be equipped with the capability to fully utilize and optimize the storage resources— including charging and discharging cycles for peak demand shaving—in case the town reevaluates its options in the future. The price of battery storage technology is constantly decreasing, and by "stacking" different uses of energy storage (i.e., microgrid resiliency, frequency regulation, and PV integration), microgrid owners may soon be able to achieve a competitive levelized cost of storage.[8]

2.2.21 Active Network Control System

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

2.2.22 Demand Response

As outlined above, the MCS has the capability to participate in DR programs by increasing generator output or curtailing flexible loads on a signal from O&R. The 2014 study resulted in the Town joining the NYISO ICAP SCR program through Demand Response Partners, Inc.

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

- Emergency DR Program (EDRP)
- Day Ahead DR Program (DADRP)
- Demand Side Ancillary Services Program (DSASP)

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

The DADRP is a program in which energy users can bid their load reductions into the NYISO day-ahead energy market, permitting flexible loads and resulting in increased supply. The DSASP gives retail customers who meet certain requirements the opportunity to bid into the day-ahead and real-time markets.

2.2.23 Clean Power Sources Integration

The proposed energy sources—natural gas and solar energy—will provide the microgrid with reliable, relatively low-emission electricity. In the future, it may be possible to expand the footprint or generation assets to include additional clean power sources. At that time, the Project Team will consider biomass, battery storage, and fuel cells. 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 purposed microgrid in Clarkstown includes two new natural gas generators and two new solar PV arrays. If the microgrid owners negotiate a long-term power purchase agreement (PPA) with O&R, the Project Team expects the generators to run continuously throughout the year. In

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

the event the system serves as a qualified facility, the system will be leveraged for load following. The MCS will fully utilize the optimum output of generation sources at the lowest cost by analyzing fuel costs, maintenance, and energy cost as part of security constrained optimal power flow (SCOPF).

2.2.25 Storage Optimization

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

2.2.26 PV Monitoring, Control, and Forecasting

The microgrid's PV inverter will usually operate at its maximum power point (MPP) in order to maximize the power production of the overall system, and because there is no associated operation and maintenance (O&M) cost. In some situations, the PV array might have to reduce its output for load following in islanded mode or to participate in frequency control. In such situations, the control is almost exclusively local with the output set point communicated by the central controller. As with other renewable energy sources, power output depends on weather and time of day. The MCS will fully integrate and optimize output from the new solar arrays at the Rockland County Courthouse and Rockland County Legislature buildings.

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.

2.2.28 Selling Energy and Ancillary Services

The proposed microgrid will sell excess energy from the solar arrays and reciprocating generators to O&R under net metering agreements and/or power purchase agreements.

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 1.0 MW and 1.5 MW natural gas generators will be technically capable of participating in most ancillary service markets, but it will not reliably have 1 MW of capacity available for participation in these markets. Other ancillary service markets, such as spinning and non-spinning reserves, do not provide competitive payments to small-scale generators like the 1.0 MW and 1.5 MW natural gas units. The Project Team has concluded that the microgrid most likely will not participate in NYISO ancillary service markets unless the reciprocating generators can be expanded.

Overbuilding the reciprocating generators would allow the microgrid owner(s) to sell extra electricity capacity into NYISO frequency regulation or ICAP (installed capacity) energy markets. However, preliminary analysis indicates it is not economically viable to do so. With one extra MW of generation capacity, the microgrid could also participate in the novel NYISO Behind the Meter: Net Generation program. Expansive discussion of these programs is outside the scope of this feasibility study, but the Project Team will consider these options in future phases of the competition.

2.2.29 Data Logging Features

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

2.2.30 Leverage Private Capital

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

2.2.31 Accounting for Needs and Constraints of Stakeholders

Developing the best possible value proposition for the community, utility, local industry, and other community stakeholders is at the center of this feasibility study. 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 exhibit benefit to the community. Active participation from the government, utility, and community groups will ensure that a community microgrid will add tangible and scalable value to Clarkstown and the surrounding areas. Additional detail about costs and benefits by stakeholder group can be found in Section 3.2.3.

2.3 Distributed Energy Resources Characterization (Sub Task 2.3)

As described above, the proposed west footprint includes two new DERs while the proposed east footprint includes two new DERs and seven existing diesel generators. This section will discuss the benefits of the proposed resources and how they will meet the microgrid's objectives in greater detail.

2.3.1 Existing Generation Assets

The east footprint currently has seven diesel generators for emergency power (see Table 5 for details about the assets). The three largest units are fixed, and the remaining four are mobile generators on trailers. Each existing diesel generator has some on-site fuel storage, but not enough to operate in island mode operation for extended periods of time without refueling. In addition, these units are rated for standby duty and can be brought online quickly, and the units currently have grid paralleling switchgear which will be upgraded as part of the microgrid build out. They are envisioned to provide additional redundancy capacity for the microgrid. There are no suitable existing generation resources in the west footprint that can be incorporated.

Table 5. Existing Distributed Energy Resources

Table describes the existing DERs to be incorporated into the microgrid, including their description, fuel source, capacity, and address. Table also provides the labels for Figure 2a and Figure 2b.

Name	Technology	Capacity (kW)	Fuel	Address
East Footprint				
DER1	Diesel Generator	400	Diesel	1 South Main St.
DER2	Diesel Generator	264	Diesel	10 Maple Ave.
DER3	Diesel Generator	300	Diesel	20 Maple Ave.
DER4	Diesel Generator	161	Diesel	20 Maple Ave.
DER5	Diesel Generator	161	Diesel	20 Maple Ave.
DER6	Diesel Generator	161	Diesel	20 Maple Ave.
DER7	Diesel Generator	161	Diesel	20 Maple Ave.

2.3.2 Proposed Generation Assets

The design proposes two new generation assets in the east footprint and two new generation assets in the west footprint. Proposed generation assets are summarized in Table 6. The east footprint will include a 1.5 MW natural gas-fired continuous duty reciprocating generator and a 100 kW solar PV array. The west footprint will include a 1 MW natural gas-fired continuous duty reciprocating generator and a 100 kW solar PV array. The west footprint's DERs will be constructed at the Rockland County Legislature, and the east footprint's DERs will be located at the Rockland County Courthouse. The PV arrays will easily be incorporated into the microgrid system with inverters that will synchronize their output in both grid-parallel mode and islanded mode.

Table 6. Proposed Generation Assets

Table describes the gas-fired reciprocating generators and the solar PV arrays. Included are their capacity, fuel, and address.

Name	Technology	Fuel	Capacity (kW)	Address
East Footprint				
DER8	New Natural Gas Generator	Natural Gas	1500	1 South Main St.
DER9	New Solar Panel	Sun	100	1 South Main St
West Footprint				
DER10	New Natural Gas Generator	Natural Gas	1000	11 New Hempstead Rd
DER11	New Solar Panel	Sun	100	11 New Hempstead Rd

The design proposes reciprocating generators in Clarkstown because both the electrical and thermal loads are relatively small. The electric load is not nearly large enough to sustain a combined cycle turbine with a heat recovery system, and there is no adequate thermal off-taker to merit addition of combined heat and power (CHP) capability. The Project Team analyzed the benefits and costs of several generator technologies and found that 1-1.5 MW reciprocating natural gas generators provided the best combination of energy resiliency, cost, and efficiency in Clarkstown.

2.3.3 Generation Asset Adequacy, Resiliency, and Characteristics

The proposed design provides Clarkstown with several additional energy resources. In grid-connected mode, the proposed PV arrays and natural gas-fired generators will operate in parallel with the main grid. Both footprint's natural gas-fired generator is capable of meeting the aggregate demand during island mode while in east footprint, the existing diesel generators provide additional generation redundancy. The microgrid design ensures adequate power will be available from spinning generators if the solar PV arrays are off-line due to weather or time of day.

To avoid power supply disruptions and protect the microgrid generation assets from damage, both the existing twelve-inch natural gas pipeline at the Rockland County Legislature and six-inch natural gas pipeline at the Rockland County Courthouse that will feed the proposed natural gas-fired reciprocating engines are buried to protect them from severe weather. The Project Team is still determining the best way to safeguard the generators from weather; at a minimum, the proposed natural gas reciprocating generators will be housed in a container to protect them from rain, snow, strong winds, and falling trees.

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

- Automatic load following capability – generation units and controls will be able to respond to frequency fluctuations within cycles, allowing the microgrid to maintain demand and supply balance in island mode.
- Black-start capability – the generators will have auxiliary power (batteries) required to start and establish island mode grid frequency.

2.4 Load Characterization (Sub Task 2.2)

The Project Team sized proposed DERs according to electrical load demands. The load characterizations below describe the electrical loads served by the microgrid. Descriptions of the load sizes to be served by the microgrid along with redundancy opportunities to account for downtime are included.

2.4.1 Electrical Load

The Project Team evaluated six primary electrical loads for the east footprint: the Town Hall, Fire Department, Police Department, Rockland County Courthouse, Load Cluster 1 (eight retail stores and three restaurants), and Load Cluster 2 (one grocery store, three restaurants, and one retail store). The Project Team also evaluated seven primary electrical loads for the west footprint: Rockland County Sheriff's Department, Rockland County Corrections, Rockland County Highway Department, Rockland County Legislature, Animal Medical at New City, Load Cluster 3 (eight residential buildings), and an office building.

Proposed facilities and load clusters are listed in Table 7, and their loads are summarized in Table 8. Typical 24-hour load profiles for each facility and load cluster can be found in the Appendix.[9] Clarkstown's proposed community microgrid will incorporate an animal hospital, eight county or public facilities, several commercial buildings, and eight residential buildings, all within close proximity to the primary O&R feeders on South Main Street and New Hempstead Road.

Table 7. Town of Clarkstown List of Prospective Microgrid Facilities

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

	Property	Address	Classification
East Footprint			
1	Town Hall	10 Maple Ave.	Public
2	Fire Department	15 Maple Ave.	Public
3	Police Department	20 Maple Ave.	Public
4	Rockland County Courthouse	1 South Main St.	Public
5	Load Cluster 1 (one grocery store, three restaurants, one retail store)	39-55 South Main St.	Commercial
6	Load Cluster 2 (eight retail stores, three restaurants)	12-22 South Main St.	Commercial
West Footprint			
7	Rockland County Sheriff's Department	55 New Hempstead Rd.	Public
8	Rockland County Corrections	55 New Hempstead Rd.	Public
9	Rockland County Highway Department	23 New Hempstead Rd.	Public
10	Rockland County Legislature	11 New Hempstead Rd.	Public
11	Animal Hospital of New City	22 New Hempstead Rd.	Private
12	Load Cluster 3 (eight residential buildings)	54-70 New Hempstead Rd.	Residential
13	Office Building	28 New Hempstead Rd.	Commercial

After extensive consultation with O&R representatives, the Project Team has included new automatic switches in the design to reliably isolate loads and generation in islanded mode. Figure

[9] The Project Team was unable to obtain 24-hour load profiles from O&R; the 24-hour load profiles were therefore estimated from the monthly load data using a simulator.

2a and Figure 2b illustrate the proposed microgrid design and layout, including loads, switches, existing electrical infrastructure, and proposed electrical infrastructure.

Figure 2a. East Footprint Equipment Layout

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

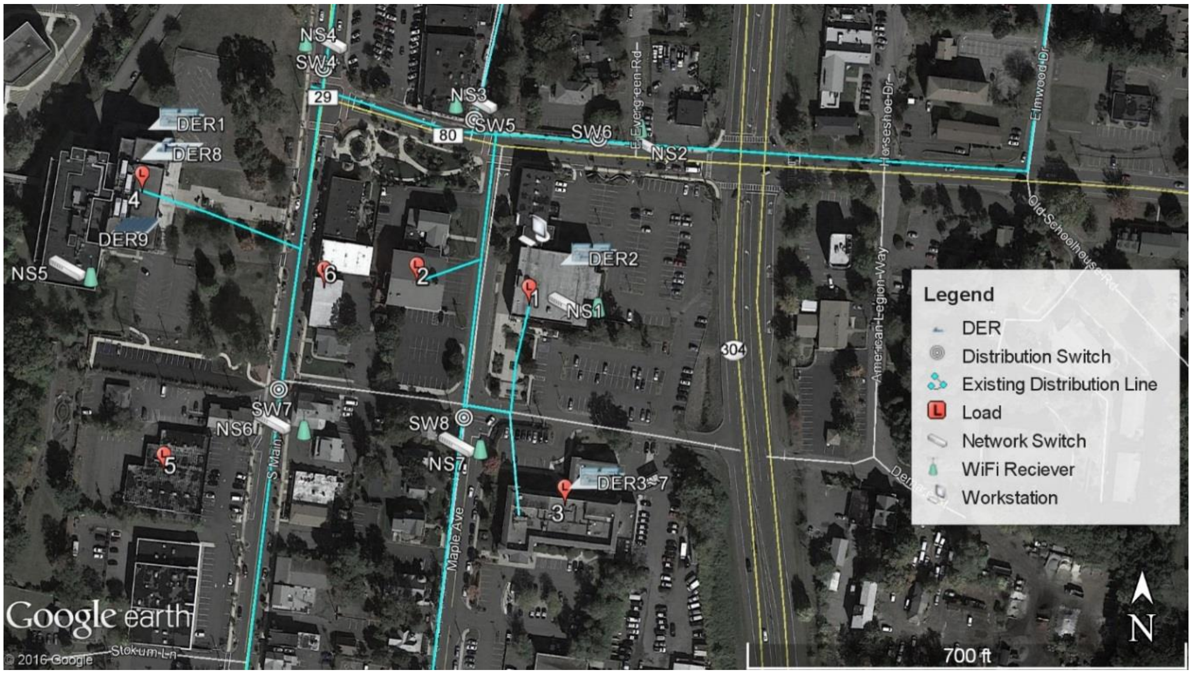
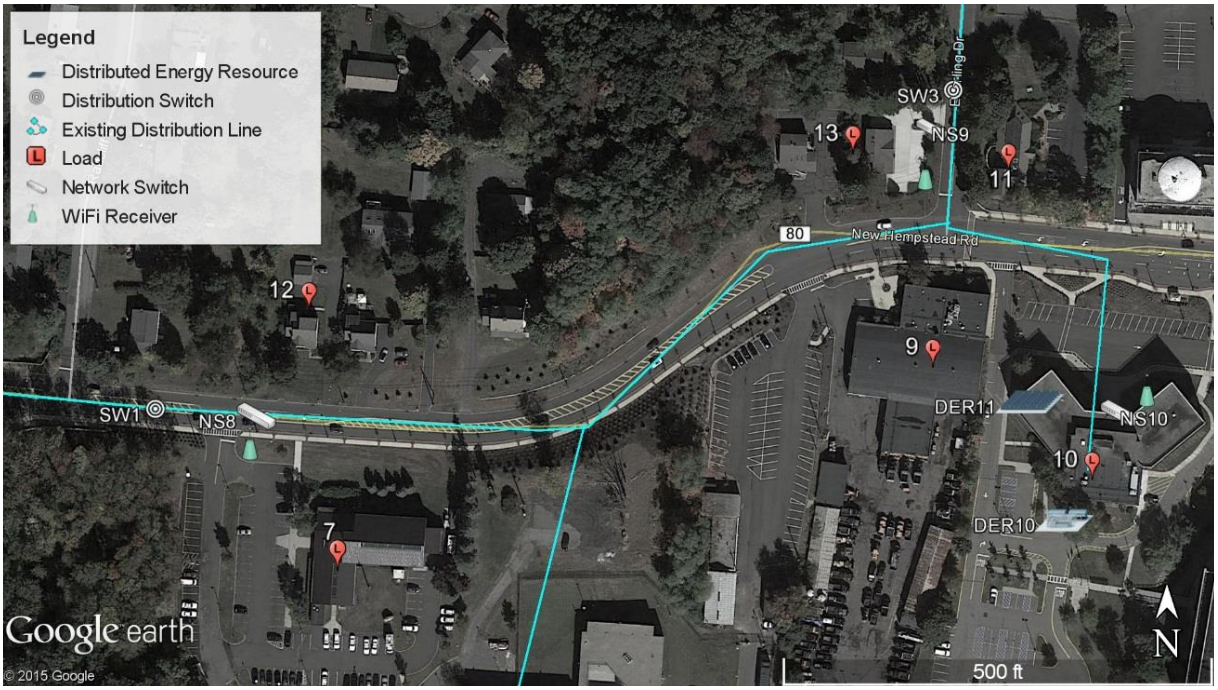


Figure 2b. West Footprint Equipment Layout

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



O&R provided the Project Team with twelve months of electrical metering data for connected facilities (January through December 2014), summarized in Table 8.[10] The aggregate peak demand in 2014 for the east footprint was 1,311 MW, and the average demand was 689 MW. The aggregate peak demand in 2014 for the west footprint was 982 kW, and the average demand was 507 kW.

Table 8. Clarkstown's 2014 Microgrid Load Points

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

	Electric Demand (kW)		Electric Consumption (kWh)			Thermal Consumption (MMBTU) [11]		
	2014 Peak	2014 Average	2014 Annual	2014 Monthly Average	2014 Weekly Average	2014 Annual	2014 Monthly Average	2014 Weekly Average
East Footprint Loads	1,311	689	6,034,675	503,640	117,125	1,122	94	22
West Footprint Loads	982	507	4,445,679	370,473	86,157	NA[12]	NA	NA

Figure 3a and Figure 3b provide typical aggregate hourly load profiles for the east footprint and west footprint. Both hourly load profile patterns rapidly rise at 06:00, slowly increase and peak at 12:00, remain at peak value until 16:00, and gradually decrease to the night-time baseline from 16:00 to 21:00.

[10] The Project Team is unable to obtain monthly electrical load data for Animal Hospital in New City, Load Cluster1, Load Cluster2, Load Cluster 3, and Office Building. These load data is simulated by the Project Team.

[11] Despite the thermal load indicated here, this thermal consumption is basically heating performed by a system which cannot be replaced by a CHP unit. No sufficient thermal off-taker exists to support facility in Clarkstown.

[12] The Project Team was unable to obtain the 2014 thermal consumption data in the west footprint.

Figure 3a. Typical 24-Hour Cumulative Load Profile for East Footprint

Illustrates the sum of individual east footprint facility loads for a typical 24-hour profile.

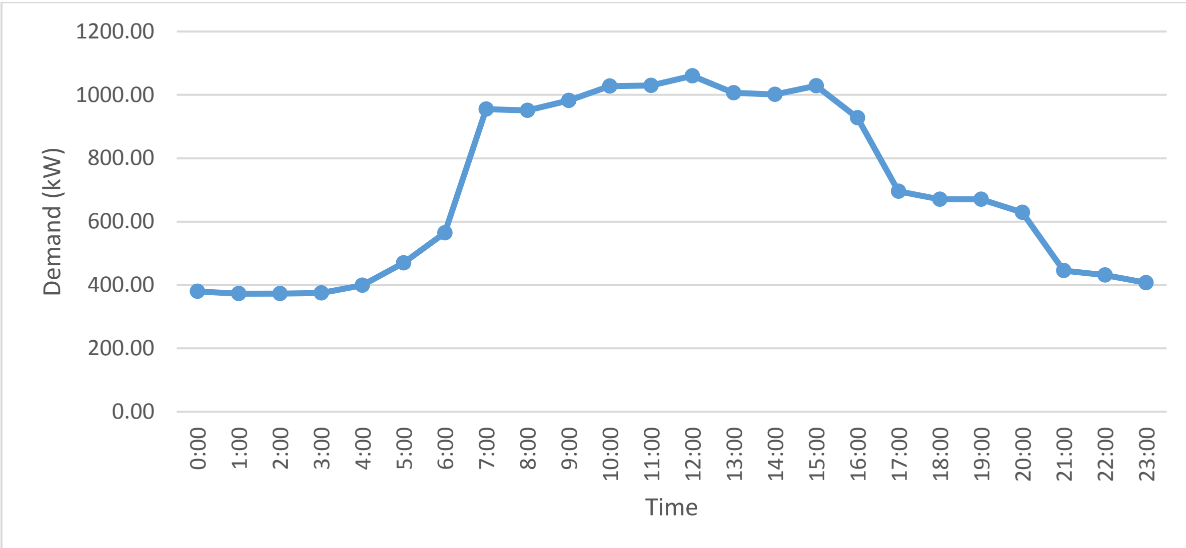
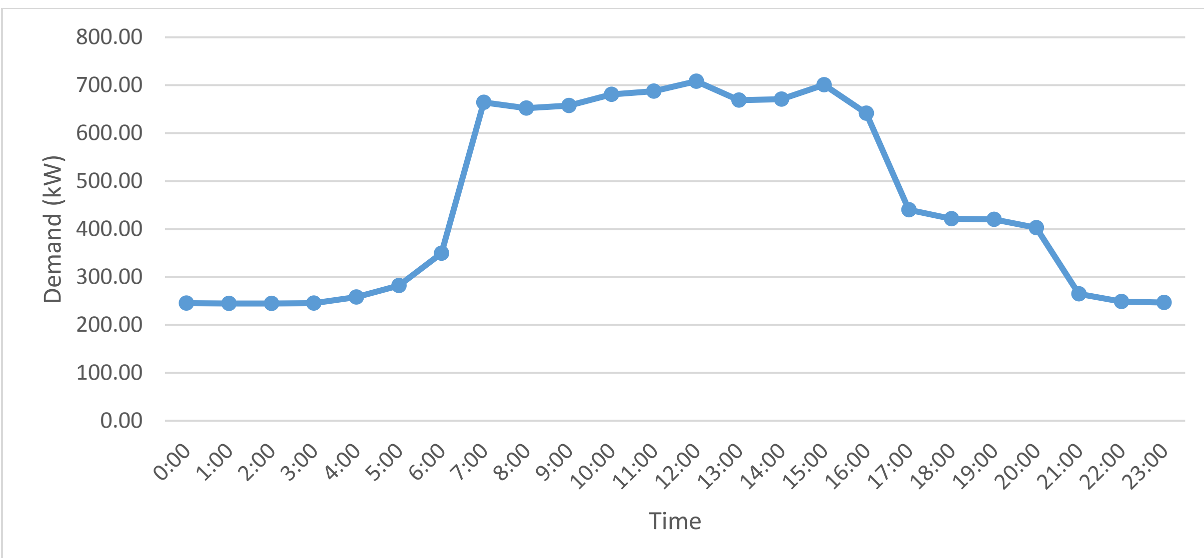


Figure 3b. Typical 24-Hour Cumulative Load Profile for West Footprint

Figure illustrates the sum of individual west footprint facility loads for a typical 24-hour profile.



The proposed natural gas reciprocating generators will operate continuously in both grid-connected and islanded mode. Although the output of the solar arrays will vary according to weather conditions and insolation, they will be most productive when facility demand is highest.

When the solar arrays operate close to their nameplate capacities, the east footprint's generation capacity will approach 1.6 MW with a guaranteed 1.5 MW from the natural gas generator, while the west footprint's generation capacity will approach 1.1 MW with a guaranteed 1 MW from the natural gas generator. The proposed natural gas engines are rated at net output and therefore there is no parasitic load against the nameplate. Moreover, the engines are somewhat oversized and should always out produce peak demand. Aggregate demand from the east footprint facilities averaged 689 kW and never exceeded 1,311 kW in 2014. Aggregate demand from the west footprint loads averaged 507 kW and never exceeded 982 kW in 2014.[13] In the both east and west footprint, the proposed DERs should therefore have adequate capacity to supply the microgrid loads with electricity in island mode. The proposed generators are flexible and able to turn down to 50% of rated output with no loss in performance, however given the proposal to run them continuously this should be a rare occurrence. Energy efficiency investments in microgrid facilities will not impact the generators except during islanded operation, during which time they would be supporting slightly diminished demand.

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

The solar arrays should have downtime available at various points throughout the year because the natural gas generators will normally cover aggregate demand; if the natural gas generators go off-line for maintenance, the microgrid will rely on grid-supplied power (or diesel backup generators in the east footprint).

2.4.2 Thermal Consumption

Thermal consumption is limited across the facilities within the microgrid. The relatively small facility sizes and lack of year-round thermal usage eliminate the potential for incorporating an economical CHP unit.

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 and islanded modes. Even with only one central controller, the east footprint and west footprint can be operated independently in different modes based on the O&R grid situation. Details concerning the infrastructure and operations of the proposed microgrid in normal and emergency situations are described below.

[13] 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 982 and 1,311 kW, but the Project Team was unable to obtain synchronized real-time load data for all included facilities.

2.5.1 Grid Connected Parallel Mode

The microgrid will most often operate in grid-connected mode. In this mode, the west footprint's proposed 1.5 MW natural gas-fired engine generator and the east footprint's proposed 1 MW natural gas-fired engine generator will operate continuously, exporting energy to the larger O&R grid. The proposed solar PV arrays will stay on-line throughout the year, but their output will depend on weather and insolation. The east footprint design includes diesel backup generators in the Police Department, Town Hall, and Rockland County Courthouse with a total capacity of 1,608 kW. Refer to Table ES-2 for a complete list of microgrid DERs.

If the larger grid experiences a contingency while the microgrid is connected, the parallel mode control scheme allows for the export of a predetermined amount of active and reactive power from microgrid DERs. By injecting power into the larger grid, the microgrid may be able to balance frequency and voltage to avert an outage. If the natural gas generators have sufficient excess capacity, they will ramp up generation as necessary to fulfill the necessary power requirement.

2.5.2 Intentional Islanded Mode

The proposed energy management and control scheme will balance generation with microgrid demand and maintain adequate frequency, voltage, and power flow across the microgrid network in islanded mode. Islanded mode can be intentionally used during forecasted O&R grid outages or disturbances to maintain electricity supply for microgrid facilities. Both the east and west footprint systems will first deploy energy from the solar arrays and manage the natural gas generators to meet remaining demand in real time. Because the output of the solar arrays cannot be controlled, the spinning generators will provide flexible real-time response. Refer to the simplified one-line diagrams in Figure 4a and Figure 4b for detailed device representations 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, PCC, and proposed utility infrastructure investment are also fully discussed below.

2.6.1 Electrical Infrastructure

The electrical grid in Clarkstown is owned and operated by O&R. Electricity enters the east footprint's system from the feeder at North Main Street. Power will first pass through the proposed automatic switch on South Main Street (SW4 on Figure 4a) and then pick up the loads in the east footprint by main or branch feeders. Electricity enters the west footprint's system from the feeder at New Hempstead Road. Power will first pass through the proposed automatic switch normally closed on New Hempstead Road (SW1 on Figure 4b) and then it will pick up all other loads along the New Hempstead Road electrical line in the west footprint. New automated switches (SW3, SW5, SW6, SW7, and SW8 on Figure 4a and Figure 4b) distributed throughout the area will enable different routings of power flows and the isolation/bypass of certain areas as needed. Clarkstown's One-Line Diagram is shown below in Figure 4a and Figure 4b.

The following tables (Table 9 to Table 11) describe the microgrid components and are referenced throughout the rest of the document. For a list of all included DERs, see Table ES-2.

Table 9. Clarkstown's Distributed Switches Description

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

Name	Description	New/Upgrade
SW1	Automatic switch for load/feeder isolation	New
SW2	Inverter internal breaker	New
SW3	Automatic switch for load/feeder isolation	New
SW4	Automatic switch for load/feeder isolation	New
SW5	Automatic switch for load/feeder isolation	New
SW6	Automatic switch for load/feeder isolation	New
SW7	Automatic switch for load/feeder isolation	New
SW8	Automatic switch for load/feeder isolation	New
SW9	Original equipment manufacturer (OEM) Generator breaker	Upgrade
SW10	OEM Generator breaker	Upgrade
SW11	OEM Generator breaker	Upgrade
SW12	OEM Generator breaker	Upgrade
SW13	OEM Generator breaker	Upgrade
SW14	OEM Generator breaker	Upgrade
SW15	OEM Generator breaker	Upgrade
SW16	OEM Generator breaker	New
SW17	Inverter internal breaker	New
SW18	OEM Generator breaker	New

Table 10. Clarkstown's Network Switch Description

IT network switches with their descriptions, status as existing or proposed, and addresses.

Name	Description	Status	Address
NS1	Near DER2, DER3, DER4, DER5, DER6, DER7, Supervisory Control and Data Acquisition (SCADA)/Energy Management System (EMS), and Workstation for communication	Proposed	Refer to Equipment Layout
NS2	Near Switch 6 for communication	Proposed	Refer to Equipment Layout
NS3	Near Switch 5 for communication	Proposed	Refer to Equipment Layout
NS4	Near Switch 4 for communication	Proposed	Refer to Equipment Layout
NS5	Near DER 1, DER8, and DER9 for communication	Proposed	Refer to Equipment Layout
NS6	Near Switch 7 for communication	Proposed	Refer to Equipment Layout
NS7	Near Switch 8 for communication	Proposed	Refer to Equipment Layout
NS8	Near Switch 1 for communication	Proposed	Refer to Equipment Layout
NS9	Near Switch 3 for communication	Proposed	Refer to Equipment Layout
NS10	Near DER 10 and DER11 for communication	Proposed	Refer to Equipment Layout

Table 11. Clarkstown's Server Description

The workstation and servers, their status as proposed, and their addresses. The microgrid servers and workstation will be placed at the Town Hall.

Name	Description	Status	Address
Workstation	Operator/Engineer workstation	Proposed	10 Maple Ave.
Server1	Primary EMS and SCADA	Proposed	10 Maple Ave.
Server2	Secondary EMS and SCADA	Proposed	10 Maple Ave.

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

Figure 4a. Clarkstown One-Line Diagram East

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

REDACTED PER NDA WITH O&R

Figure 4b. Clarkstown One-Line Diagram West

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

REDACTED PER NDA WITH O&R

2.6.2 Points of Interconnection and Additional Investments in Utility Infrastructure

The proposed interconnection points and necessary additional microgrid components are listed in Table 12. The proposed PCC between O&R's feeder and the microgrid is located at the feeder on Main Street (SW4 in Figure 4a) for the east footprint; the proposed PCC between O&R's feeder and the microgrid is located at the feeder on New Hempstead Road (SW1 in Figure 4b) for the west footprint.

Table 12. List of Components

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

Electrical Device	Quantity	Purpose/Functionality
Microgrid Control System Protocol Converter (Siemens SICAM PAS or equivalent)	1 Primary 1 Backup	Protocol converter responsible for operating the microgrid's field devices via protocol IEC-61850.
Automated Pole Mount Circuit Breaker/Switch (Siemens 7SC80 relay or equivalent)	8	Installs new breakers/switches at distribution overhead feeders. Isolates the feeders and downstream loads from the microgrid.
Generation Controls (OEM CAT, Cummins, etc.) (Load Sharing Woodward or equivalent)	9	Serves as the primary resource for coordinating the paralleling load matching and load sharing of spinning generation.
PV Inverter Controller (OEM Fronius or equivalent)	2	Controls PV output and sends data to the main microgrid controller for forecasting.
Network Switch (RuggedCom or equivalent)	10	One located at the control center for SCADA/EMS servers and workstation connection and the remaining are 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 the back-feeding of power to the larger O&R grid. However, the microgrid is capable of exporting energy back to O&R.

2.6.4 Thermal Infrastructure

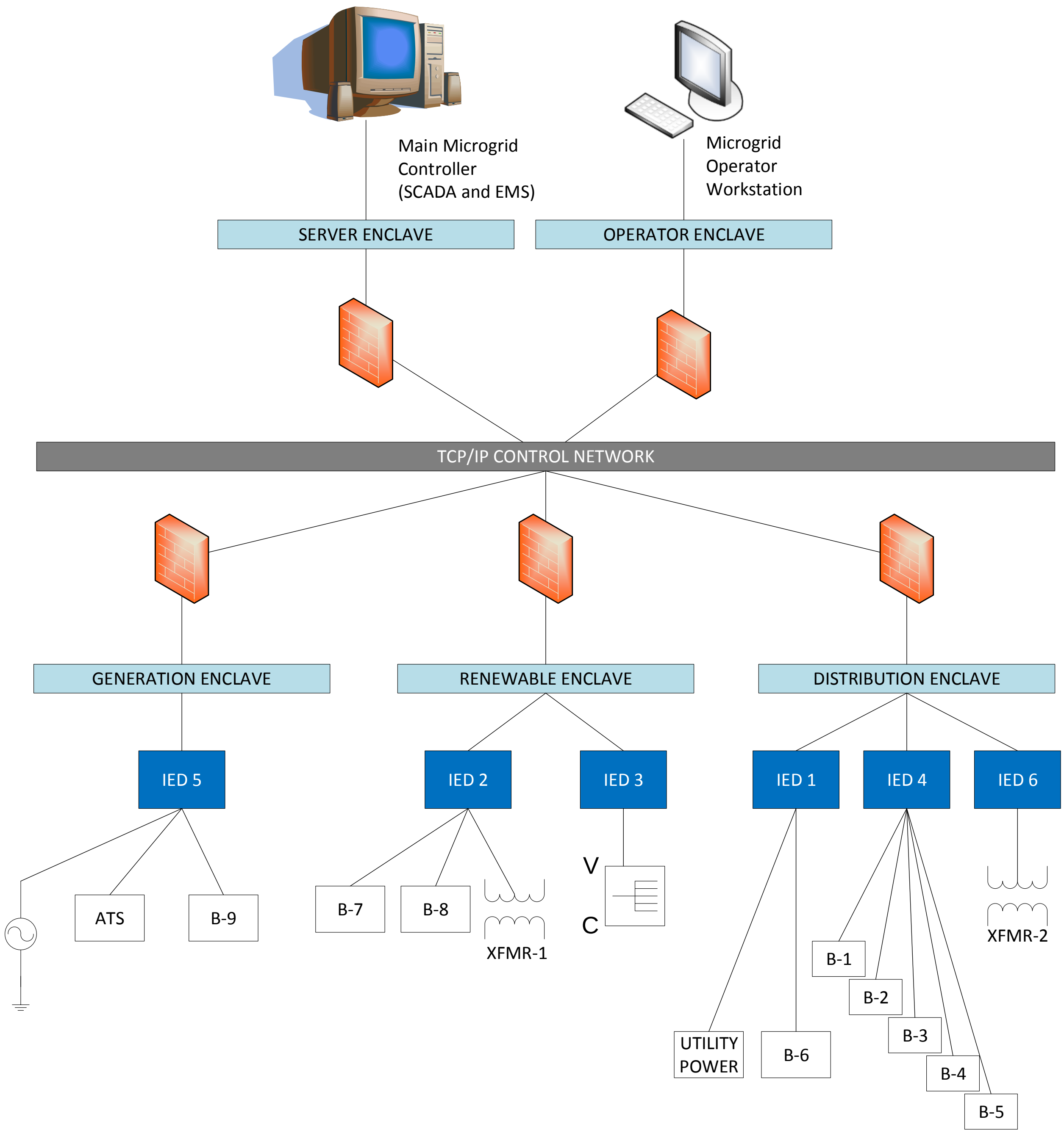
There is currently natural gas infrastructure in Clarkstown, however there is no known thermal off-taker in either footprint. Because the design does not include thermal cogeneration, there is no need for new thermal conveyance infrastructure. At the Rockland County Legislature, there is a twelve-inch high-pressure natural gas line that will provide an adequate supply of fuel to the 1.0 MW natural gas-fired generator. At the Rockland County Courthouse, there is a six-inch high-pressure natural gas line that will provide an adequate supply of fuel to the 1.5 MW natural gas-fired generator.

2.7 Microgrid and Building Control Characterization (Sub Task 2.5)

This section provides a more detailed description of the microgrid's modes of operation. The microgrid control system will include an EMS and a SCADA based control center (see Figure 5), hereafter collectively referred to as the main microgrid controller. Distributed IEDs will communicate with the main microgrid controller over the 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 O&R. 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 O&R grid (described in Section 2.7.7).

Figure 5. Diagram of a Typical Microgrid Control System Hierarchy

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



2.7.1 Microgrid Supporting Computer Hardware, Software, and Control Components

The following is a preliminary list of hardware equipment needed for the Clarkstown microgrid.

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

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

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

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

2.7.2 Grid Parallel Mode Control

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

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

2.7.3 Energy Management in Grid Parallel Mode

The proposed microgrid will integrate software and hardware systems to ensure reliability and effective performance. Optimization of microgrid performance involves three distinct phases: measurement and decision, scheduling and optimization, and execution and real-time optimization.

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

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

When local generation is available, the commercial value of produced electricity will depend on a number of factors, including renewable output, duration, and load management for tariff considerations. The commercial value will be offset by the baseline costs of operation.

2.7.4 Islanded Mode Control

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

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

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

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

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

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 that 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. The N+1 strategy ensures that extra generation is always on-line to handle the loss of the largest spinning generator and assumes the running generator with the highest capacity could go off-line unexpectedly at any time.

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

- Generators that do not start
- Generators that trip off unexpectedly during microgrid operation
- Switchgear that fails to operate
- Switchgear that fails to report status
- Loss of power from either of the natural gas generators
- Loss of power from the solar arrays

The MCS will optimize the microgrid's operation by managing generation assets. Proposed DERs will provide stable, sustainable, and reliable power. The MCS will continuously balance generation and load in real-time, monitoring relevant variables (i.e., system frequency and voltage) and adjusting generator output as necessary. The main microgrid controller will first deploy energy from renewable generation assets and adjust the output of the natural gas generators to match remaining electricity demand. If the natural gas generator goes down for maintenance or fails to operate, the MCS will bring backup diesel generators on-line (in the east footprint). The microgrid design relies on the fast ramp rate of the reciprocating generators to compensate for changing output from the solar arrays. However, other designs may incorporate battery storage to smooth these rapid fluctuations and ensure a reliable supply of energy when sunlight is not available.

The Booz Allen team found the cost of battery storage to be prohibitively high for the Clarkstown microgrid system. The analysis considered the potential of using storage for three purposes:

- System reliability: short-term backup, often used for voltage or frequency support or to smooth intermittent renewable ramp rates.
- Energy shifting: storing excess generation for a few hours, usually to offset higher priced periods (e.g., shifting excess solar generation from 1-3 PM to 4-6 PM when grids tend to peak).
- Longer term storage: storing energy from intermittent renewables for later use to firm up the supply to 24 hours or to improve/extend island mode operation.

The analysis indicated storage was not needed to improve system reliability (the fast ramp rates of natural gas generators and backup diesel generators provide an acceptable level of reliability). The high cost of battery storage and absence of time-of-use energy rates challenged the economics of using storage to shift generation or extend island mode operation.

2.7.6 Black Start

The proposed natural gas-fired reciprocating generators and existing diesel generators will be equipped with black-start capabilities. If the Clarkstown grid unexpectedly loses power, the microgrid controller will initiate island mode by orchestrating the predefined black-start sequence. The microgrid then enters unintentional islanding mode. This mode of operation will require each generator to have a DC auxiliary support system with enough power to start the generator multiple times in case it fails to start the first time. The MCS will first attempt to start power flow using the proposed gas generators. If the natural gas generator fails to start or are under maintenance, other small diesel generators will perform the black start.

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

1. PCC breaker opens
2. All active generation is disconnected
3. The main microgrid controller waits a pre-set amount of time (approximately 30 seconds) in case O&R power comes back
4. The main microgrid controller disconnects the entire current load (after estimating aggregate electricity demand)
5. The microgrid generators are synchronized with each other (one will usually provide reference voltage and frequency)
6. The main microgrid controller reconnects the microgrid loads

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

2.7.7 Resynchronization to O&R Power

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

While in island mode, the system will constantly monitor the status of the utility feeder at the points of common coupling and determine when appropriate levels of current and voltage have been restored. When power has been restored, the control system will synchronize and parallel the microgrid generation with the utility service through the utility circuit breaker at the switch on the main feeder (SW1 and SW4 in Figure 4a and Figure 4b, respectively). The 100 kW PV systems will be disconnected temporarily. This will allow the spinning generation to match the microgrid load and maintain microgrid frequency without relying on potentially unpredictable PV power dips or spikes. Before the microgrid system starts paralleling with the utility, it will balance the generation and load so as not to exceed either minimum or maximum export limits or time durations set forth in the utility interconnection agreement. Once power is restored and the main breaker is closed, other isolation switches throughout the feeders will close to serve power to other loads in Clarkstown. After the microgrid has re-connected to the larger grid, the PV arrays will be synchronized and brought on-line.

2.8 Information Technology and Telecommunications Infrastructure (Sub Task 2.6)

The existing IT and telecommunication infrastructure in Clarkstown 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 Town Hall, 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

Clarkstown already takes advantage of its existing fiber optic backbone ring from Verizon and existing Ethernet switches for reliable Internet and local area network (LAN) activities. Having the fiber optic backbone and reliable IT services at Clarkstown makes convergence feasible from a telecommunications standpoint. O&R, or a third party system operator, will need to install a new WAN layer 3 network switch router to enable monitoring and control of the microgrid remotely by O&R. The wireless components of the control system, which work on open architecture protocols, use a TCP/IP Ethernet-enabled component that controls each of the uniquely addressed modules to wirelessly communicate via a standard, non-licensed radio frequency mesh 900 megahertz (MHz) industrial scientific and medical (ISM) band signal network.

2.8.2 IT Infrastructure and Microgrid Integration

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

2.8.3 Network Resiliency

Cyber security falls into the two primary stages (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 Windows, or PC-based security teams.

For the planning stage, design considerations address cyber security by assigning roles to network-attached components on Orange and Rockland's WAN thereby controlling data flow and access permissions over the integrated MCS and overarching IT architecture.[14] 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 continuous monitoring and control of data flow. The firewall routes noncritical traffic such as utility's unrelated corporate printers and other drivers, email, and all other non-essential internet services (which could be backdoors for hackers into the MCS) to a dedicated "demilitarized zone" 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 O&R's 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 Orange and Rockland 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.

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.

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

The data transmitted throughout the proposed Clarkstown 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.

Cyber Security will also be considered during the operations stage to maintain against ongoing threats. Although in the past MCS vendors have performed only minimal software regression tests for bugs, in recent years the MCS vendors have been working on these issues continuously to mitigate security risks. It is important to note the proposed MCS network attached components can be upgraded online as software updates become available. The MCS could be upgraded automatically whenever an update is available or manually after testing the updates in a non-production environment. In either case, a networked server is used to deliver the updates. Each approach has its own benefits and drawbacks. Automatic upgrading installs updates as soon as they are available, but these updates might not function as expected in the given environment. Upgrading manually allows for testing to ensure correct functioning but the upgrades might be delayed over automatic upgrades. In either case, a networked server is used to deliver the updates.

It is strongly recommended these updates be tested or simulated first in a non-production environment. The simulated model is easy to mimic with artificial (input/output) I/O points. Any reputable control systems programmer/integrator does such testing before the commissioning stage; the same I/O model and hardware configuration could be used for the security update tests in the future. 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.

2.9 Microgrid Capability and Technical Design and Characterization Conclusions

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

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

- Funding for the project's capital costs must be obtained.
- The utility (O&R) must agree to the new interconnection and electrical distribution network because it will incorporate O&R lines and switches.
- The Rockland County Courthouse and Rockland County Legislature must agree to host the proposed reciprocating generators and solar PV arrays.
- The Rockland County Courthouse, Police Department, and Town Hall must support the interconnection of existing backup generators to the microgrid.
- The existing and proposed generation assets and microgrid components must be available for maintenance at all times.

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

The proposed design includes several new pole mounted automatic distribution switches to isolate the microgrid regions. New generators and solar PV arrays will provide reliable, low emission electricity in both island mode and grid-connected mode. Existing natural gas infrastructure in Clarkstown will support continuous operation of the proposed natural gas reciprocating generators.

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

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

- Private investors will own the DERs and the microgrid controls, and O&R may own the new and upgraded distribution infrastructure. O&R has preliminarily indicated to the

Project Team a willingness to own and operate the distribution assets related to the microgrid as they will be directly affixed to O&R's existing distribution system

- The two natural gas-fired reciprocating generators and two new 100 kW solar arrays will sell electricity to O&R at the average local supply charge (the price O&R currently pays to purchase electricity, excluding transmission, distribution, and capacity charges).
- O&R, as the local expert in energy distribution and the current owner and operator of the Town's distribution infrastructure, may operate the microgrid. O&R's existing infrastructure is used extensively in the preliminary microgrid design, so participation from the utility is vital to the project's success.
- The current regulatory, legal, and policy environment will stay consistent. The proposal falls within the existing frameworks.

Preliminary analyses indicate that by selling electricity at O&R's average supply price, private investors may realize a positive rate of return on the proposed DERs.

This feasibility study does not consider the possibility of O&R accepting a higher supply price for electricity because this could pass higher prices on to customers (without public funding or state incentives) and therefore contradict one of the project's central goals. SPV investors may be eligible for approximately $70,000 from each of the Federal ITC and NY Sun.

The microgrid design relies on the SPV to finance the construction of the natural gas reciprocating generators and the two 100 kW solar PV array, while O&R may construct the required microgrid infrastructure and control components. However, simply selling electricity at O&R's average supply price may not generate sufficient cash flow to attract investor interest in the project in the absence of NY Prize.

3.1 Commercial Viability – Customers (Sub Task 3.1)

The Clarkstown microgrid will include ten facilities and three load groupings across the East and West Footprints; these are described below in Table 13 and include a wide range of municipal services, commercial space, and residential. The SPV will own the proposed DERs and microgrid controls, and O&R may own new and upgrade distribution infrastructure as well as operate the microgrid. It is assumed that private investors support the financial requirements of the SPV. O&R will contribute useful expertise to the day-to-day operation of the microgrid, while private investors and the utility will provide the majority of the capital outlay required for this project.

Several facilities in the East footprint will provide critical services to the Town during emergency situations, including the Town Hall, and the Fire and Police Departments, and in the West footprint, including the county Sheriff and Dept. of Corrections. Although the remaining facilities do not provide critical services, they can serve as shelters during emergencies, allow access to retail services, and allow county government to continue functioning in a long term outage. The East footprint also has extensive, existing diesel backup generation totaling nearly 1 MW that will be incorporated that will require only breakers and controls to interconnect; the footprints are configured such that there is no requirement for new distribution lines. The project will affect several groups of stakeholders in the Clarkstown community that are not physically connected to the microgrid; the benefits and challenges to these stakeholders are discussed further in this section.

3.1.1 Microgrid Customers and Investors

Four generators will provide power to the Clarkstown microgrid: a 1.5 MW natural gas unit and 100 kW PV array in the East footprint and a 1 MW natural gas unit and a 100 kW PV array in the West footprint. The microgrid will enter island mode when it detects an outage or disturbance on the larger O&R system. The microgrid will also have the technical ability to enter island mode for economic reasons but will not be permitted to do so as it would adversely affect downstream loads and existing system redundancy. In their day-to-day operations, most of the connected facilities serve the Clarkstown and Rockland County communities, and will make their services available to a larger group of stakeholders during emergency situation.

The Table 13 below identifies each of the direct microgrid customers and the scenarios during which they will purchase electricity from the microgrid.

Table 13. Microgrid Customers

Table provides a list of facilities that will be connected to the microgrid.

Property	Address	Classification	Critical Service	Back-up Generation	Normal vs Island Mode
East Footprint					
Town Hall	10 Maple Ave.	Public	Yes	Yes	Both
Fire Department	15 Maple Ave.	Public	Yes	No	Both
Police Department	20 Maple Ave.	Public	Yes	Yes	Both
Rockland County Courthouse	1 South Main St.	Public	No	Yes	Both
Load Cluster 1 (four restaurants, retail store)	39-55 South Main St.	Commercial	No	No	Both
West Footprint					
Rockland County Sheriff's Department	55 New Hempstead Rd.	Public	Yes	No	Both
Rockland County Corrections	55 New Hempstead Rd.	Public	Yes	No	Both
Rockland County Highway Department	23 New Hempstead Rd.	Public	No	No	Both
Rockland County Legislature	11 New Hempstead Rd.	Public	No	No	Both
Animal Hospital of New City	22 New Hempstead Rd.	Private	No	No	Both
Load Cluster 3 (eight residential buildings)	54-70 New Hempstead Rd.	Residential	No	No	Both
Office Building	28 New Hempstead Rd.	Commercial	No	No	Both

Cash flows from electricity sales will consistently cover variable costs and yield positive operating revenues. The Federal ITC Program may recover around 30% of the capital cost of the solar array, as will NY Sun. With the available incentives and rebates, the project is net positive, but would only provide moderate return on investment for investors, meaning that should the project not receive the aforementioned rebates, the project may rely on NYSERDA NY Prize Phase III funding in order to be a reliable investment for the Town, private investors, and O&R.

3.1.2 Benefits and Costs to Other Stakeholders

Prospective stakeholders in the Clarkstown microgrid extend beyond direct investors and facilities to include other O&R customers, existing generation asset owners, residents of the areas surrounding Clarkstown, and Rockland County. Direct benefits will accrue to the Town, County, proposed distributed energy resource asset owners, connected facilities, and local utility. The surrounding communities and larger state of New York will enjoy indirect benefits from the microgrid (further discussed in Section 3.2.3). During an emergency power outage, the microgrid will maintain power to extensive public and municipal services, commercial clusters, and a handful of residents. With the exception of the residential, each of the facilities provides a public service and many can be opened as emergency shelter as needed and provide basic life support and sustenance.

The natural gas units and the solar arrays together possess a maximum generation capacity of 2.7 MW, which is 2.5 MW of continuous load reduction for the larger O&R grid from the two natural gas engines during both peak demand events and normal periods of operation and 200 kW of variable support from the PV array. The East footprint contains extensive diesel backup generation that will be intertied into the microgrid to provide load support, but the proposed natural gas units are large enough to meet expected peak demands. This will reduce or eliminate the need for calling on the diesel assets and will negate the need to stockpile large quantities of fuel for the generators. The diesel generators will retain the ability to support peaks as loads grow over time and to provide islanded electricity if the main generator is down for maintenance or otherwise loses capacity during an emergency.

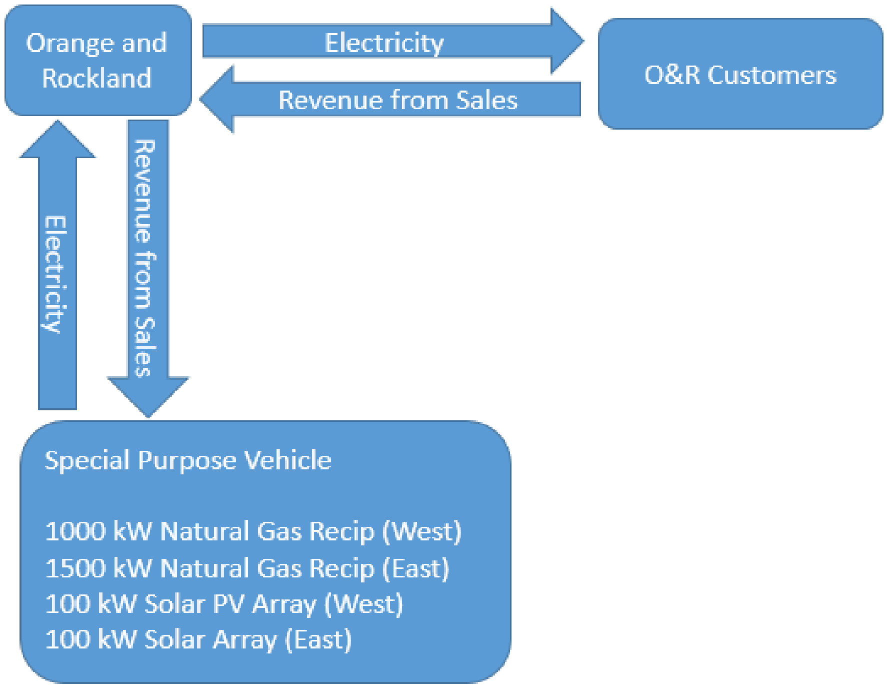
3.1.3 Purchasing Relationship

The SPV will own the DERs (both natural gas units and both PV arrays) and microgrid controls and O&R may own all new and upgraded distribution infrastructure. In grid-connected mode, the SPV will sell electricity from the proposed reciprocating generators and solar arrays to O&R under a long-term PPA.[15] Microgrid facilities will maintain the current utility-purchaser relationship with O&R during grid-connected mode. Electricity will flow through the existing distribution system and rates will be captured through the existing billing mechanism. In island mode, however, the facilities will be electrically disconnected from the larger grid and directly supplied by the proposed generation assets via the O&R distribution network. Islanded operation contracts will be established during development and construction and will address the order in which islanded facilities are brought back on-line following an island event and the associated cost for participating in the microgrid. See Figure 6 below for the purchasing relationships.

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

Figure 6. Normal Operation Purchasing Relationship

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



3.1.4 Solicitation and Registration

The Town and utility will work with identified facilities in Table 13 to participate in the project. This outreach will include informal discussions and, ultimately, signed agreements of participation in the microgrid and acceptance of the tariff or fee structure. Formal registration of facilities with the microgrid will be managed by programming the logic controllers to include or exclude the facility from islanded services based on their agreement with the utility. The Project Team views registration as an operational feature of the microgrid and not a legal requirement.

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

3.1.5 Energy Commodities

The microgrid's generation assets will produce electricity, but will have no ability to participate in DR or other paid ancillary service programs. Proposed generation assets include a 1.5 MW natural gas-fired reciprocating engine, a 1 MW natural gas-fired reciprocating engine, and two 100 kW solar PV array. Together these DERs will provide up to 2.7 MW of electricity for the microgrid and the larger Clarkstown community, with 1.6 MW on the East footprint and 1.1 MW on the West footprint. O&R will distribute the purchased electricity in load agnostic fashion across its grid.

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

3.2 Commercial Viability – Value Proposition (Sub Task 3.2)

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

3.2.1 Business Model

An SPV will own the proposed DERs and the microgrid controls, while O&R may own new and upgraded distribution infrastructure and operate the system. In grid-connected mode, the SPV will sell electricity to O&R via long term power purchase agreements or another custom procurement model. In islanded mode, the PPA with O&R will remain in place and the utility will still purchase power from the SPV and deliver it to microgrid connected facilities. SPV members will receive shares of operating cash flow that correspond to their initial investments. Investors will determine the most appropriate financing mix to achieve their financial goals. As O&R may be responsible for the portions of the installation, ownership, and operation of the non-revenue generating distribution infrastructure, as well as the operation of the microgrid, the SPV will remit payment to O&R to offset these costs. The exact contractual mechanisms and payment amounts supporting this operational arrangement will be addressed in Phase II of NY Prize.

Table 14 below provides an overview of the Clarkstown microgrid project, including an analysis of project strengths, weaknesses, opportunities, and threats (SWOT).

Table 14. Clarkstown Microgrid SWOT

Discussion of the strengths, weaknesses, opportunities, and threats (SWOT) associated with the Clarkstown microgrid project.

Strengths	Weaknesses
• O&R participation in operation of the project and ownership of distribution components 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) • Draws on O&R's expertise to facilitate operation of the microgrid (load aggregation, load following, voltage regulation, and other requirements) • Engages key critical facilities as well as local residents and businesses	• Separating significant capital costs from the revenues necessitates further agreement between revenue drivers (DERs) and distribution infrastructure owners (O&R). DER owners may balk at paying revenue into non-revenue generating components
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 distributed energy resources • Provides a proof point for utility operated microgrids in partnership with silent DERs investor group • Provides data for O&R and NYSERDA on the benefits of using non-CHP natural gas reciprocating generators as DER assets. The market for non-CHP reciprocating generators is far larger than the market for CHP because it is not limited by thermal demand	• Changes in regulatory requirements could impact the proposed business model and stakeholder goals. For example, if utilities are again permitted to own generation assets in the future, O&R may wish to hold competing DERs • If natural gas prices increase, it will significantly raise the microgrid's marginal cost of producing electricity, which may prompt a re-negotiation of O&R's purchasing price

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

- **Financial** – SPV members will seek a long-term PPA, or some other form of long-term purchase agreement, with O&R to guarantee steady future revenue streams. As long as the agreement reliably guarantees fair compensation for generator output over the project lifespan, SPV members must be content with flexible compensation rates and a low amount of risk. O&R's average supply price of electricity is sufficient for the SPV to recover capital investments but allows for very limited positive net income. This weakness is partially offset by NY Prize Phase III funding, which will support a financially attractive project.

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

3.2.2 Replicability and Scalability

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

Technical Replicability. The proposed microgrid technology does not present a barrier to project replicability. The primary components of the microgrid, including the proposed generation assets, switches, SCADA, and the EMS, are widely available and could be repeated in any given location. All interconnections with the O&R grid are industry standard. Natural gas infrastructure is an essential component of the project's replicability; without a steady natural gas supply, other cities would have to sacrifice the reliability (by relying on solar or wind power) or emissions efficiency (by using diesel or fuel oil) that make this project feasible.

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

The proposed generation assets qualify for a relatively small total incentive payment—the ITC and NY Sun may offset around 30% of the solar array's capital cost, but the natural gas reciprocating generator is not covered by any state or federal incentive programs. The project's commercial viability therefore depends on NYSERDA NY Prize Phase III funding, which will not be available to most community microgrid projects. This hinders the project's replicability.

Scalability. The microgrid is scalable, however the electrical infrastructure is such that any upsize of the footprint would require somewhat significant investment. The current proposal of two footprints is a result of the electrical layout, and connecting the footprints or expanding either, would require extensive new switching or AMI installations and the pickup of numerous new loads. The generation would need to be scaled up but sufficient space exists for additional generating assets.

3.2.3 Benefits, Costs, and Value

The microgrid will provide both direct and indirect benefits to a wide range of stakeholders. SPV owners will receive stable cash flows for the lifecycle of the project, the Town and citizens will benefit from a more resilient electricity system, and the community will have access to shelter and municipal services during emergency grid outages. Preliminary analysis indicates cash flows from electricity sales and incentive programs will cover variable generation costs. Moreover, the project will generate sufficient returns to recover capital costs. The project's investor attractiveness will depend on NY Prize Phase III funding, however. Projected costs and benefits are discussed in Table 15 through Table 8.

Except for a marginally increased price of electricity during island, the customers will not bear any of the project's costs, and local residents will bear no costs. The tables below provides an overview of the benefits and costs to members of the SPVs, direct microgrid customers, citizens of Clarkstown and surrounding municipalities, and the State of New York.

Table 15. Benefits, Costs, and Value Proposition to SPV Owners

Benefits, costs, and value proposition to SPV owners.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
SPV (Private Investors)	- Investors will receive annual cash flows from electricity sales from the natural gas reciprocating generator and PV array, and microgrid connection or participation fees - NY Prize Phase III funding would recover 50% of capital costs	- Initial capital outlay will be moderate because the SPV must purchase and install generation assets - Installed capital costs for DERs - Ongoing maintenance of DERs - Financing costs associated with initial capital outlay will persist for many years	- Low risk returns ensured through long-term purchase contracts make the DERs an attractive investment

Table 16. Benefits, Costs, and Value Proposition to Orange & Rockland Utilities

Benefits, costs, and value proposition to O&R.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
Orange & Rockland Utilities	- The utility will continue to sell electricity to direct customers - The utility will avoid total loss of revenues in emergency outage situations - Local generation reduces the amount of power that must be imported from the larger grid; this may defer future transmission & distribution investments - The utility will realize cost savings on decreased line congestion - Improved reliability provided to customers within the microgrid footprint	- The utility will be responsible for the purchase of electricity from the natural gas units and PV arrays. Costs would be recouped through sales to existing O&R customers	- The utility can serve as a market connector without the costs associated with constructing and operating distributed energy resource assets or microgrid infrastructure - The utility will enjoy improved grid resilience by integrating local generation assets with local distribution networks - O&R will have a new supply of electricity that is valued at their average supply charge, but they will have a slightly reduced T&D charge in the area

Table 17. Benefits, Costs, and Value Proposition to the Town of Clarkstown

Benefits, costs, and value proposition to Clarkstown.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
Town of Clarkstown	- The microgrid will provide a resilient and redundant energy supply to critical services - Meet NY state energy goals by encouraging DER construction and improving energy resilience - Connection of numerous local and county facilities - Further integration as a smart community - Reduced requirement for diesel backup	- Clarkstown will bear no costs for the microgrid	- Critical and important services will maintain power during outages, allowing Clarkstown to be a point of relief for local citizens and surrounding areas - The microgrid project will serve as a catalyst for customers becoming more engaged in energy service opportunities and will inspire residential investment in DERs, such as solar PV and battery storage, as citizens see benefits associated with avoiding peak demand hours, producing enough electricity to be independent from the larger grid, and selling electricity in a local market - Generating electricity with solar PV arrays and a natural gas-fired recip. system will offset the need for emergency diesel backup

Table 18. Benefits, Costs, and Value Proposition to Connected Facilities

Benefits, costs, and value proposition to connected facilities.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
Connected Facilities	- Resilient and redundant energy supply to support operations - Access to a local market for distributed energy resources make investments in small DERs more attractive to connected facilities	- Potential for slightly higher electricity prices during island mode, depending on contract negotiations in NY Prize Phase II	- Maintain operations during emergency outages and provide valuable critical services to the Clarkstown community - Potential for partnerships and a local market for excess generation will encourage industrial stakeholders to build large-scale generation assets - Local market for excess energy makes investments in small DERs (such as solar panels) profitable for connected facilities

Table 19. Benefits, Costs, and Value Proposition to the Larger Community

Benefits, costs, and value proposition to the larger community.

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	- Because the larger community will not be connected to the microgrid, this stakeholder group will not bear any significant 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, Clarkstown will likely need to install AMI meters in hundreds of facilities or O&R would need to allow a vastly expanded footprint on their lines.

Table 20. Benefits, Costs, and Value Proposition to New York State

Benefits, costs, and value proposition to New York State.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
New York State	- DER assets will offset high-emission peaking assets during peak demand events - Cash flows will provide tangible evidence of microgrid project's commercial viability - Indirect benefits (such as outages averted) will demonstrate the benefits of microgrids paired with DERs 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 - Meet NY Reforming the Energy Vision goals by encouraging DER construction and improving energy resiliency	- Depending on financing plans, growth of microgrid popularity, and increased use of natural gas-fired generators, the state may need to develop additional plans for expanding natural gas infrastructure	- Successful construction and operation of a community microgrid will demonstrate the tangible value of microgrid projects - Indirect benefits associated with microgrids will encourage and inspire citizens to strive for DERs in their own communities - Success of SPV model aligns with REV goals—this project provides a successful 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 expand renewable energy in the Town. The proposed microgrid supports the New York State Energy Plan by providing a power distribution platform for locally-owned DER assets. The ownership model has the potential to be extremely successful by leveraging private capital as well as local utility expertise, and it is replicable. The proposed organizational construct provides an approach that has not yet been implemented on a large scale in NY State with private finance having full ownership of the generation assets while the local utility retained full operational control. While there are potential barriers to such an arrangement, the Project Team believes that this somewhat novel approach to the microgrid incentivizes both investors and the utility sufficiently to gain buy-in. Further, when the utility desires to be engaged in the ownership and operation of the microgrid from the outset, it creates strong momentum for success. Table 14, above in Section 3.2.1, outlines the strengths and weaknesses of this proposed model and the opportunities that it may present. This project could therefore serve as a valuable example of innovative, profitable cooperation between IOUs, municipalities, and private investors.

By coordinating the microgrid as a local distributed system platform (DSP), the Clarkstown 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.

3.3 Commercial Viability – Project Team (Sub Task 3.3)

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

3.3.1 Stakeholder Engagement

The Project Team has been engaged and in constant communication with local stakeholders from the outset. Booz Allen and its partners in the Town have also communicated with each of the proposed facilities to gauge electric and thermal demand and discuss other aspects of the project development. The Project Team has also spoken to medical facilities that may be interested in joining the project.

3.3.2 Project Team

The Clarkstown microgrid project is a collaboration between the public sector, led by the Town of Clarkstown, and the private sector, led by O&R and Booz Allen Hamilton with significant support from Power Analytics and Siemens. Each of the private sector partners is exceptionally well qualified in the energy and project management space, and Clarkstown has strong interest in improving its energy reliability and expanding its clean energy generation capacity. Tables 21 and 22 below provide information about the Project Team.

Table 21. Project Team

Background on Booz Allen Hamilton, Siemens AG, Power Analytics, and O&R.

<table>
<tr><th>Booz Allen Hamilton</th><th>Headquarters: McLean, VA</th><th>Annual Revenue: $5.5 B</th><th>Employees: 22,700</th></tr>
<tr><td colspan="4">History and Product Portfolio: Booz Allen was founded in 1914. In the ten decades since its founding, Booz Allen has assisted a broad spectrum of government, industry, and not-for-profit clients including the American Red Cross, all branches of the Department of Defense, the Chrysler Corporation, NASA, and the Internal Revenue Service. Booz Allen’s energy business includes helping clients analyze and understand their energy use and develop energy strategies, recommending technology solutions to achieve their energy goals, and executing both self- and 3rd party funded projects including energy efficiency, renewable energy, and smart grids.</td></tr>
<tr><th>Siemens AG</th><th>Headquarters: Munich, Germany;
U.S. Headquarters: Washington, DC</th><th>Annual Revenue: €71.9 B</th><th>Employees: 343,000</th></tr>
<tr><td colspan="4">History and Product Portfolio: Siemens AG was founded in 1847 and is now one of the world’s largest technology companies. Siemens AG specializes in electronics and electrical engineering, operating in the industry, energy, healthcare, infrastructure, and cities sectors. Siemens AG develops and manufactures products, designs and installs complex systems and projects, and tailors a wide range of solutions for individual requirements. The Siemens Microgrid Team develops comprehensive solutions leveraging the strength of Siemens’ portfolio – from generation sources such as gas, wind, and solar, to transmission & distribution products, to control software solutions and services.</td></tr>
<tr><th>Power Analytics</th><th>Headquarters: San Diego, CA</th><th>Annual Revenue: $10-15M</th><th>Employees: 50</th></tr>
<tr><td colspan="4">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.</td></tr>
<tr><th>Orange & Rockland Utilities</th><th>Headquarters: Pearl River, NY</th><th>Annual Revenue: $13 B (Con Ed)</th><th>Employees: 1,100</th></tr>
<tr><td colspan="4">History and Product Portfolio: Orange and Rockland Utilities, Inc., a wholly owned subsidiary of Consolidated Edison, Inc., is an electric and gas utility headquartered in Pearl River, NY. O&R and its two utility subsidiaries, Rockland Electric Company and Pike County Light & Power Co., serve a population of approximately 750,000 in seven counties in New York, northern New Jersey and northeastern Pennsylvania.</td></tr>
</table>

Table 22. Project Team Roles and Responsibilities

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

Team Member	Roles and Responsibilities		
	Project Development	Construction	Operation
Orange & Rockland Utilities	O&R will work with the Project Team to develop the concept and provide input. They may further provide the financial support for the purchase of microgrid control systems and infrastructure.	O&R may provide a share of the initial capital outlay that corresponds to the microgrid control infrastructure.	O&R may provide the necessary domain expertise to operate the microgrid. 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.
Town of Clarkstown	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 will have primary responsibility for the shovel-in-the-ground construction and installation of hardware and generation assets.	Ensuring proper functioning and maintenance of the microgrid technology components throughout.
Power Analytics	Power Analytics is the partner for energy software solutions. The PA team, in conjunction with Siemens and Booz Allen, is responsible for the design of the SCADA and system software components and controls.	Power Analytics will lead the installation of control and energy management software following hardware installation and in concert with Siemens.	Provide IT systems support; may play an active role in system management through the EnergyNet software platform.
Suppliers	There are no suppliers required during this development phase, however project partners and suppliers Siemens and Power Analytics are closely involved in feasibility and design portions of the project. BAH is in touch	Siemens or another engineering and technology firm will be the hardware supplier, including switches and other physical controls. Power Analytics or	The installer of the hardware and software will continue to provide maintenance and advisory services as require to ensure proper and efficient functioning of their components. The

Team Member	Roles and Responsibilities		
	Project Development	Construction	Operation
	with several additional suppliers of hardware and software including Duke Energy, O&R Solutions, Enel Green Power, Anbaric Transmission, Bloom, and Energize.	another software company will be the EMS and SCADA provider, responsible for software and server components.	software provider will work in cooperation with O&R to assess the best approach to daily operations of the software system.
Financiers/Investors	The SPV will be created during the project development phase. Investors for DERs may include any of the entities mentioned in the row above.	Debt and equity investors will supply the cash required to complete the construction and installation of generation assets and microgrid controls.	Generation asset owners will realize revenues from the sale of electricity and thermal resources. O&R will realize revenues from payments from DER owners.
Legal/Regulatory Advisors	Regulatory advice is housed within Booz Allen. Further counsel will be retained as necessary to create the SPV and arrange financing.	Legal and regulatory will be a combination of Booz Allen, the Town, O&R, and any outside counsel required.	Legal and regulatory will be the responsibility of the Town, the utility, and any investors in the SPV.

3.3.3 Financial Strength

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

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

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

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

3.4.1 Microgrid Technologies

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

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

The Clarkstown microgrid includes numerous components that have been previously used and validated. Solar PV and natural gas are both widely used technologies, with more than 6 gigawatt (GW) of solar PV installed in 2015 in the United States. Nationwide there are hundreds of GW of installed natural gas generating capacity and it is the single largest source of generation in the country. The switch components are all industry standard and are widely used in utilities worldwide, and the 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.[16] 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.[17]

3.4.2 Operation

SPV investors will contribute funds to O&R's operation and maintenance of the project. Regular maintenance and checks of equipment will be conducted based on manufacturer or installer recommendations and will ensure the proper function of all grid elements. The microgrid is a classic shared value entity; the utility, Town, and investors will benefit financially, and the continued success of the grid requires support and collaboration from all three.

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

[16] Siemens case studies; available from http://w3.usa.siemens.com/smartgrid/us/en/microgrid/pages/microgrids.aspx.
[17] http://www.poweranalytics.com/company/pdf/M-12-GE-PPT-X-001-03%202012%20UCSD%20Virtual%20summit.pdf.

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

3.4.3 Barriers to Completion

The primary barriers to completion of the Clarkstown microgrid proposal are financial and in the coordination of operations. The microgrid will require somewhat significant capital costs that the Town and utility are not in a position to provide. Private investors will be solicited to support the project, and financial returns should be sufficient to generate investment interest assuming the project qualifies for a NY Prize Phase III award. Additionally, coordination between the SPV and O&R is an absolute requirement to the smooth and successful operation. The utility may operate the project assets and infrastructure and agreements will be required to formalize the operating parameters, generator down-time, and other decisions that impact operations and revenue streams. None of the barriers to completion are believed to be insurmountable.

3.4.4 Permitting

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

3.5 Financial Viability (Sub Task 3.5)

The distributed energy resource assets included in the microgrid design will produce revenue streams from electricity sales to O&R. These assets will require significant initial capital outlay as well as annual operation and maintenance costs. The microgrid project qualifies for federal solar tax credits through the ITC program, as well as NY Sun. 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 23. The revenues will sum to approximately $1.6 million per year, which will exceed the yearly generation costs (estimated to be around $1.2 million per year). See Table 23 for the total savings and revenues and Table 24 for the total capital and operating costs.

Table 23. Savings and Revenues

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

Description of Savings and Revenues	Savings or Revenue	Relative Magnitude	Fixed or variable
Electricity sales from 1 MW reciprocating generator[18]	Revenue	~$635,000/yr	Variable
Electricity sales from 1.5 MW reciprocating generator[19]	Revenue	~$955,000/yr	Variable
Total electricity value from 100 kW + 100 kW solar PV arrays[20]	Revenue	~$20,000/yr	Variable
Total Revenue		**$1.6 MM/yr**	Variable

[18] Based on sales at O&R supply charge ($0.085/kWh) for 85% of total hours.

[19] Ibid.

[20] Based on sales at O&R supply charge for 14% of total hours.

Table 24. Capital and Operating Costs

Expected costs from construction and operation of the microgrid.

Description of Costs[21]	CapEx or OpEx	Relative Magnitude	Fixed or Variable
1 MW Natural Gas reciprocating generator	Capital	~$1,300,000	Fixed
1.5 MW Natural Gas reciprocating generator	Capital	~$1,950,000	Fixed
100 kW Solar PV array (x2)	Capital	~$240,000	Fixed
Microgrid Control Systems	Capital	~$450,000	Fixed
Distributed Equipment	Capital	~$330,000	Fixed
IT Equipment (Wireless stations and cabling)	Capital	~$70,000	Fixed
Total CapEx		**$4.6 MM**	Fixed
Design considerations and simulation analysis	Planning and Design	$750,000	Fixed
Project valuation and investment planning	Planning and Design	$100,000	Fixed
Assessment of regulatory, legal, and financial viability	Planning and Design	$75,000	Fixed
Development of contractual relationships	Planning and Design	$75,000	Fixed
Total Planning and Design		**$1,000,000**	Fixed
1 MW Natural Gas fuel [22]	Operating	~$350,000/yr	Variable
1.5 MW Natural Gas fuel[23]	Operating	~$525,000/yr	Variable
1 MW Natural Gas O&M	Operating	~$105,000	Fixed
1.5 MW Natural Gas O&M	Operating	~$155,000	Fixed
100 kW Solar PV Maintenance (x2)	Operating	~$2,000/yr	Fixed
Microgrid Components O&M	Operating	~$70,000	Fixed
Total OpEx		**$1.2 MM/yr**	Variable

The proposed microgrid may qualify for two incentive programs in the Federal ITC and NY Sun. The programs may each recover around 30% of the total PV capital cost, though this may decrease over time as the ITC steps down. Other possible sources of incentive revenue include NYSERDA Phase III NY Prize funding (up to $5 million, but will not exceed 50% of capital costs). See Table 25 for a list of available incentive programs.

Given the location of the proposed microgrid on the O&R feeder structure, the microgrid will not be able to island for economic purposes. Therefore, DR payments are not available to the

[21] All capital and O&M costs are from Siemens based on industry standard amounts.
[22] Based on natural gas price of $5.08/Mcf ($47/MWh generated) and an 85% capacity factor.
[23] Ibid.

microgrid. There is also no potential for the microgrid to island when the location based marginal price rises above the cost of DERs production nor can there be a microgrid based shift to hourly, time-of-use pricing.

Table 25. Available Incentive Programs

Table includes all 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 II	~$1,000,000	Required
NYSERDA NY Prize Phase III	~$2,300,000	Required
NY Sun	~$145,000	Preferred
Federal Solar ITC	~$145,000	Preferred

3.5.2 Financing Structure

The development phase is characterized by the negotiation and execution of the construction financing and debt structure and agreements with any equity partners. Awards from Phase II of the NY Prize Community Microgrid Competition will supply most of the funding for project design and development, with the SPV providing capital for any costs that exceed available NYSERDA funding. We anticipate NYSERDA to supply 75% of the required funds for Phase II with the balance coming from a cost-share. This is based on our understanding of the Phase II cost structure as described in NYSERDA RFP-3044. Clarkstown and the Project Team will provide needed in-kind services consisting primarily of system expertise and support. Development will conclude with formal contract relationships between the utility and the customers of the microgrid, available and relevant rate and tariff information from the NYPSC, and firm financing for the construction of the project (described below).

The SPV and O&R will strive to leverage Phase III funding from NYSERDA to complete the construction phase. Phase III NY Prize funding, which will provide up to $5 million to the SPV for microgrid and DER equipment and installation, will cover half of the capital cost of the project (estimated to be approximately $4.6 million in total), and private and utility funding will represent the balance of the financing.

The Project Team assumes the Town will grant the physical space to site the DERs at no cost because it is the primary beneficiary of the proposed microgrid. The SPV will maintain ownership over all generation assets and O&R over the control infrastructure.

3.6 Legal Viability (Sub Task 3.6)

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

3.6.1 Regulatory Considerations

State and Utility Regulation

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

Local Regulation

Under Section 239(m) of the Rockland County Municipal Code, adoption or amendment of a comprehensive plan, adoption or amendment of a zoning ordinance or local law, issuance of special permits (or conditional use permits), approval of site plans, granting of use or area variances, or other authorizations which a referring body may issue under the provisions of any zoning ordinance or local law, such as a change of zone, must be referred to the Commissioner of Planning if it is within 500 feet of any of the following:

- A municipal boundary;
- A boundary of an existing or proposed state or county park or recreation area, including the Long Path (a regional hiking trail that traverses Rockland County);
- The right-of-way of any existing or proposed county or state parkway, thruway, expressway, road or highway (including the Palisades Interstate Parkway and the New York State Thruway);
- A right-of-way for any existing or proposed stream or drainage channel owned by the county or for which the county has established channel lines;
- Or the existing or proposed boundary of any county or state owned land on which a public building or institution is situated.

Under Section 239(n), all preliminary or final plats or development of undeveloped plats must be referred to the County Planning Agency Commissioner if they are within 500 feet of the same criteria as described above. Given that the generation assets will be placed on both Town and County property, it is likely that the procedures outlined above will apply to the proposed design.

Air Quality

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

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

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

New York state has enacted amendments to Environmental Conservation Law Articles 19 (Air Pollution Control) and 70 (Uniform Procedures), and NYS 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 US Environmental Protection Agency (EPA). Title V Permits are required for all facilities with air emissions greater than major stationary source thresholds. New York's air pollution control permitting program combines the federal air operating permitting program with long-standing features of the state program. The primary rules for applications are found in 6NYCRR:

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

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

3.7 Project Commercial and Financial Viability Conclusions

The microgrid project will include ten facilities and three load groupings in the Town of Clarkstown in two footprints, the East footprint and the West footprint. They are physically separated but virtually connected. Four facilities and two load clusters compose the electrical loads of the proposed east footprint: the Town Hall, Fire Department, Police Department, Rockland County Courthouse, Load Cluster 1 (which includes four restaurants, and two retail stores), and Load Cluster 2 (which includes eight retail stores and three restaurants). Six facilities and one load cluster compose the electrical load of the proposed west footprint: the Rockland

County Sheriff's Department, Rockland County Corrections, Rockland County Highway Department, Rockland County Legislature, Animal Medical at New City, Load Cluster 3 (eight residential buildings), and an office building. The project will follow a hybrid ownership model wherein a Special Purpose Vehicle (SPV) owns all four DERs and the utility, O&R, may own the new control infrastructure. O&R may assume operational responsibility for the DERs in order to successfully integrate the new generation into the existing O&R distribution system and maintain electrical fidelity on the grid.

The proposed microgrid's financial feasibility may depend largely on NY Prize Phase III funding. Its design includes four new DERs: a 1.5 MW natural gas unit and a 100 kW solar PV array on the East footprint, and a 1 MW natural gas unit and a 100 kW solar PV array on the West footprint. Taken together, the proposed generation will satisfy the peak load recorded in 2014, and with the inclusion of nearly 1 MW of diesel backup across several generators on the East footprint, will have ample support in the event of unforeseen peak events.

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

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

The estimates and value propositions in this document are predicated on several assumptions. First, private investors will own the DERs and microgrid software controls, and O&R will own the distribution infrastructure. O&R has indicated to the Project Team a desire to own and operate the distribution assets related to the microgrid and private investors have indicated initial interest in the project. Second, the two natural gas-fired reciprocating generators and two new 100 kW solar arrays will sell electricity to O&R at the average local supply charge (the price O&R currently pays to purchase electricity, excluding transmission, distribution, and capacity charges). O&R, as the local expert in energy distribution and the current owner and operator of the Town's distribution infrastructure, may operate the project. O&R's existing infrastructure is used extensively in the preliminary microgrid design, so operational participation from the utility is vital to the project's success. Lastly, the current regulatory, legal, and policy environment will stay consistent as this proposal falls within the existing frameworks.

4. Cost Benefit Analysis

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

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

4.1 Facility and Customer Description (Sub Task 4.1)

There are three primary rate classes based on type of facility and average electricity consumption: residential, small commercial (less than 50 megawatt hour (MWh)/year), and large commercial (greater than 50 MWh/year).

The Clarkstown microgrid will include thirteen facilities from various rate classes and economic sectors. Nine of the proposed microgrid facilities belong to the large commercial rate class requiring approximately 9,867 MWh of electricity per year. Three of the proposed microgrid facilities belong to the small commercial rate class requiring approximately 78 MWh of electricity per year. One of the proposed microgrid facilities belongs to the residential rate class requiring approximately 80 MWh of electricity per year. Additionally the average aggregate demand in 2014 was 1.14 MW and rose as high as 2.254 MW.

The microgrid facilities fall into four economic sectors: public, commercial, health and residential. The public facilities are the town hall, fire department, police department, Rockland county courthouse, Rockland county sheriff's department, Rockland county corrections, Rockland county highway department, and Rockland county legislature, which consume approximately 85.6% of the microgrid's total annual usage. The commercial facilities are the first two load clusters, the Animal Hospital of New City, and an office building that consume approximately 13.6% of the microgrid's total annual usage. The residential facility includes one residential load cluster and compromises 0.8% of the microgrid's total annual electricity usage.

The generation assets included in the microgrid design will be capable of meeting 100% of the average aggregate facility energy usage during a major power outage, but they will approach their generation limits if the facilities reach peak energy use any without load reduction. In these situations, the diesel generators may need to come online to supply additional electricity to the campus. For information on each facility's average daily operation during a major power outage, see Table 26.

Table 26. Facility and Customer Detail Benefit[24]

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 O&R

[24] Load data was provided to Booz Allen by O&R.

4.2 Characterization of Distributed Energy Resource (Sub Task 4.2)

The microgrid design incorporates two new natural gas generators, two new solar PV arrays, and seven existing diesel generators. The proposed natural gas units and solar PV arrays will produce an average of 2.15 MW of electricity throughout the year,[25] and the existing diesel generators will provide a maximum of 1.61 MW of backup power in emergency situations.

The natural gas generators have a nameplate capacity of 1.5 MW and 1.0 MW and will operate nearly continuously. Assuming a capacity factor of 85%, the natural gas units will produce approximately 11,169 MWh and 7,446 MWh, respectively, over the course of the year. If a major power outage occurs, the natural gas units can produce a maximum of 36 MWh and 24 MWh (each generators' full nameplate capacity) of electricity per day, respectively. Peak production would provide for over 100% of the microgrid's average daily demand. Assuming a heat rate of 9.5 MMBTU/MWh,[26] the natural gas units will incur a fuel cost of approximately $47/MWh.[27]

Limited by weather conditions and natural day-night cycles, each 0.1 MW solar PV array is expected to produce approximately 122 MWh per year. Because many outages are caused by severe weather events, solar panels cannot be relied upon to provide energy during emergency outages without supplementary battery storage. However, each solar array will produce an average of around 0.34 MWh of electricity per day, which represents 2.45% of average daily electricity demand from microgrid-connected facilities. Maintenance costs for each solar array will be around $4,000 per year,[28] which means the total cost of producing solar electricity will be about $34/MWh.[29]

The existing diesel generators at will be used only in emergency situations when the microgrid requires a black start or when the proposed natural gas units and solar arrays are not producing sufficient electricity to meet aggregate demand. The combined nameplate capacity of the diesel generators is 1.61 MW. This generation capacity could be vital in emergency situations, or when the solar array or natural gas units go offline for maintenance. The Booz Allen team predicts the natural gas units will operate approximately 100% of the time during the 1.62 hours of larger grid outage per year,[30] for a total of around 2.6 MWh of power per year.[31] The collection of diesel generators that have a total nameplate capacity of 1.64 MW requires around 118.3 gallons

[25] Natural gas generator capacity factor: 85% (EPA estimate for 10 MW generator, http://www3.epa.gov/chp/documents/faq.pdf), solar array capacity factor: 14% (NREL PV Watts Calculator).
[26] 2013 EIA average for natural gas fired Gas Turbine (http://www.eia.gov/electricity/annual/html/epa_08_02.html).
[27] Price of natural gas: $5.08 per Mcf (average O&R supply price from 2013-2015).
[28] Annual fixed O&M cost: $20/kW per year (NREL, http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html).
[29] Capital cost: $2,400 (Siemens estimate), Variable cost: 20 years of production at a cost of $20/kW per year (Siemens lifecycle estimate, NREL).
[30] Grid outage data from DPS 2013 Electric Reliability Performance Report (O&R average CAIDI).
[31] The Booz Allen team forecasts a 100% level of operation from the backup generator based on historical loads and expected generator output. The natural gas generators can provide a maximum of 1.61 MW of generation. Solar output is unreliable, but it should provide significant support on the most irradiated days of the year when peak demand is highest.

of fuel per hour of operation.[32] In the event of a major power outage, these generators could produce a maximum of 38.6 MWh/day. See Tables 27 and 28 for a detailed list of all proposed and existing distributed energy resources in Clarkstown.

32 Diesel Consumption Rate: 0.071 Gallon/kWh, pro-rated from the average fuel consumption of the diesel generators.

Table 27. Distributed Energy Resources – East Footprint

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 1.62 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)	Average 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 Backup Diesel Generator	Rockland County Courthouse	Diesel	0.4	0.648	0.0018	9.6	73 Gallons[33]	10.13 MMBTUs[11]
DER2 - Existing Backup Diesel Generator	Town Hall	Diesel	0.264	0.428	0.0012	6.336	73 Gallons[11]	10.13 MMBTUs[11]
DER3 - Existing Backup Diesel Generator	Police Department	Diesel	0.3	0.486	0.0013	7.2	73 Gallons[11]	10.13 MMBTUs[11]
DER4 - Existing Backup Diesel Generator	Police Department	Diesel	0.161	0.261	0.0007	3.864	73 Gallons[11]	10.13 MMBTUs[11]
DER5 - Existing Backup Diesel Generator	Police Department	Diesel	0.161	0.261	0.0007	3.864	73 Gallons[11]	10.13 MMBTUs[11]
DER6 - Existing Backup Diesel Generator	Police Department	Diesel	0.161	0.261	0.0007	3.864	73 Gallons[11]	10.13 MMBTUs[11]

[33] All seven diesel generators efficiencies' were averaged together for simplicity.

Distributed Energy Resource Name	Location	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Potential Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
							System fuel	Units of MMBTUs
DER7 - Existing Backup Diesel Generator	Police Department	Diesel	0.161	0.261	0.0007	3.864	73 Gallons[11]	10.13 MMBTUs[11]
DER8 - Natural Gas Generator	Rockland County Courthouse	Natural Gas	1.5	11,169	30.6	36	9.26 Mcf	9.5 MMBTUs
DER9 - Solar PV Array	Rockland County Courthouse	Sunlight	0.1	123	0.34	0.8	N/A	N/A

Table 28. Distributed Energy Resources – West Footprint

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

Distributed Energy Resource Name	Location	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Potential Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
							System fuel	Units of MMBTUs
DER10 - New Natural Gas Generator	Rockland County Legislature	Natural Gas	1.0	7,446	20.4	24	9.26 Mcf	9.5 MMBTUs
DER11 - New Solar Panel	Rockland County Legislature	Sunlight	0.1	123	0.34	0.8[34]	N/A	N/A

[34] Based on 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 continuously throughout the year (other than regularly scheduled maintenance), providing a constant level of load support. Although continuous operation will limit the natural gas generators' ramp-up capability during peak demand events, it will maximize revenue for the owners. The existing diesel backup generators will also be available to reduce peak load in cases of extreme demand. See Table 29 for the maximum generation capacities of the proposed and existing DERs.

The proposed solar arrays will be their most productive on the days with greatest irradiance when peak demand events are common, thus providing peak load support when it is most needed. Each of them will provide around 0.028 MW of load support on average over the course of a year (including capacity factors). However, because generation depends on weather conditions and time of day, the solar arrays are not a reliable source of peak load support.

Table 29. 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 generators were not included because they are not expected to generate electricity outside of emergency island mode situations.

Distributed Energy Resource Name	Location	Available Capacity (MW)	Does distributed energy resource currently provide peak load support?
DER8 - Natural Gas Generator	Rockland County Courthouse	Maximum of 1.5 MW	No
DER9 - Solar PV Array	Rockland County Courthouse	Maximum of 0.1 MW	No
DER10 - New Natural Gas Generator	Rockland County Legislature	Maximum of 1 MW	No
DER11 - New Solar Panel	Rockland County Legislature	Maximum of 0.1 MW	No

4.3.2 Deferral of Transmission/Distribution Requirements

The 2.153 MW of average local generation produced by the DERs will marginally reduce the volume of electricity traveling into the O&R system, potentially deferring the upgrade or replacement of distribution infrastructure.

4.3.3 Ancillary Service

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

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

4.3.4 Development of a Combined Heat and Power System

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

4.3.5 Environmental Regulation for Emission

The microgrid's generation assets will drive a net 3,372 MTCO2e (metric tons CO2 equivalent) increase in GHG emissions in Clarkstown as compared to the New York State energy asset mix. The proposed generation assets will produce around 18,860 MWh of electricity per year. The natural gas units and backup diesel generators will emit approximately 10,217 MTCO2e per year, [35] while the solar arrays emit none. The current New York State energy asset mix would emit approximately 6,846 MTCO2e to produce the same amount of electricity.[36] The microgrid's generation assets will therefore result in a net increase in emissions by 3,372 MTCO2e.

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 MMTCO2e in 2014, and will begin decreasing in the near future. The state sells an "allowance" for each ton of CO2e emitted in excess of the limit at allowance auctions, but does not require assets under 25 MW to purchase allowances. The natural gas units are defined as "small boilers" by NYS DEC limits (fuel input of 10-25 MMBTU/hour). The NYS DEC is currently developing output-based emissions limits for distributed energy resource assets. These limits on SO2, NOx, and particulate matter (to be captured in 6 NYCRR Part 222) should be published in late 2015 or early 2016. The main source of emissions regulations for small boilers is currently the EPA 40 CFR part 60, subpart JJJJJJ—however, this law does not include gas-fired boilers.

The natural gas generator will require an operating permit in addition to other construction permits. The costs of obtaining this permit will be in line with the cost of a construction permit and not comparable to the price of emissions allowances. The existing diesel gas generator is already permitted and therefore will not incur any significant emissions costs.

[35] Natural Gas Generator Emissions Rate: 0.55 MTCO2e/MWh (EPA, http://www3.epa.gov/chp/documents/faq.pdf)
NG generator Emissions Rate: 0.51 $MTCO_2e$/MWh (assuming 117 lb CO_2e per MMBTU; EIA, http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11).

[36] Assuming an asset mix of 15% coal, 31% natural gas, 6% oil, 17% hydro, 29% nuclear, 1 % wind, 1% sustainably managed biomass, and 1% "other fuel". This adds up to around 0.36 $MTCO_2e$/MWh. Info from EPA (http://www3.epa.gov/statelocalclimate/documents/pdf/background_paper_3-31-2011.pdf).

Table 30 catalogs the CO2, SO2, NOx, and Particulate Matter (PM) emissions rates for the natural gas and diesel generators.

Table 30. Emission Rates

Table shows the emission rates for each emitting 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)
DER8 & DER10 – Natural Gas generators	Rockland County Courthouse & Legislature	CO_2	0.553
		SO_2	0.0000067[37]
		NO_x	0.00055[38]
DER3 - DER7 – Backup Diesel Generation	Rockland County Courthouse, Town Hall, and Police Department	CO_2	0.7196[39]
		SO_2	0.1911[40]
		NO_x	2.9074[41]
		PM	0.2046[42]

4.4 Project Costs (Sub Task 4.4)

4.4.1 Project Capital Cost

The microgrid design requires the following new pieces of distributed equipment across 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 13.8 kV utility feeder lines
- Automated breakers installed throughout Clarkstown 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 installed capital cost of the distributed equipment and IT is estimated to be $860,000. The 1.5 MW natural gas generator, 1.0 MW natural gas generator, and the two 0.1 MW solar PV arrays will carry installed costs of $1.95 million, $1.3 million and $480,000, respectively.[43] This brings the total installed capital cost to approximately $4.1 million, not including interconnection

[37] Emissions calculator, EPA.
[38] EPA, http://www3.epa.gov/chp/documents/faq.pdf.
[39] Diesel Generator Emissions rate: 0.72 $MTCO_2e$/MWh (assuming 161 lb CO_2e per MMBTU; EIA, http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11).
[40] Michigan Department of Environmental Quality; Environmental Science and Services Division. "Potential to Emit, Diesel Fired Generator Calculation Worksheet."
[41] Ibid.
[42] Ibid.
[43] Natural Gas Generators Capital Cost: $1,300/kW (Siemens natural gas generators estimate), Solar PV Capital Cost: $2,400/kw (Siemens Solar PV estimate).

fees and site surveys. See Tables 31 and 32 below for estimated installed costs for each microgrid component.

The team estimates nearly every piece of microgrid equipment has a useful lifespan of 20 years. The only component with a shorter lifespan is the microgrid control system (Siemens SICAM PAS or equivalent), which will be replaced by more advanced software after seven to eight years.

Table 31 details capital cost of the distributed equipment; it includes the microgrid control system and centralized generation controls that will allow the operator and electronic controllers to manage the entire microgrid. Hardening measures for the distributed equipment have been embedded into their reported costs.

Table 31. Distributed Equipment Capital Cost

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

Distributed Equipment Capital Costs				
Capital Component	**Quantity**	**Installed Cost ($) (+/- 30%)**	**Component Lifespan (Years)**	**Purpose/Functionality**
Microgrid Control System (Siemens SICAM PAS or equivalent)	1 Primary 1 Back-up	$50,000 (total)	7 - 8	Control system responsible for operating the microgrid sequencing and data concentration under all operating modes.
Microgrid Control Center (Siemens MGMS or equivalent)	1	$300,000	20	Provides data trending, forecasting, and advanced control of generation, loads and AMI/SCADA interface, interface to NYISO for potential economic dispatch.
Automated Pole Mount Circuit Breaker/Switch (Siemens 7SC80 relay)	7 New 1 Upgrade	$210,000 $5,000	20	New breakers/switches at distribution load feeders to isolate microgrid from the utility feed.
Generation Controls (OEM CAT, Cummins, etc.)	9	$36,000	20	Serves as the primary resource for coordinating the paralleling and load matching of spinning generation
PV Inverter Controller (OEM Fronius, etc.)	2	$8,000	20	Controls PV output and sends data to MGMS for forecasting
Network Switches	10	$7,500	20	Located at IEDs and controllers for network connection, allowing remote monitoring and control.
WiMax Base Station	1	8,000	20	Located near microgrid control cabinet. Communicates wirelessly with WiMax subscriber units for remote control and monitoring of breakers and switches. Should be installed at high location.

Distributed Equipment Capital Costs				
Capital Component	**Quantity**	**Installed Cost ($) (+/- 30%)**	**Component Lifespan (Years)**	**Purpose/Functionality**
WiMax Subscriber Units	10	20,000	20	Each subscriber unit can communicate back to the WiMax base station for MGMS/MCS monitoring and control or remote relay to relay GOOSE messaging.
WiMax configuration and testing	-	$23,000	-	The configuration and testing of the WiMax hardware
Installation Costs	-	$200,000	-	Installation of capital components in the microgrid

Table 32. 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**
1.5 MW Natural Gas Unit	1	$1,950,000	20	Generation of electricity
1.0 MW Natural Gas Unit	1	$1,300,000	20	Generation of electricity
0.1 MW Solar PV arrays	2	$480,000	30	Generation 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 $0.60 per cable.[44] The total installation cost of cabling is approximately $5.65 per foot for Cat-5e cables.[45] 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 $20,000.[46]

[44] Commercially available RJ-45 connectors, $0.30 per connector.
[45] Installation costs for Cat5e: $5.45/ft, Component cost for Cat5e: $0.14/ft (commercially available).
[46] The Project Team estimated ~3500 feet of Cat5e cable will be necessary.

4.4.2 Initial Planning and Design Cost

The initial planning and design of the microgrid includes four preparation activities and total to approximately $1 million.

1. The first set of activities are the design considerations and simulation analysis which will cost approximately $750,000 to complete.
2. The second activity focuses on the financial aspects of the project including project valuation and investment planning which will cost approximately $100,000.
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 $75,000.
4. The fourth activity focuses on the development of contractual relationships with key partners will cost approximately $75,000.

A breakout of the initial planning and design costs are illustrated in Table 33 below.

Table 33. 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 ($)[47]	What cost components are included in this figure?
$750,000	Design considerations and simulation analysis
$100,000	Project valuation and investment planning
$75,000	Assessment of regulatory, legal, and financial viability
$75,000	Development of contractual relationships
$1,000,000	**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.

Annual service for the natural gas units will cost around $260,600 per year.[48] The microgrid will also incur $11,400/year in total costs for annual fixed system service agreements for the solar PV arrays and backup diesel generators.[49]

The DERs will also incur variable O&M costs that fluctuate based on output. These include fuel and maintenance costs outside of scheduled annual servicing. For example, the natural gas units will require capital for fuel, consumable chemicals, and other operating expenses. The diesel

[47] Estimates developed by Booz Allen Project Team and independent consultant.
[48] Natural Gas O&M: $0.014/kWh. (Siemens Estimate).
[49] Solar PV array ($20/kW-year) and $4.60/kW-year for backup diesel generators (Electric Power Research Institute, "Costs of Utility Distributed Generators, 1-10 MW").

usage of the backup generators is difficult to predict because they will be used only during some emergency outage situations.

The solar PV arrays will not require fuel to operate, and it should not require service outside of the normally scheduled maintenance. Normally scheduled maintenance should cost approximately $20/kW per year.[50]

Annual service for all non-DER microgrid components will cost approximately $70,000 per year.[51]

Table 34 outlines all fixed operations and maintenance (O&M) costs associated with annual operation of the microgrid.

Table 34. Fixed Operating and Maintaining Cost

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

Fixed O&M Costs ($/year)	What cost components are included in this figure?
~ $260,600 including both fixed and variable costs	Natural Gas Unit Service Agreement– Annual costs of maintenance and servicing of unit
~ $4,000 total	Solar PV System Service Agreement – Annual costs of maintenance and servicing of unit
~ $7,400 total	Backup Diesel Generators – Annual costs of maintenance and servicing of unit
$70,000	Non-DER Microgrid Components Service Agreement - Annual costs of maintenance and servicing of components

4.4.4 Distributed Energy Resource Replenishing Fuel Time

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

At full operation, the diesel generators will require a total of 117.4 gallons of diesel fuel per hour at full load. The generators have about 960 gallons of diesel storage installed, so at a 100% level of output this generator can operate for a maximum 12 hours (on the microgrid's largest generators) without replenishing its fuel supply.

The solar PV array does not require fuel for operation, but its output depends on weather and time of day. Table 35 shows the fuel consumption and operating times for all of the microgrid DERs.

[50] NREL (projects $0/kWh variable maintenance costs): http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html.
[51] O&M for non-DER microgrid components: $70,000/year (Siemens).

Table 35. 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 Backup Diesel Generator	Rockland County Courthouse	Diesel	12	350[52]	Gallon
DER2 – Existing Backup Diesel Generator	Town Hall	Diesel	12	230[43]	Gallon
DER3 – Existing Backup Diesel Generator	Police Department	Diesel	12	260[43]	Gallon
DER4, 5, 6 and 7 – Existing Backup Diesel Generators	Police Department	Diesel	2.5	30	Gallon
DER8 – New Natural Gas Generator	Rockland County Courthouse	Natural Gas	N/A	N/A	Mcf
DER9 – New Solar PV Array	Rockland County Courthouse	Sunlight	N/A	N/A	N/A
DER10 – New Natural Gas Generator	Rockland County Legislature	Natural Gas	N/A	N/A	Mcf
DER11 – New Solar PV Array	Rockland County Legislature	Sunlight	N/A	N/A	N/A

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

4.5.1 Backup Generation Cost during a Power Outage

The proposed generation will continue to provide baseload power in the event of an extended power outage with the natural gas generators being the most reliable and productive. They have nameplate capacities of 1.5 MW and 1.0 MW, respectively, and operating at 85% efficiency and could supply a combined average of 2.125 MW to the microgrid throughout the year. Because the natural gas generators will use natural gas from the pipeline as fuel, disruptions to its fuel source are unlikely. On average, the natural gas units will generate a maximum of 36 MWh and 24 MWh per day, using around 333 Mcf (342 MMBTU) and 222 Mcf (228 MMBTU)

[52] Used comparable generators to find average size of each fuel storage tank (http://www.machinerytrader.com).

respectively of natural gas. The natural gas generators will not require startup or connection costs in order to run during island mode and should not incur any daily variable costs other than fuel.

The solar array will be available for backup generation during a power outage, but its production is too inconsistent for it to qualify as a true backup generator. Extreme weather is responsible for many emergency outages in New York State, and such weather will greatly reduce the output of the solar panels. However, when outages occur due to high electricity demand during the most irradiated days of the year, the solar panels will be at their most productive and could provide up to 0.2 MW total of load support to the Clarkstown microgrid. Table 36 shows all of the costs associated with operating the DERs during a power outage, including fuel and variable O&M costs.

The seven backup diesel generators will only come online when the natural gas unit and solar array do not provide sufficient power when the microgrid is in islanded mode. The natural gas generators can produce a combined 2.5 MW at full capacity and should be capable of satisfying the microgrid's power demand in most situations. In the cases when the load peaks the backup diesel generators will be necessary; this will result in 100% coverage of total expected outage time, which translates to a maximum production of 38.6 MWh per day. The backup diesel generators will require around 2,817 gallons per day at this level of production. One-time startup costs or daily non-fuel maintenance costs for any of the diesel generators is not anticipated.

Table 36. Cost of Generation during a Power Outage – East Footprint

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)	Power Outage 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 O&M)
						Quantity	Unit		
Rockland Co. Courthouse	DER1 - Existing Backup Diesel Generator	Diesel	0.4	100%	9.6	700.8	Gallons	N/A	$2,465[53]
Town Hall	DER2 - Existing Backup Diesel Generator	Diesel	0.264	100%	6.336	462.5	Gallons	N/A	$1,627
Police Department	DER3 - Existing Backup Diesel Generator	Diesel	0.3	100%	7.2	525.6	Gallons	N/A	$1,849
Police Department	DER4 - Existing Backup Diesel Generator	Diesel	0.161	100%	3.864	282.1	Gallons	N/A	$992
Police Department	DER5 - Existing Backup Diesel Generator	Diesel	0.161	100%	3.864	282.1	Gallons	N/A	$992
Police Department	DER6 - Existing Backup Diesel Generator	Diesel	0.161	100%	3.864	282.1	Gallons	N/A	$992
Police Department	DER7 - Existing Backup Diesel Generator	Diesel	0.161	100%	3.864	282.1	Gallons	N/A	$992
Rockland Co. Courthouse	DER8 - Natural Gas Generator	Natural Gas	1.5	100%	36	333.3	Mcf	N/A	$2,120
Rockland Co. Courthouse	DER9 - Solar PV Array	Sunlight	0.1	14%	0.3454	N/A	N/A	N/A	$5.50[55]

[53] = Daily fuel cost during an outage + (Yearly O&M/365).

[54] This output assumes that the PV arrays are still operational after an emergency event. In the case that the PV arrays are damaged, the microgrid will use the natural gas generator as the key source of emergency power.

[55] = Yearly O&M/365.

Table 37. Cost of Generation during a Power Outage – West Footprint

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)	Power Outage 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 O&M)
						Quantity	Unit		
Rockland County Courthouse	DER8 - Natural Gas Generator	Natural Gas	1.0	100%	24	222.2	Mcf	N/A	$1,415
Rockland County Courthouse	DER9 - Solar PV Array	Sunlight	0.1	14%	0.34[56]	N/A	N/A	N/A	$5.50[57]

[56] This output assumes that the PV arrays are still operational after an emergency event. In the case that the PV arrays are damaged, the microgrid will use the natural gas generator as the key source of emergency power.
[57] = Yearly O&M/365.

4.5.2 Cost to Maintain Service during a Power Outage

There are no costs associated with switching the microgrid to island mode during a power outage other than the operational costs already accounted for in Table 36 and 37. Please refer to Table 36 and 37 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)

Many of the microgrid supported facilities provide services public services to the entire community. For example, the fire and police departments provide emergency services to the entire Clarkstown community. For estimates of the population served by each critical facility, see Table 38.

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. Based on the portfolio of services that each facility provides and the electricity dependency of each service, Table 38 provides an estimate of how effectively each facility can perform its normal services without electricity.

Table 38. 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[58]	
		When Backup Power is Available	When Backup Power is Not Available
Town Hall	~ 87,100	0%	> 50%
Fire Department	~ 87,100	0%	> 50%
Police Department	~ 87,100	0%	> 50%
Rockland County Courthouse	~ 87,100	0%	> 75%
Load Cluster 1	~ 65 [59]	0%	> 75%
Load Cluster 2	~ 85[60]	0%	> 75%
Rockland County Sheriff's Department	~ 87,100	0%	> 50%
Rockland County Corrections	~ 250	0%	> 90%
Rockland County Highway Department	~ 87,100	0%	> 75%
Rockland County Legislature	~ 87,100	0%	> 75%
Animal Hospital of New City	~ 15[61]	0%	> 75%
Load Cluster 3	~ 30	0%	> 50%
Office Building	~ 12	0%	> 75%

4.7 Industrial Economics Benefit-Cost Analysis Report

As follows is a direct cost-benefit analysis deliverable from Industrial Economics. IEc was hired by NYSERDA to conduct a benefit-cost analysis of each feasibility study. The benefit-cost analysis of the Clarkstown microgrid was delivered to the Project Team on March 7, 2016.

4.7.1 Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the Town of Clarkstown has proposed development of a microgrid that would serve the following facilities:

- Town Hall – a local municipal building

[58] 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).

[59] Estimate of 15 employees per restaurant (http://www.statista.com/statistics/196672/employees-per-establishment-in-us-fast-food-restauants-since-2002/) and 5 per retail store.

[60] Estimate of 15 per restaurant (http://www.statista.com/statistics/196672/employees-per-establishment-in-us-fast-food-restauants-since-2002/), 5 per retail store.

[61] Information found on company website (http://animalmedicalnc.com/).

- Fire Department – the local fire station
- Police Department – the local police station
- Rockland County Courthouse – the local courthouse
- Load Cluster 1 – a group of facilities that includes one grocery store, three restaurants and one retail store
- Load Cluster 2 – a group of facilities that includes eight retail stores and three restaurants
- Rockland County Sheriff's Department – the county police department
- Rockland County Corrections – the county correctional facility, which houses approximately 300 prisoners
- Rockland County Highway Department – a county building
- Rockland County Legislature – the county legislative building
- Animal Hospital of New City – a local animal hospital
- Load Cluster 3 – a group of eight residential buildings housing 30 residents
- Office Building – a local office building

The microgrid would incorporate seven existing DERs – diesel generators with a total capacity of 1.61 MW – and four new distributed energy resources: a 1.5 MW natural gas unit; a 1 MW natural gas unit; and two 100 kW photovoltaic arrays. The town anticipates that the new DERs would produce electricity for the grid during periods of normal operation; in contrast, the diesel generators would only operate on an emergency basis. The system as designed would have sufficient generating capacity to meet average demand for electricity from the facilities during a major outage. Project consultants also indicate that the system would have the capability of providing black start support to the grid.

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.62 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[63]

[62] 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 CO_2 emissions. As the NYPSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO_2, NO_x, and $PM_{2.5}$, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

[63] 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

4.7.3 Results

Table 39 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 10.8 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 39. BCA Results (Assuming 7 Percent Discount Rate)

Economic Measure	Expected Duration of Major Power Outages	
	Scenario 1: 0 Days/Year	Scenario 2: 10.8 Days/Year
Net Benefits - Present Value	-$9,300,000	$71,000
Benefit-Cost Ratio	0.7	1.0
Internal Rate of Return	n/a	8.4%

underground network system). Reliability metrics can be calculated in two ways: including all outages, which indicates the actual experience of a utility's customers; and excluding outages caused by major storms, which is more indicative of the frequency and duration of outages within the utility's control. In estimating the reliability benefits of a microgrid, the BCA employs metrics that exclude outages caused by major storms. The BCA classifies outages caused by major storms or other events beyond a utility's control as "major power outages," and evaluates the benefits of avoiding such outages separately.

Scenario 1

Figure 7 and Table 40 present the detailed results of the Scenario 1 analysis.

Figure 7. Present Value Results, Scenario 1

(No Major Power Outages; 7 Percent Discount Rate)

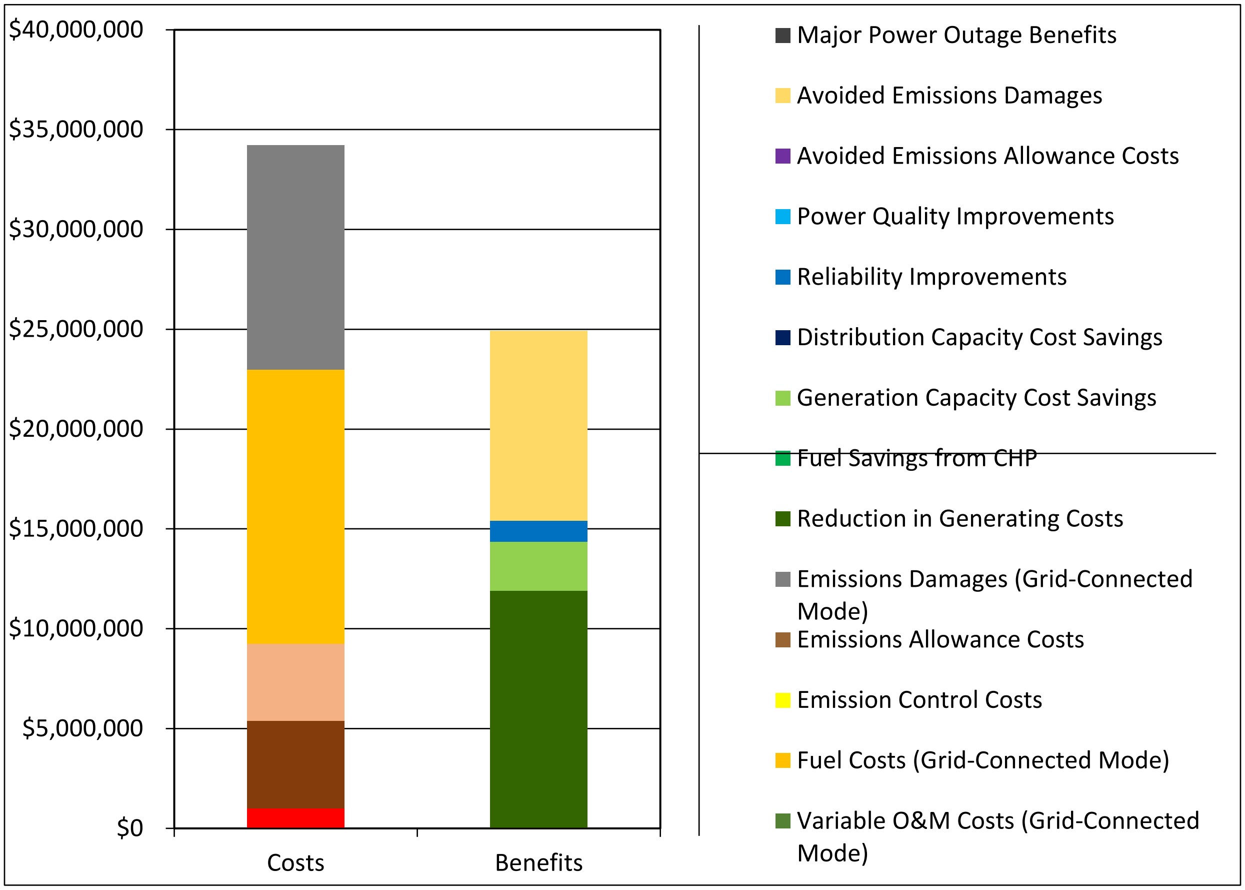


Table 40. Detailed BCA Results, Scenario 1

(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	$4,400,000	$381,000
Fixed O&M	$3,880,000	$342,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$13,700,000	$1,210,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$11,300,000	$734,000
Total Costs	**$34,200,000**	
Benefits		
Reduction in Generating Costs	$11,900,000	$1,050,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$2,460,000	$217,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$1,040,000	$91,700
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$6,400	$564
Avoided Emissions Damages	$9,500,000	$620,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$24,900,000**	
Net Benefits	**-$9,300,000**	
Benefit/Cost Ratio	**0.7**	
Internal Rate of Return	**n/a**	

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 $4.4 million, including costs associated with installing a microgrid control system; equipment for the substations that will be used to manage the microgrid; the IT infrastructure (communication cabling) for the microgrid; the new 1 MW and 1.5 MW natural gas units; the two 100 kW photovoltaic arrays; and the power lines needed to distribute the electricity the microgrid would generate. Operation and maintenance of the entire system would be provided under fixed price service contracts, at an estimated annual cost of $342,000. The present value of these O&M costs over a 20-year operating period is approximately $3.9 million.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's primary generators. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the Project Team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.[64] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $13.7 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the Project Team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the natural gas generators are estimated at approximately $734,000 annually. The majority of these damages are attributable to the emission of CO2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $11.3 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. In the case of the Town of Clarkstown's proposed microgrid, the primary source of cost savings would be a reduction in demand for electricity from bulk energy suppliers, with a resulting reduction in generating costs. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $11.9 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. These reductions in demand for electricity from bulk energy suppliers would also result in avoided emissions of CO2, SO2, NOx, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $6,400 and avoided emissions damages with a present value of approximately $9.5 million.[65]

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.[66] Based on standard capacity factors for solar and natural gas generators, the Project Team estimates the project's impact on demand for generating capacity to be approximately 215 kW per year (the team estimates no impact on distribution capacity). Based on this figure, the BCA estimates the present value of the project's generating capacity benefits to be approximately $2.5 million over a 20-year operating period.

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

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

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

The Project Team has indicated that the proposed microgrid would be designed to provide ancillary services, in the form of black start support, to the NYISO. Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the market for black start support is highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing this service.

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $92,000 per year, with a present value of approximately $1 million over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[67]

- System Average Interruption Frequency Index – 1.08 events per year.
- Customer Average Interruption Duration Index – 97.2 minutes.[68]

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.[69] 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 0.7; i.e., the estimate of project benefits is approximately 70 percent of project costs. Accordingly, the analysis moves to Scenario 2,

[67] www.icecalculator.com.
[68] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Orange & Rockland.
[69] http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1.

taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[70,71]

As noted above, the Town of Clarkstown's microgrid project would serve the following facilities: Town Hall, the Fire Department, the Police Department, Rockland County Courthouse, Load Cluster 1 – a group of facilities that includes one grocery store, three restaurants and one retail store, Load Cluster 2 – a group of facilities that includes eight retail stores and three restaurants, Rockland County Sheriff's Department, Rockland County Corrections, Rockland County Highway Department, Rockland County Legislature, Animal Hospital of New City, Load Cluster 3 – a group of eight residential buildings housing 30 residents, and the Office Building. The project's consultants indicate that at present, only Town Hall, the Police Department, and Rockland County Courthouse are equipped with backup generation; the level of service these units can support is 100 percent of the ordinary level of service at these facilities. Operation of these units costs approximately $6,000 per day. Should these units fail, all of the facilities could maintain operations by bringing in portable diesel generators with sufficient power to maintain all services. The operation of these units would cost approximately $25,000 per day. In the absence of backup power – i.e., if the backup generators failed and no replacements were available – the facilities would experience losses in service capabilities ranging from 50 to more than 90 percent (see Table 41):

[70] 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.

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

Table 41. Percent Loss in Services in the Absence of Backup Power, Scenario 2

Facility Name	Percent Loss in Services when Backup is Not Available
Town Hall	> 50%
Fire Department	> 50%
Police Department	> 50%
Rockland County Courthouse	> 75%
Load Cluster 1	> 75%
Load Cluster 2	> 75%
Rockland County Sheriff's Department	> 50%
Rockland County Corrections	> 90%
Rockland County Highway Department	> 75%
Rockland County Legislature	> 75%
Animal Hospital of New City	> 75%
Load Cluster 3	> 50%
Office Building	> 75%

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:

- Town Hall, the Fire Department and the Police Department would rely on their existing backup systems, experiencing no loss in service capabilities while the backup systems operate. If the backup generators fail, all three facilities would experience a 50 percent loss of service.
- The remaining ten facilities or clusters of facilities would rely on portable generators, experiencing no loss in service capabilities while these units are in operation. If the portable generators fail, Rockland County Courthouse, Load Cluster 1, Load Cluster 2, Rockland County Highway Department, Rockland County Legislature, Animal Hospital of New City, and the Office Building would experience a 75 percent loss in service effectiveness, while Rockland County Corrections would experience a 90 percent loss in service effectiveness, Load Cluster 3 would experience a 50 percent loss in service effectiveness, and the Rockland County Sheriff's Department would experience a 50 percent loss in service effectiveness.
- In all cases, the supply of fuel necessary to operate the backup generators would be maintained indefinitely.
- At each facility or cluster of facilities, there is a 15 percent chance that the backup generator would fail.

The economic consequences of a major power outage also depend on the value of the services the facilities of interest provide. The impact of a loss in service at these facilities is based on the following value of service estimates:

- Town Hall, a value of approximately $42,000 per day[72]
- Fire Department, a value of approximately $1,300 per day[73]
- Police Department, a value of approximately $11,400 per day[74]
- Group A (Rockland County Courthouse, Rockland County Legislature, Rockland County Highway Department, Office Building): a value of approximately $78,000 per day[75]
- Load Cluster 1, a value of approximately $151,000 per day[76]
- Load Cluster 2, a value of approximately $77,000 per day[77]
- Group B (Rockland County Sheriff's Department and Animal Hospital of New City), a value of approximately $223,000 per day[78]
- Rockland County Corrections, a value of approximately $29,000 per day[79]
- Load Cluster 3, a value of approximately $560 per day[80]

Based on these values, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the facilities of interest is approximately $82,000 per day.

Summary

Figure 8 and Table 42 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 10.8 days per year without power. If the average annual duration of the outages the microgrid prevents is below this figure, its costs are projected to exceed its benefits.

[72] www.icecalculator.com.
[73] Based on FEMA methodology, 100% probability of an outage, with an outage duration of 1 day.
[74] Based on FEMA methodology, 100% probability of an outage, with an outage duration of 1 day.
[75] www.icecalculator.com. The service value for these facilities was developed for the group as a whole, based on the common number of hours of electricity they would require during an outage (eight hours per day).
[76] www.icecalculator.com.
[77] www.icecalculator.com.
[78] www.icecalculator.com; The service value for these facilities was developed for the group as a whole, based on the common number of hours of electricity they would require during an outage (24 hours per day).
[79] www.icecalculator.com.
[80] Based on FEMA methodology, 100% probability of an outage, with an outage duration of 1 day.

Figure 8. Present Value Results, Scenario 2

(Major Power Outages Averaging 10.8 Days/Year; 7 Percent Discount Rate)

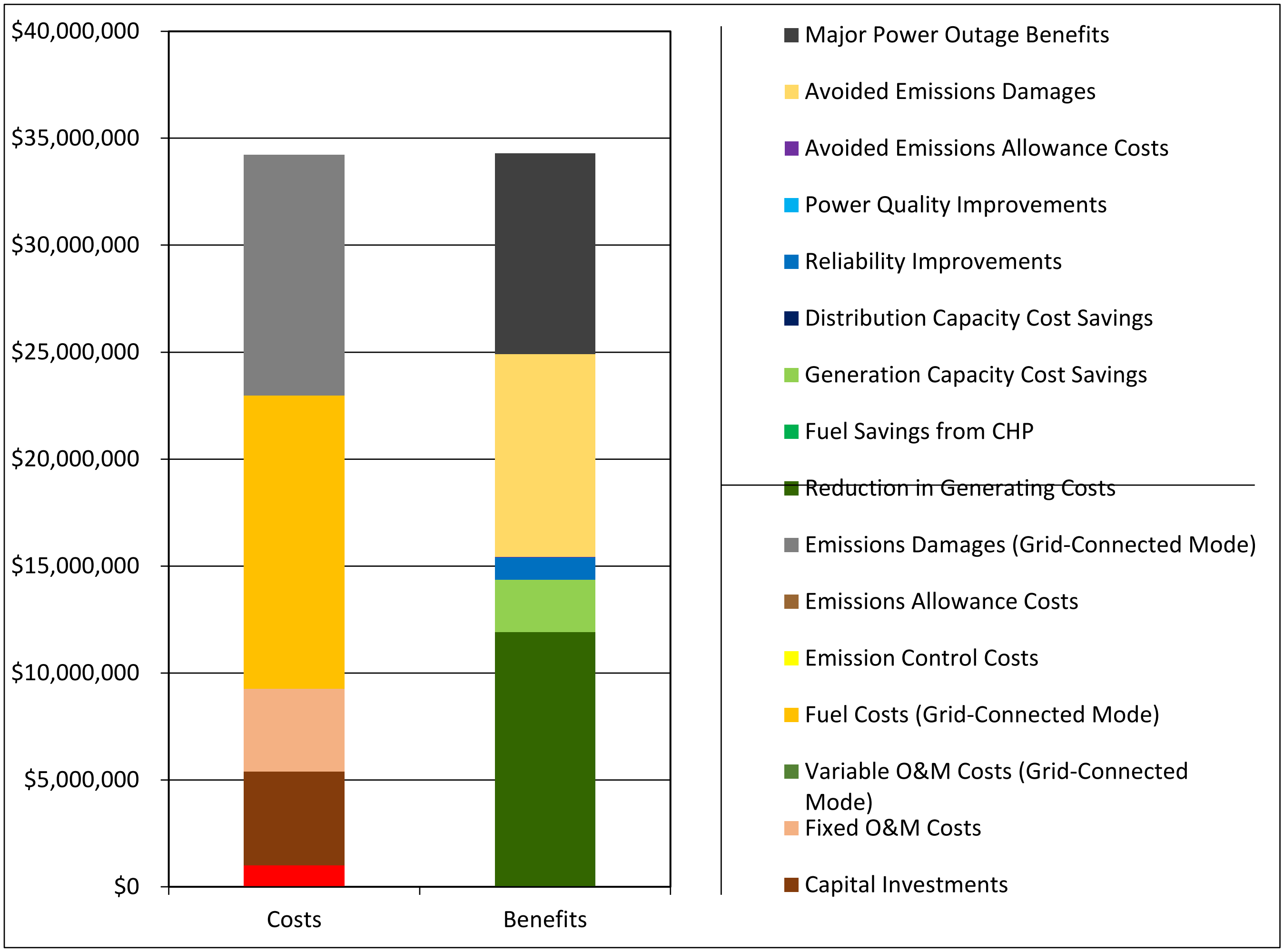


Table 42. Detailed BCA Results, Scenario 2

(Major Power Outages Averaging 10.8 Days/Year; 7 Percent Discount Rate)

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,000,000	$88,200
Capital Investments	$4,400,000	$381,000
Fixed O&M	$3,880,000	$342,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$13,700,000	$1,210,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$11,300,000	$734,000
Total Costs	**$34,200,000**	
Benefits		
Reduction in Generating Costs	$11,900,000	$1,050,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$2,460,000	$217,000
Transmission & Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$1,040,000	$91,700
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$6,400	$564
Avoided Emissions Damages	$9,500,000	$620,000
Major Power Outage Benefits	$9,370,000	$835,000
Total Benefits	**$34,300,000**	
Net Benefits	**$71,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**8.4%**	

The Project Team assumed an electricity sales price of $0.085 per kWh in Clarkstown. This is the supply cost for O&R, the average amount spent by O&R to import electricity into their distribution system. On a long term, fixed volume PPA, the Project Team believes this to be the most accurate pricing model. Industrial Economics modeled the 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 O&R grid. In Clarkstown, the Hudson Valley LBMP is $37.00 per MWh,[81] or $0.037 per kWh, a more than 56% reduction in price from the supply cost. The benefits allowed for capacity cost reductions do not bring the electricity prices to parity. This has a predictable influence on the economics of the projects and is the driving force behind the divergent cost benefit analyses developed by the Project Team and by IEc. The Project Team is unaware of any community microgrid business model or generation set that is financially self-sufficient at the LBMP.

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

5. Summary and Conclusions

5.1 Lessons Learned and Areas for Improvement

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

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

Clarkstown is the only community in the Project Team's portfolio that is financially viable in the absence of a thermal component. The reciprocating generators proposed in Clarkstown return enough revenue to make the investment attractive and do not require a combined heat and power element to keep the project afloat. There are three factors behind this, the combination of which may serve as a future screen for potentially profitable projects. The first factor is the relatively low price of natural gas and the commensurately lower operating costs of generator, which are driven by fuel prices. The second is the relatively high electricity price in O&R territory, which allow for enhanced revenue streams against decreased costs. And thirdly, the combined size of the generators, at 2.5 MW, is large enough to generate sufficient revenue to absorb the cost of the microgrid controls capital and O&M costs. This last factor is particularly important, because even the most advantageous gas and electricity prices will not support sufficient revenue for cost recovery if the generators are approximately less than a MW.

The Clarkstown microgrid includes approximately 85% municipal loads, each of which is eligible for reduced rate New York Power Authority (NYPA) financing. The Project Team understands that the Hamlet of New City, one of the jurisdictions within the footprint, has a competitive bond rating and interest rate that may obviate the need for NYPA financing, but the presence of such significant municipal loads allows for a wider array of financing options. Such scenarios could allow lower return projects to be viable through municipal financial support in situations where they are not otherwise investible by private equity.

The Clarkstown microgrid straddles the Town of Clarkstown and Hamlet of New City, in addition to incorporating a number of Rockland County facilities. While this is not intrinsically problematic, it does create issues in coordinating across numerous governmental stakeholder groups and review processes. It is a sufficiently intensive process to bring a single jurisdiction to a common vision and outlook for a project such as this, and that is scaled up when dealing with three different sets of municipal interests.

In comparison to working with a municipal utility, working with the investor-owned O&R was a more time-intensive process. As a utility with a moderately large footprint, customer base, and transmission and distribution network, O&R has many issues to manage that require its attention, among which microgrids and NY Prize were just one. However, O&R was receptive to Project Team proposals to upgrade the existing distribution system and switches in the microgrid footprint and worked with the Project Team to ensure that proposals did not adversely affect O&R operations. 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 O&R 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. In Clarkstown, the design proposal largely addresses constraints in the existing electrical infrastructure. O&R operates a double redundant system within the footprint and, to maintain this redundancy, the microgrid cannot island at-will. Working with O&R the Project Team was able to construct the footprint and infrastructure to allow for O&R operational considerations as well as robust energy resilience for local facilities. This work across an electrical footprint that was not immediately advantageous to a microgrid allowed a fair proposal, but without a willingness to engage on the part of the utility, similar infrastructural realities could prevent project development.

Second, the availability of natural gas infrastructure is a major contributor to positive project feasibility. In communities without natural gas, generation is typically limited to solar PV and the tie in of existing diesel backup generation, given the high costs of storage and biomass and the larger footprints required for wind. Given the intermittency of solar, and the low capacity factor in New York State (approximately 15%), solar installations of a few hundred kW do not provide reliable generation support for an islanded microgrid. In contrast, natural gas-fired generation provides a high reliability baseload, is relatively clean and efficient, and allows for cogenerated thermal sales if there is a proximate off-taker.

Financial. Across the portfolio of communities managed by the Project Team, natural gas availability and thermal off-takers are the leading elements of financially viable projects. Simply, natural gas generation is more cost efficient and provides highly reliable revenue streams through electricity sales, and offers thermal 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.

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 Clarkstown, support from the utility for this effort has been robust and the community liaison has been exceptionally engaged. This liaison, a local law enforcement official, has the interest and initiative to move the project ahead, but wide community organization has been slow to coalesce. There has been little in the way of negative feedback, simply an overall difficulty in moving a critical mass of stakeholders forward. Community engagement is key 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. 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. Clarkstown'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 and would be a potentially useful addition to this proposal. Lastly, the larger the microgrid grows, the more switches and controls are need to be installed, connected, and maintained for smooth islanding and grid-reconnect processes. In the aggregate, such infrastructure is costly and does not provide many direct returns. Utilities are also likely to push back if the microgrid grows to occupy significant portions of their infrastructure. To that end, the Project Team has worked diligently with the local utilities to find acceptable footprints that meet the goals of NYSERDA and respect the operational concerns of the utilities.

5.1.3 Stakeholder Lessons Learned

Developers. Some of the NY Prize project proposals 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 thermal off-takers; these conditions drive project profitability. Moreover, many of the municipalities are interested in part or full ownership of the projects, but either do not have available funds or lose the project economics without the available tax credits and incentives. In these situations, there may be opportunities for developers to leverage the tax benefits through design-build-own-operate arrangements.

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

Investor-owned-utilities in the Project Team's portfolio, including O&R in Clarkstown, 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. O&R in particular was an active partner in discussions to identify the most advantageous footprint for microgrid feasibility and its own operational considerations.

Academics. Academic considerations in microgrid development may center around three areas. First, research into a relatively small grid systems with multiple generators (some spinning, some inverter-based), temporally and spatially variable loads, and multidirectional power flows may inform better designs and more efficient placement of generation and controls relative to loads. The second is optimizing financial structures for collections of distributed energy resources and control infrastructure. To-date, most microgrids in the United 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 community microgrid development. Setting expectations ahead of future microgrid initiatives will help communities begin with more concise and actionable goals for their community microgrids.

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

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

5.2 Benefits Analysis

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

5.2.1 Environmental Benefits

New York State's normal energy portfolio is very clean, with primary energy sources being hydropower and nuclear. Therefore, having a microgrid powered by a natural gas generators will increase the overall emissions per kWh. However, the natural gas generators are cleaner than many peaking assets, which come online when statewide demand is high, and are significantly cleaner than the backup diesel generators that would otherwise be utilized in Clarkstown. The proposed microgrid also offers a platform for expanding renewable generation in the future. The microgrid's generation assets will not exceed current New York State emissions limits for generators of their size and will not need to purchase emissions permits to operate.

5.2.2 Benefits to the Town of Clarkstown

Critical and important facilities in the Town of Clarkstown will receive resilient backup power from the proposed generation assets, ensuring they are available in outage situations and reducing the need for further investments in backup generation. The electricity generated with the solar PV arrays and the natural gas-fired reciprocating generator will also offset higher-emission peaking assets during peak demand events and offset diesel emissions during times of outage. The Project Team met with the community in-person on February 2, 2016 to provide a summary of the project analysis and a recommended approach for a path forward.

5.2.3 Benefits to Residents in and around Clarkstown

Residents of Clarkstown 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 Clarkstown and nearby surrounding communities will have access to microgrid-served municipal and commercial services in the event of an outage. In the future, the microgrid could be expanded to connect more facilities.

5.2.4 Benefits to New York State

New York State will benefit from the continued localization of energy resources, reducing load and congestion on the grid. Moreover, the expansion of distributed energy resources will further the goals of REV and provide a more resilient overall grid. A successful implementation of the Clarkstown 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 Clarkstown microgrid is feasible. This document details the capabilities of the microgrid, its primary technical design, the commercial, financial, and legal viability of the project, and the costs and benefits of the microgrid. The microgrid meets all of the NYSERDA required capabilities and most of its preferred capabilities.

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

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

Finally, the project will demonstrate the widely distributed benefits of microgrids paired with DER assets. The utility will see increased revenues and grid performance, customers will see stabilized electricity prices provided by a more reliable grid system, the community will reap the positive benefits of living in and around the microgrid, and industrial customers will benefit from reduced energy costs and the value of avoided outages. For these reasons, the Project Team strongly recommends this project be selected for continued participation in the NYSERDA New York Prize Community Microgrid Competition.

Appendix

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

REDACTED PER NDA WITH O&R