

**27 - Town of Mount Kisco**

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# **Town of Mount Kisco Microgrid Feasibility Study**

## **Microgrid Project Results and Final Written Documentation**

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## Abstract

Together with the Town of Mount Kisco (Mount Kisco), Booz Allen Hamilton has completed the feasibility study for a proposed community 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 have been analyzed and detailed in previous deliverables and are summarized in this document. The Mount Kisco microgrid project faces the challenge of high capital costs, but it benefits from an advantageous mix of generation and loads. A new 3.5 megawatt (MW) combined heat and power (CHP) unit, a new 200 kilowatt (kW) solar photovoltaic (PV) array, and an existing 50 kW solar PV array will provide reliable, low-emission electricity and steam to customers while providing a proof of concept for a community microgrid in investor-owned utility (IOU) territory. Many of the takeaways of the feasibility study may be generalized across the spectrum of NY Prize and community microgrids.

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

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## Acronyms and Abbreviations

AC	Alternating Current
AMI	Advanced Metering Infrastructure
ATS	Automatic Transfer Switch
BCA	Benefit Cost Analysis
BEMS	Building Energy Management Systems
BTU	British thermal unit
CAIDI	Customer Average Interruption Duration Index
CHP	Combined Heat and Power
DC	Direct Current
DER	Distributed Energy Resources
DNP3	Distributed Network Protocol
DR	Demand Response
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
LED	Light-Emitting Diode
Mcf	One Thousand Cubic Feet of Natural Gas
MCS	Microgrid Control System
MHz	Megahertz
MMBTU	One Million British Thermal Units
MMTCO <sub>2e</sub>	Million Metric Tons CO <sub>2</sub> Equivalent
MTCO <sub>2e</sub>	Metric Tons CO <sub>2</sub> Equivalent
MW	Megawatt
MWh	Megawatt-hour
NPV	Net Present Value
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
PCC	Point of Common Coupling
PLC	Programmable Logic Controller
PPA	Power Purchase Agreement
PV	Photovoltaic
RAID	Redundant Array of Independent Disks
REV	Reforming the Energy Vision
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SCOPF	Security Constrained Optimal Power Flow
SOA	Service Oriented Architecture
SOW	Statement of Work
TCP/IP	Transmission Control Protocol/Internet Protocol

## 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 Mount Kisco (Mount Kisco). This deliverable presents the findings and recommendations from the previous four tasks, discusses the results and lessons learned from the project, and lays out the environmental and economic benefits for the project. The design demonstrates the Town can improve energy resilience with intentional and emergency island mode capabilities, 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 3.7 MW of clean energy generation capability. The study concludes the technical design is feasible.

The Mount Kisco microgrid project will tie together two critical facilities (per NYSERDA’s definition) and three other important facilities into a community microgrid. Table ES – 1 lists all the facilities under consideration for the microgrid concept at this time, and Figure ES- 1 shows their locations in the Town of Mount Kisco.

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

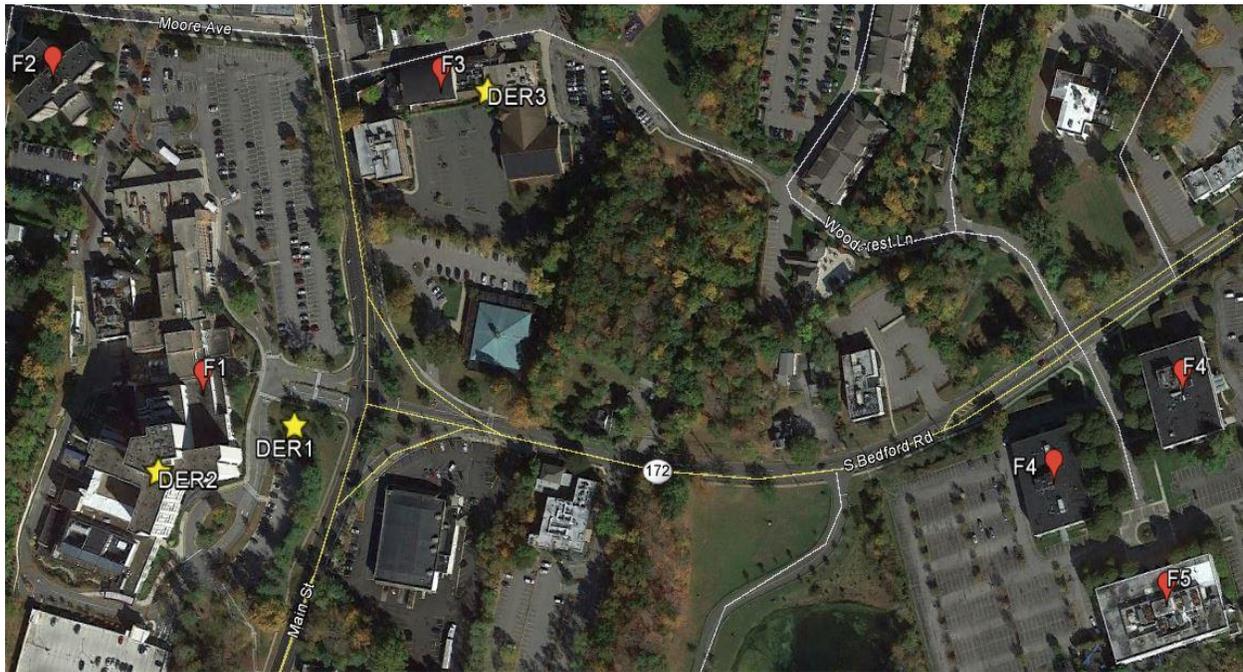
Table lists the facilities in the Town of Mount Kisco’s proposed microgrid, including their classifications as public, health, or school. The table also denotes critical and important facilities.

Name on Map	Property	Classification
F1	Northern Westchester Hospital	Hospital*
F2	Northern Westchester Hospital Staff Housing (Thermal only)	Residential/Healthcare**
F3	Boys and Girls Club of Northern Westchester	Shelter**
F4	Mount Kisco Medical Group (and Pediatric building)	Hospital/Healthcare*
F5	Diamond Properties Office Building	Commercial**
		* Critical Facility
		** Important Facility

In addition to the facilities in Table ES-1, there are significant additional medical facilities within the footprint of the microgrid, including ambulatory and outpatient services at 34 and 83 South Bedford Road and an adjacent CVS Pharmacy. While these are not included on the one-line diagrams in Deliverable 2, they will be carefully considered in a Phase II effort and, pending more detailed electrical infrastructure information, there does not appear to be any reason why they cannot be included.

### 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 following existing and proposed generation assets:

- One existing 50 kW solar PV array at the Boys and Girls Club of Northern Westchester (331 Main Street)
- One proposed 3.5 MW natural gas-fired continuous duty reciprocating generator with CHP capability at the Northern Westchester Hospital (400 Main Street)
- One proposed 200 kW PV rooftop array at the Northern Westchester Hospital (400 Main Street)

The existing and proposed generation assets will provide 100% of the electricity requirements of the facilities in Table ES-1, above, during emergency outage conditions. The CHP unit is sized to meet the entire microgrid load so long as the microgrid's peak load does not exceed the 2014 peak demand. The combination of the CHP unit and the solar arrays should be sufficient to meet peak demand of the microgrid, absent significant load growth. The backup power supplied by the microgrid will ensure essential services remain accessible to Northern Westchester County during long-term grid outages, providing relief for residents throughout the region. In addition, the CHP unit will supply 41% of the hospital's annual thermal energy demand. Existing natural gas infrastructure in Mount Kisco will support continuous operation of the CHP unit. 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 Mount Kisco microgrid, wherein one special purpose vehicle (SPV) owns the CHP unit and microgrid infrastructure and the hospital owns the solar array proposed for their rooftop. 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 CHP unit and microgrid infrastructure will be owned by private investors; Mount Kisco may also elect to purchase shares in the SPV. Because the proposed solar array will be located on the roof of Northern Westchester Hospital, the hospital will presumably own the majority stake in the array. The Team proposed Consolidated Edison (Con Ed) leverage its energy domain expertise to operate and maintain the microgrid components and controls. Revenues streams from electricity and thermal energy sales will accrue to SPV investors and will cover variable generation costs. In Mount Kisco, this proposed ownership model provides the greatest benefits to the utility and customer base within the Town, ensuring revenues and costs are relatively in balance.

The microgrid will incur initial capital costs of \$8.6 million as well as yearly operation, maintenance, and fuel costs totaling \$1.8 million per year. Overall revenue streams from the project are estimated at \$2.2 million per year and will be captured primarily through the sale of electricity during grid-connected mode and the sale of thermal resources to the hospital. Other revenues from the proposed microgrid will include tax credits, incentives, and DR programs. In addition, the value of electricity savings from the 200 kW solar PV array during grid connected mode is estimated at \$20,000 per year.

The cost and revenue figures reflected in this Deliverable are based on the most recent and up-to-date information available to the Project Team. As a result of ongoing due diligence, the figures reported in Deliverable 3 are amended in Deliverable 4 and in this document to reflect the best available information on operations, maintenance, and capital costs of the microgrid infrastructure and generation assets. The changes are reflected here to provide the most accurate project characterization available and are within +/- 30% accuracy.

The proposed microgrid's commercial feasibility may depend on NY Prize Phase III funding. While the Project Team forecasts yearly revenues that should reliably cover yearly generator operation and maintenance (O&M) costs, new distribution lines could add up to \$3 million to total initial capital costs if built underground. Revenue from generator operation would not be sufficient to cover this elevated capital cost, so the project may require extra subsidies (i.e., NYSERDA NY Prize funding) to attract adequate third party funding to fund the remaining capital costs.

The Mount Kisco microgrid concept, with new reliable and renewable 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 five

critical and important facilities, including the Northern Westchester Hospital, is a significant addition to the resilience of the Town in times of emergency and extended grid outages.

## 1. Introduction

Working with the Town of Mount Kisco (Mount Kisco) and Consolidated Edison (Con Ed), a team from Booz Allen Hamilton (hereafter Booz Allen or the Project Team) designed a preliminary microgrid concept that will connect five critical and important facilities with two new generation assets and an existing solar PV array. The design proposes a new 3.5 MW CHP unit at the Northern Westchester Hospital, a new 200 kW solar PV array on the rooftop of the Northern Westchester Hospital, and the incorporation of an existing 50 kW solar PV array at the Boys and Girls Club of Northern Westchester (BGC).

Section 2 of this document describes the configuration further. Section 3 provides an overview of the project's viability and Section 4 provides the cost benefit analysis information. Also in this document, the Project Team discusses the observations, findings, and recommendations from the entirety of the analysis. The Team 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

The Mount Kisco microgrid will improve the resilience of the local electricity grid in emergency outage situations, accommodate distributed energy generation, stabilize energy prices during peak events, and reduce reliance on high emissions peaking assets during peak demand events. The Town of Mount Kisco 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.

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

- Some important services in Mount Kisco do not have backup generation. Although the hospital owns backup generators (as mandated by national codes), the Project Team is not aware of any spinning backup generators at the Mount Kisco Medical Group (MKMG) or

the Boys and Girls Club of Northern Westchester (BGC). These facilities are therefore vulnerable to prolonged interruptions or outages in grid-supplied power.

- Extreme weather events and seasonal weather changes cause energy price volatility, and consumers are seldom able to respond to these price signals. There are no clear incentives to shift load or self-generate in response to price changes. Other than reducing consumption, ratepayers have few options when prices soar.
- In order to improve its energy profile and reduce its carbon footprint, the community prefers low-emission options for distributed energy resources. An integrated microgrid adds value to advanced distributed energy resource technologies, increasing the viability of CHP and the solar arrays.
- Mount Kisco was impacted by Hurricanes Floyd, Irene, and Sandy as well as heatwaves, northeasters, and snowstorms. These storms resulted in costly damages, including the impacts of power losses to critical services, government offices, and local businesses. See Table 1 for an overview of major outages in Mount Kisco.

**Table 1. Outage Summary by Category**

Overview of major outages in Mount Kisco and Westchester County and the number of households affected by each outage as reported by Mount Kisco Multi-Hazard Mitigation Plan published October 2013.<sup>1</sup>

Cause	Mount Kisco Outages	Westchester County Outages
<b>Hurricane Sandy (10/2012)</b>	2,500 <sup>2</sup>	206,000 <sup>3</sup>
<b>2011 Blizzard (10/2011)</b>	75% of customers <sup>4</sup>	71,000 <sup>5</sup>
<b>Hurricane Irene (08/2011)</b>	3,300 <sup>6</sup>	203,821 <sup>7</sup>
<b>2010 Northeaster* (03/2010)</b>		173,000 <sup>8</sup>
<b>Tropical Storm Ernesto* (09/2006)</b>		80,000 <sup>9</sup>
<b>July 2006 Heatwave and Storms* (07/2006)</b>		45,000 <sup>10</sup>
*Information for Mount Kisco outages not available		

<sup>1</sup>[http://www.mountkisco.org/pages/mtkiskonyc\\_manager/Inc%20VillageTown%20of%20Mt%20Kisco%20Multi%20Haz%20Mit%20Plan.pdf](http://www.mountkisco.org/pages/mtkiskonyc_manager/Inc%20VillageTown%20of%20Mt%20Kisco%20Multi%20Haz%20Mit%20Plan.pdf)

<sup>2</sup> Page 4-32. “In Mount Kisco, Con Edison reported more than 2,500 customers lost power” Also noted on page 4-65.

<sup>3</sup> Page 4-31. “Con Edison reported more than 206,000 customers lost power in Westchester County” Also noted on page 4-65.

<sup>4</sup> Page 4-64. “The Blizzard of October 2011 knocked out power to approximately 71,000 customers in Westchester County. This storm also knocked out power to approximately 75% of Mount Kisco customers”

<sup>5</sup> Page 4-64. “The Blizzard of October 2011 knocked out power to approximately 71,000 customers in Westchester County. This storm also knocked out power to approximately 75% of Mount Kisco customers”

<sup>6</sup> Page 4-64. “Tropical Storm Irene...reportedly knocked out power to approximately 203,821 households in Westchester County and New York City. Con Edison reported approximately 3,300 households without power in Mount Kisco.”

<sup>7</sup> Page 4-64. “Tropical Storm Irene...reportedly knocked out power to approximately 203,821 households in Westchester County and New York City. Con Edison reported approximately 3,300 households without power in Mount Kisco.”

<sup>8</sup> Page 4-64. “The Nor-easter of March 2010 knocked out power to approximately 173,000 households in Westchester County and New York City.”

<sup>9</sup> Page 4-64. “The remnants of Tropical Storm Ernesto caused approximately 80,000 households in Westchester County to lose power.”

<sup>10</sup> Page 4-64. “Severe storm caused an additional 35,000 households in Westchester County to lose power.”

Implementing a community microgrid will improve energy resiliency, reduce the greater need for high-emission peaking assets (by expanding distributed energy resources), and reduce the strain on the local electricity transmission and distribution network. Cogenerated steam from the CHP unit will replace thermal energy from the hospital’s natural gas-fired boilers and remove the need to replace these boilers in the future.

Mount Kisco has two healthcare facilities, including one full-service hospital, and a shelter, the Boys & Girls Club, clustered within 0.3 miles of each other. This proximity encourages the construction of a microgrid because several important facilities can be incorporated into the design without the need for long-range distribution lines.<sup>11</sup> Healthcare facilities are also critically important to communities during extreme weather events (to treat associated injuries), and national fire codes mandate that they have reliable sources of backup power. Monitoring and life-support equipment often depend on a stable supply of electricity, so connecting healthcare facilities to the microgrid will help protect citizens of northern Westchester County during extreme weather events and grid outages.

The Project Team estimates the microgrid’s main DERs will generate an instantaneous average output of approximately 3 MW of electricity throughout the year.<sup>12</sup> Although Mount Kisco 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 Con Ed in the surrounding area. The project could serve as a model for the critical congestion points in the area, providing data on how distributed energy resources affect required transmission capacity for NYSERDA and the NY Independent System Operator (NYISO). Coupled with other distributed energy resource projects in the area or elsewhere, the aggregate reduction of load on the transmission system could be material. Moreover, the proposed microgrid can island without negatively impacting any non-connected facilities on the feeder network because it is at the end of the feeder the facilities are interconnected with new lines; this allows the possibility of blue sky islanding for operational or economic reasons.

The Town provides an opportunity to examine the prospects of a replicable, modular microgrid solution located just outside New York City. New York State has experienced severe longstanding congestion at critical points on the transmission system linking upstate and downstate New York, some of which could be eliminated by investing in distributed energy generation and microgrids with intentional island mode capability. 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 NYISO.

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<sup>11</sup> The design still requires new distribution lines to isolate proposed facilities—there are no long-range lines required to transmit power from distant generators.

<sup>12</sup> CHP capacity factor: 85% (EPA; <http://www3.epa.gov/chp/documents/faq.pdf>)  
Solar PV capacity factor: 14% (NREL PV Watts Calculator)

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

The NYSERDA statement of work 65099 outlines 15 required capabilities and 18 preferred capabilities each NY Prize microgrid feasibility study must address. Table 2 summarizes required and preferred capabilities met by the proposed microgrid design in greater detail.

**Table 2. Microgrid Capabilities Matrix**

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

Capability	Required/Preferred	Microgrid will meet (Y/N)
Serves more than one, physically separated critical facilities	Required	Y
Primary generation source not totally diesel fueled	Required	Y
Provides on-site power in both grid-connected and islanded mode	Required	Y
Intentional islanding	Required	Y
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 <sup>13</sup>
Clean power sources integrated	Preferred	Y
Optimal power flow (economic dispatch of generators)	Preferred	Y
Storage optimization	Preferred	N
PV observability, controllability, and forecasting	Preferred	Y
Coordination of protection settings	Preferred	Y
Selling energy and ancillary services	Preferred	N <sup>14</sup>
Data logging features	Preferred	Y
Leverage private capital	Preferred	Y
Accounting for needs and constraints of all stakeholders	Preferred	Y
Demonstrate tangible community benefit	Preferred	Y
Identify synergies with Reforming the Energy Vision (REV)	Preferred	Y

<sup>13</sup> The system is technically capable of providing demand response, but it is unclear whether islanding the microgrid will qualify for DR programs (both load and generation assets will be taken offline simultaneously).

<sup>14</sup> Microgrid has the *capability* to sell energy and ancillary services, but may only sell energy in reality.

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

#### 2.2.1 Serving Multiple, Physically Separated Facilities

At this stage of the study, the Town of Mount Kisco and the Booz Allen team, in cooperation with Con Ed, have identified four facilities that will be connected to the microgrid, two of which will provide critical services (as defined by NYSERDA) to the community in the case of an outage. See Table ES-1 for a full list of prospective facilities to be tied into the microgrid.

The proposed microgrid footprint occupies approximately 50 acres in Mount Kisco. Loads will be interconnected via two new medium-voltage power lines. Facilities will communicate over Con Ed's WAN (utilizing the existing IT fiber optic backbone). Utilizing industry standard protocols, such as Distributed Network Protocol (DNP3), Open Platform Communication (OPC), Modbus, 61850, and Inter-Control Center Communications Protocol (ICCP) (IEC 60870-6) will enable the remote monitoring and control of distributed devices, regardless of manufacturer. The microgrid is designed with flexibility and scalability in order to accommodate future expansion and technologies.

#### 2.2.2 Limited Use of Diesel Fueled Generators

The Town of Mount Kisco has established a preference for a natural gas-fired generator to serve as the primary energy source. As a comparatively low-emission, high reliability fuel, natural gas is an ideal source of energy for the proposed community microgrid. Electricity from the natural gas-fired CHP unit will be supplemented by energy from two solar arrays. These arrays will operate at maximum capacity during the summer and will offset some of the greenhouse gas (GHGs) emitted by the CHP unit.

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

The microgrid will provide on-site power in both grid-connected and islanded mode. In island mode, the MCS will optimize on-site generation and automatically shed non-critical loads as needed to maintain a stable and reliable power flow. In grid-connected mode, the microgrid will optimize the use of available assets to reduce energy costs when possible and export to the Con Ed grid when economic and technical conditions align.

The proposed generation assets will function continuously in grid-connected mode, reducing local dependence on grid-supplied power. In island mode, the solar PV arrays will supplement the CHP unit's output to meet critical loads. The Project Team has concluded these assets will not require supplemental power from backup generators to provide sufficient electricity.

#### 2.2.4 Intentional Islanding

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

The MCS will automatically start and parallel the generation assets. Once the available power sources are synchronized with the grid (and each other), the system is ready to disconnect from

the larger grid, and it will begin by opening the incoming utility line breakers. After completing the transition to island mode, the MCS must maintain system voltage and frequency between acceptable limits and adjust generator output to match aggregate load.

2.2.5 Resynchronization to Con Ed Power

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

The proposed PME, and included breaker, at the point of common coupling (PCC) will connect the microgrid to the larger grid. The control system will trigger the opening or closing of this breaker as appropriate during system transitions.

2.2.6 Standardized Interconnection

The microgrid design complies with NYPSC interconnection standards. Table 3 outlines the most significant state interconnection standards that apply to this microgrid project. Con Ed customers connecting to the grid via distributed energy resource (DER) projects must also follow the New York State Standard Interconnection Requirements (SIR) identified in Table 3. The New York State Public Service Commission (NYPSC) has published Standardized Interconnection Requirements for distributed generators with less than 2 MW capacity. Although the proposed CHP unit is larger than 2 MW, generators that are close to 2 MW (approximately 2-4 MW) still usually follow normal SIR. A recent proposal to modify the New York SIR to include generators up to 5 MW has not yet been approved. The proposed CHP unit will likely need to follow the normal New York State SIR, but there is a possibility that interconnection will need to follow the Federal Energy Regulatory Commission (FERC) guidelines for small generators (2-20 MW).<sup>15</sup>

**Table 3. New York State Interconnection Standards<sup>16</sup>**

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

Standard Category	Description
<b>Common</b>	Generator-owner shall provide appropriate protection and control equipment, including a protective device that utilizes an automatic disconnect device to disconnect the generation in the event that the portion of the utility system that serves the generator is de-energized for any reason or for a fault in the generator-owner’s system

<sup>15</sup> FERC guidelines can be found at: <http://www.ferc.gov/industries/electric/indus-act/gi/small-gen.asp>

<sup>16</sup> New York State Public Service Commission. *Standardized Interconnection Requirements and Application Process for New Distributed Generators 2 MW or Less Connected in Parallel with Utility Distribution Systems* (2014). Available from [www.dps.ny.gov](http://www.dps.ny.gov).

Standard Category	Description
	<p>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</p> <p>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</p> <p>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</p> <p>The required operating range for the generators shall be from 88% to 110% of nominal voltage magnitude</p> <p>The required operating range for the generators shall be from 59.3 Hz to 60.5 Hz</p>
<b>Synchronous Generators</b>	<p>Requires synchronizing facilities, including automatic synchronizing equipment or manual synchronizing with relay supervision, voltage regulator, and power factor control</p> <p>Sufficient reactive power capability shall be provided by the generator-owner to withstand normal voltage changes on the utility’s system</p> <p>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</p> <p>Adopt one of the following grounding methods:                      Solid grounding                      High- or low-resistance grounding                      High- or low-reactance grounding                      Ground fault neutralizer grounding</p>
<b>Induction Generators</b>	<p>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</p>
<p>Source: NYS Standardized Interconnection Requirements and Application Process, NYS PSC</p>	

2.2.7 24/7 Operation Capability

The project concept envisions a reciprocating natural gas-fired generator with CHP capability as the main generation source for the community microgrid. The Town’s existing natural gas supply line can support 24/7 continuous operation of the CHP generator, which should always provide enough electricity for the microgrid facilities.

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 Mount Kisco. The new automation solution proposed in this deliverable will serve as a protocol converter to send and receive all data available to the operator over Con Ed’s WAN using industry standard protocols such as DNP3, OPC, Modbus, 61850, and IEC 60870-6).

2.2.9 Voltage and Frequency Synchronization when Connected to the Grid

Microgrid controllers will automatically synchronize the frequency and voltage of all DER-generated power, which will include a rotating energy source as well as inverter-based energy

sources. Synchronization is key to maintaining a stable power network. The larger grid also requires constant synchronization of energy sources, but it's 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 the distribution of generation and loads, can also affect the frequency and voltage stability. The Project Team will consider these factors and develop a microgrid design that accounts for them in the next phase of the NY Prize competition. The comparatively small size of the microgrid introduces new, fast, and dynamics-related problems that will be carefully studied during the engineering design phase.

In islanded mode, the MCS will maintain control of the generating units to maintain voltage and frequency. In addition, the MCS will combine load shedding and generation control to maintain the demand supply balance.

#### 2.2.11 Diverse Customer Mix

Connected facilities have varying impacts on power quality and stability based on load size and economic sector. A microgrid with too many industrial or digital electronics-based loads may be less reliable because these loads can negatively affect power quality and stability. The microgrid power management system will allow for an acceptable mix of commercial, and industrial customers. The Mount Kisco microgrid facilities will have the following impacts on aggregate load:<sup>17</sup>

- Northern Westchester Hospital – 72% of load
- Mount Kisco Medical Group – 11% of load
- Boys and Girls Club – 3% of load
- Diamond Properties – 14% of load

The hospital represents by far the largest load to be connected to the microgrid. Hospitals can often curtail 25-50% of total load during peak demand events, usually by bringing backup diesel generators online.<sup>18</sup> The hospital will therefore be the prime target for load reduction during peak demand events and may be able to reduce load by as much as 600 kW.

#### 2.2.12 Resiliency to Weather Conditions

The Town of Mount Kisco is exposed to the normal range of weather conditions that affects the Northeastern United States. Extreme weather events include, but are not limited to, torrential

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<sup>17</sup> Estimated based on each facility's typical 24 hour load profile from a typical month in 2014.

<sup>18</sup> EnerNOC estimate.

rain, snow, and wind that could cause falling objects and debris to disrupt electric service and damage equipment and lives. Mount Kisco has experienced several significant recent disruptions to power service during hurricanes Irene and 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 CHP unit (the microgrid's main generation asset) will be constructed inside the hospital's boiler room and will therefore be safe from forces of nature. If constructed overhead, the new medium-voltage distribution lines may be exposed to severe weather; however, burying these lines underground may represent a crippling capital cost. The Project Team will weigh the benefits and costs of overhead and underground line placement during the next phase of the NY Prize competition.

#### 2.2.13 Black Start Capability

The proposed CHP unit will be equipped with black-start capabilities. If the Mount Kisco grid unexpectedly loses power, the MCS will initiate island mode by orchestrating the predefined black-start sequence. The CHP will require an auxiliary source of DC power to have the ability to start multiple times in case of failure. It will ramp up to 60 hertz (Hz) and prepare to supply each of the microgrid loads in sequence. After the CHP is 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 (EE) is critical to the overall microgrid concept. The Mount Kisco has established an Energy Advisory Panel and a Conservation Advisory Council (CAC) to guide future growth and address current climate concerns, but it has not developed a comprehensive energy plan that will have considerable impact on GHG reductions, energy efficiency, or energy resiliency. However, individual facilities and local government buildings have achieved several meaningful independent energy efficiency upgrades. For example, the New York Power Authority (NYPA) has upgraded street lighting in the Town, the hospital has upgraded lighting to T8 fluorescent lamps and invested in high-efficiency motors for its variable frequency drives, and there are light-emitting diodes (LEDs) across the municipality. The hospital also added natural gas-powered chillers based on an energy study performed in the 1990s. Cogenerated steam from the CHP unit will replace steam from old water tube boilers constructed in the 1970s, further improving the hospital's energy efficiency. The Town is interested in performing an energy audit but has not been able to gather the necessary capital.

#### ***Existing Mount Kisco Energy Efficiency Programs***

The Energy Advisory panel and CAC have recommended the Town pursue certification as a Climate Smart Community, a New York State initiative that helps address ten sustainability focus areas. Two of the top six sustainability focus areas include EE measures, such as adopting a green procurement policy and a green building code for residential or commercial construction.

The Project Team estimates the reduction potential for the four facilities to be approximately 130 kW. The project will incorporate Con Ed EE programs to reduce load at existing facilities and will seek to qualify microgrid facilities for NYSERDA funded EE programs.

Applicable EE programs include:

- Con Ed programs for Small Businesses: Con Ed will perform a free energy survey and will pay for up to 70% of recommended customized EE upgrades. Any small business with central air conditioning is also eligible for the installation of a free smart thermostat. The Mount Kisco Medical Group and Boys and Girls Club may qualify for these programs.
- Con Ed programs for Commercial and Industrial Facilities: Con Ed will pay up to 50% of the cost of an energy survey. These programs also offer equipment upgrade incentives and enhanced incentives for new EE technology. The Northern Westchester Hospital may qualify for these programs.
- NYSERDA Commercial Existing Facilities Program: This program offers facilities two options for participation. Under the pre-qualified path, NYSERDA will compensate participating facilities up to \$60,000 for qualifying retrofits or EE upgrades (such as lighting; commercial refrigeration; heating, ventilation, and air conditioning (HVAC); and gas equipment upgrades). Facilities can also apply for custom incentives under the performance-based path (if a facility wishes to participate in this path, it is crucial to involve NYSERDA early in the planning and development process). The hospital, Medical Group, and Diamond Properties building may qualify for this program.

#### 2.2.15 Cyber Security

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

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, and if the device is ever disconnected, the program will disable that port and prevent an unauthorized device from entering the IT system.

#### 2.2.16 Use of Microgrid Logic Controllers

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

### 2.2.17 Smart Grid Technologies

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

### 2.2.18 Smart Meters

The Town of Mount Kisco does not have smart meters installed throughout its coverage area. While ideal, smart meters are not required for the Mount Kisco 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 for the proposed microgrid.

### 2.2.20 Energy Storage

The Project Team’s analysis of battery storage technologies found their cost to be prohibitively high. Despite this, the MCS will be equipped with the capability to fully utilize and optimize the storage resources—including charging and discharging cycles for peak demand shaving—in case the 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.<sup>19</sup>

### 2.2.21 Active Network Control System

The microgrid will be under continuous and close monitoring and control when it operates in either grid-connected or 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 Con Ed.

### 2.2.22 Demand Response

The MCS has the capability to participate in demand response (DR) programs by increasing generator output or curtailing flexible load on a signal from Con Ed. This gives the Mount Kisco microgrid project the opportunity to participate in Con Ed’s Commercial System Relief Program (CSR) and/or Distribution Load Relief Program (DLRP), which would provide the utility load

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<sup>19</sup> Lazard’s Levelized Cost of Storage Analysis, Version 1.0.

relief during peak demand events. Con Ed provides comparatively lucrative capacity payments to participants that can guarantee load reduction, paying \$10/kW-month and \$6/kW-month in the CSRP and DLRP respectively. Moreover, by enrolling in three consecutive years upfront, the project can qualify for an additional Three Year Incentive Payment.

However, the current design does not include sufficient excess generator capacity to *reliably* participate in DR programs. The microgrid will be capable of *voluntary* participation in Con Ed DR programs, but the payments from these programs will not represent significant sources of revenue compared with payments from the reservation program. The hospital may be able to reduce load during peak demand events by bringing backup diesel generators on-line, but the Project Team was unable to determine whether this is a reliable strategy.

It is unclear whether disconnecting from the larger grid and entering island mode will qualify the microgrid for participation in Con Ed DR programs. Because entering island mode would take both generation and load off the larger grid, the Project Team has assumed that Con Ed will not accept island mode as acceptable load reduction for participation in DR programs.

#### 2.2.23 Clean Power Sources Integration

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

As recommended by Con Ed, the proposed community microgrid is fairly small, with only four facilities and three generation resources. If the microgrid owners negotiate a long-term power purchase agreement (PPA) with Con Ed, the Project Team expects the generators to run continuously throughout the year. In 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 in a unique approach that includes fuel cost, maintenance, and energy cost as part of security constrained optimal power flow (SCOPF).

#### 2.2.25 Storage Optimization

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

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

The microgrid's PV inverters will usually operate at their maximum power point (MPP) because there is no associated O&M cost. In some rare 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 existing solar array at the Boys and Girls Club and the new array at the hospital.

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

#### 2.2.27 Protection Coordination

Microgrid protection strategies can be quite complex depending on the network topology and distribution of load and generation. The existing protection scheme assumes unidirectional power flow of a certain magnitude. The microgrid introduces the possibility of bidirectional power flow in both grid-connected and islanded mode, which may complicate the necessary protection strategy. In later phases of this study, the microgrid designer will perform protection studies that account for possible bidirectional power flows and low fault currents which can occur when the microgrid is operating in island mode.

#### 2.2.28 Selling Energy and Ancillary Services

It is unclear whether the microgrid will be permitted to back-feed through Mount Kisco's main substation into the broader Con Ed transmission system. If allowed, the microgrid will sell excess energy from the solar arrays and CHP unit to Con Ed.

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 3.5 MW CHP unit 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, such as the microgrid's 3.5 MW CHP unit. The Project Team has concluded that the microgrid most likely will not participate in NYISO ancillary service markets unless the CHP unit can be expanded.

Overbuilding the CHP unit could provide microgrid owners with interesting options. The hospital has the capacity to purchase around 150% more steam, and microgrid owners could sell extra electricity capacity into the NYISO frequency regulation or ICAP (installed capacity) energy markets. With one extra MW of electricity 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 Phase II of the NY Prize competition.

#### 2.2.29 Data Logging Features

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

### 2.2.30 Leverage Private Capital

The microgrid project will seek to leverage private capital where possible in order to develop components of the microgrid. The Project Team is in discussions with potential investors, however the investment needs to be balanced against Mount Kisco's ability to provide bond financing up to their existing debt limits. More detail is provided in Section 3.5.2.

### 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 and will continue to engage with all 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 proposed microgrid will provide availability of emergency services and overall community resiliency benefits. 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 Mount Kisco microgrid design includes a 3.5 MW CHP unit, a 200 kW solar PV array at the hospital, and a 50 kW solar PV array at the Boys and Girls Club. This section will discuss the benefits of the proposed resources and how they will meet the microgrid's objectives in greater details.

### 2.3.1 Existing Generation Assets

As outlined above, Mount Kisco's microgrid will incorporate the existing 50 kW solar array at the Boys and Girls Club of Northern Westchester. This asset will operate throughout the year, but it will not reliably provide power during emergency outages due to the intermittent nature of Solar PV generation assets. The design does not currently include any diesel or natural gas-fired backup generators, but the microgrid may expand in the future to include other facilities in Mount Kisco. If these facilities possess backup generators, the option exists to connect these backup generators to the microgrid. Should existing backup generators be connected to the microgrid, they will require grid paralleling switchgear and controllers to regulate and synchronize the generator's output. Any future diesel backup generators added to the microgrid will only be activated in island mode to meet load demand in the event that the CHP unit or PV arrays cannot meet load requirements.

### 2.3.2 Proposed Generation Assets

The microgrid also includes the two new generation assets: a 3.5 MW natural gas-fired continuous duty reciprocating generator with CHP capability and a 200 kW PV array system, shown in Table 4. The CHP system will be located at the Northern Westchester Hospital and will supply 41% of the hospital's annual thermal energy demand through a steam PPA between the

SPV and hospital. Existing natural gas infrastructure in Mount Kisco will support continuous operation of the CHP unit.

Both generators will be located on the hospital’s land—the CHP unit will be located in the hospital’s existing boiler room, and the solar array will be placed on the hospital’s roof. The CHP unit will require approximately 1,500 square feet of space (56 foot x 26 foot), and will fit inside the proposed boiler room.

**Table 4. Proposed Generation Assets**

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

Name	Technology	Rating (kW)	Fuel	Address
<b>DER1</b>	CHP system	3500	Natural Gas	400 Main St
<b>DER2</b>	Solar PV Array	200	Sun Light	400 Main St

2.3.3 Generation Asset Adequacy, Resiliency, and Characteristics

The proposed design provides Mount Kisco with several additional energy resources. In grid-connected mode, the microgrid’s DERs will operate in parallel with the main grid, exporting excess power when generation exceeds demand and importing power from the larger grid to meet peak demand when necessary. In islanded mode, the MCS will first deploy energy from the solar arrays and then regulate output from the CHP unit to meet remaining electricity demand. The CHP unit is sized to meet the entire microgrid load so long as the microgrid’s peak load does not exceed the 2014 peak demand. In general, peak demand is coincident with the peak output of solar units. Therefore, the combination of the CHP unit and the solar arrays should be sufficient to meet peak demand of the microgrid, absent significant load growth.

The CHP unit will be constructed inside the hospital’s existing boiler room, where it will be protected from severe weather events. In addition, the natural gas pipeline is buried to protect it from severe weather.

The proposed CHP unit will be capable of supplying reliable electricity by providing:

- Automatic load following capability – the generator will be able to respond to frequency fluctuations within cycles, allowing the microgrid to balance demand and supply in island mode.
- Black-start capability – the generator will have auxiliary power (batteries) for black starts and can establish island mode grid frequency. After the CHP unit has established stable power flow, the main microgrid controller will synchronize the solar array inverters to match the CHP unit’s frequency and phase.
- Conformance with New York State Interconnection Standards,<sup>20</sup> described in Table 3.

<sup>20</sup> New York State Public Service Commission. *Standardized Interconnection Requirements and Application Process for New Distributed Generators 2 MW or Less Connected in Parallel with Utility Distribution Systems* (2014). Available from [www.dps.ny.gov](http://www.dps.ny.gov).

The New York State Public Service Commission publishes Standardized Interconnection Requirements for distributed generators that are smaller than 2 MW. Although the proposed CHP unit is larger than 2 MW, generators that are close to 2 MW (2-4 MW) still usually follow normal Standardized Interconnection Requirements (SIR). The proposed CHP unit will most likely follow the normal New York State SIR, but there is a possibility that interconnection will instead follow the Federal Energy Regulatory Commission (FERC) guidelines for small generators (2-20 MW).<sup>21</sup> However, the New York State PSC recently proposed modifications to the SIR that would allow generators up to 5 MW to follow the standards listed above. The Project Team expects, by the time of construction, the proposed CHP unit will need to follow the normal New York State SIR.

## 2.4 Load Characterization (Sub Task 2.2)

The Project Team sized proposed DERs according to electricity and steam demand data from Mount Kisco’s load points. The load characterizations below describe the electrical loads served by the microgrid.<sup>22</sup> Descriptions of the load sizes to be served by the microgrid along with redundancy opportunities to account for downtime are included in Section 2.4.1 and the Appendix.

### 2.4.1 Electrical Load

The Project Team evaluated four primary electrical loads for the Mount Kisco microgrid: Northern Westchester Hospital, the Boys and Girls Club of Northern Westchester (hereafter BGC), the Mount Kisco Medical Group (hereafter MKMG), and the Diamond Properties office building at 100 South Bedford Road. The Northern Westchester Hospital Staff Housing facility will only receive steam—this facility is connected to a different Con Ed feeder and does not provide critical or important services to the Mount Kisco community. Proposed facilities are listed in Table 5 and their loads are summarized in Table 6. Typical 24-hour load profiles for each facility can be found in the Appendix. Mount Kisco’s proposed community microgrid will incorporate a hospital, a healthcare facility, a shelter, and an office building, all within close proximity to the primary Con Ed feeders on South Bedford Road and Main Street.

**Table 5. Town of Mount Kisco List of Prospective Microgrid Facilities**

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

	Property	Address	Classification
1	<b>North Westchester Hospital</b>	400 Main St	Hospital
2	<b>Northern Westchester Hospital Staff Housing (Thermal only)</b>	400 Main St	Healthcare
3	<b>Boys and Girls Club</b>	351 E Main St	Shelter
4	<b>Mt Kisco Medical Group (and Pediatrics building)</b>	90-110 S Bedford Rd	Hospital/Healthcare
5	<b>Diamond Properties Office Building</b>	100 S Bedford Rd	Commercial

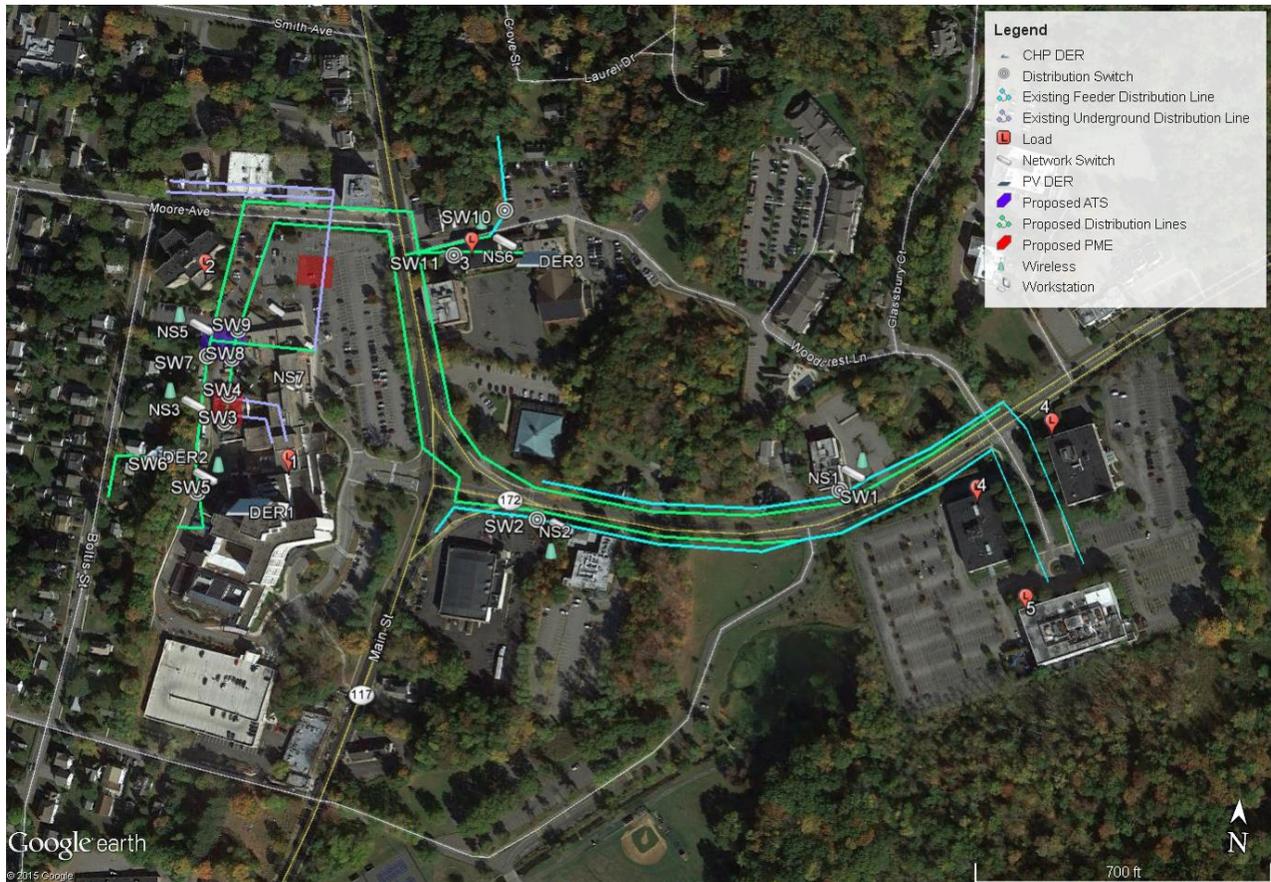
<sup>21</sup> FERC guidelines can be found at: <http://www.ferc.gov/industries/electric/indus-act/gi/small-gen.asp>

<sup>22</sup> Estimated loads are based on metering data from the facility’s account numbers via Con Ed’s on-line metering portal.

After extensive consultation with Con Ed representatives, the Project Team has determined new distribution lines will be necessary to connect microgrid facilities. The design also includes two new automatic transfer switches (ATS) and one new pad mounted equipment (PME) near the hospital. Figure 1 provides an illustration of the proposed microgrid design and layout, including loads, switches, existing electrical infrastructure, and proposed electrical infrastructure.

**Figure 1. Mount Kisco Equipment Layout**

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



Con Ed provided the Project Team with twelve months of metering data for connected facilities (January through December 2014), summarized in Table 6. The aggregate peak load in 2014 was 3.64 MW, and the monthly average was 1.938 MW.

**Table 6. Mount Kisco’s 2014 Microgrid Load Points**

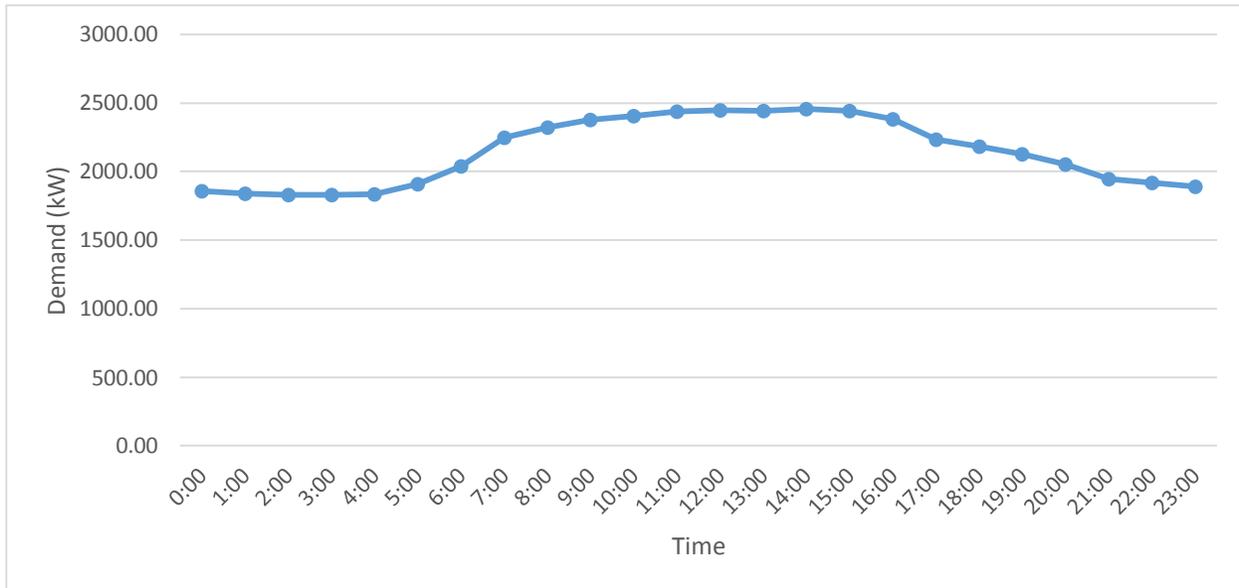
Table shows the microgrid electric demand in kW, electric consumption in kWh, and thermal consumption in MMBTU.

	Electric Demand (kW)		Electric Consumption (kWh)			Thermal Consumption (MMBTU) for Steam		
	2014 Peak	2014 Monthly Average	2014 Annual	2014 Monthly Average	2014 Weekly Average	2014 Annual	2014 Monthly Average	2014 Weekly Average
<b>Microgrid Loads</b>	3,640	1,938	16,987,552	1,415,629	329,216	113,076	9,423	2,191

Figure 2 provides a typical aggregate hourly load profile for Mount Kisco. There is relatively little variance in the facilities’ typical daily load pattern, which slowly increases from the night-time baseline around dawn, peaks in the middle of the day, and decreases back to the night-time baseline from 16:00 to 22:00.

**Figure 2. Typical 24-Hour Cumulative Load Profile from 2014 Metering Data**

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



The proposed 3.5 MW CHP unit, proposed 200 kW PV array, and existing 50 kW PV array will operate continuously in both grid-connected and islanded mode. Although the output of the solar arrays will be variable (due to weather conditions and insolation) throughout the year, they will typically be most productive when facility demand is highest.

When the solar arrays are operating close to their name plate capacity, the microgrid’s generation capacity will approach 3.75 MW, with a guaranteed 3.5 MW from the CHP unit. Aggregate

demand from microgrid facilities averaged 1.938 MW and never exceeded 3.64 MW in 2014.<sup>23</sup> The proposed DERs should therefore have adequate capacity to supply the microgrid facilities with electricity in island mode. However, due to the lack of backup generators the microgrid will rely on grid-supplied power if the CHP unit needs to go offline for maintenance.

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

#### 2.4.2 Thermal Consumption

The CHP unit will provide steam for the Northern Westchester Hospital and Staff Housing facility. The Hospital and Staff Housing facility have relatively consistent steam demand throughout the year, and will offtake 100% of the CHP's steam. The Project Team evaluated thermal energy consumption at the BGC, MKMG, and Diamond Properties office building and found that none have continuous steam demand.

The hospital currently uses a fleet of natural gas boilers to generate steam, and the hospital's FY 2016 thermal energy budget includes 98,350 MMBTUs of natural gas consumption. The proposed CHP unit will produce approximately 40,700 MMBTUs of steam per year, which represents around 41% of the hospital's annual thermal load (there is relatively little seasonality in the hospital's yearly steam consumption). There is an opportunity for increased production and sale of steam should additional electricity generation capacity be required, making the addition of increased CHP capacity a potential future option.

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

The hardware, software, and resources listed in the introduction must be synchronized to achieve the maximum benefits. Optimization challenges generally consist of an objective, constraints, and optimization variables. For the microgrid, the optimization objective is resiliency and cost minimization of the electrical energy supply where the main constraint is the investment cost. The optimization variables associated with this are distributed energy resources and controllable loads.

The optimization is done in two stages, system planning, design stage, and operational stage. During the system planning and design stages, the goal is to identify the largest set of critical loads that can be supplied by an affordable set of generators located strategically throughout the

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<sup>23</sup> This number sums the individual yearly peak demands from connected facilities. It therefore assumes that all facilities reached their peak demands at the same time, which is unlikely. The true peak demand was almost certainly less than 3.640 MW, but the Project Team was unable to obtain synchronized real-time load data for all included facilities.

distribution system. To minimize investment cost generators should also have minimal O&M cost. Optimization should be done over time accounting for different technologies, cost escalations, and load increase and distribution using Optimal Power Flow (OPF) to satisfy operational constraints while minimizing the O&M. The operational, or real time, stage optimization involves stochastic optimal control. The problem is stochastic because of randomly changing load and intermittent renewable energy resources. While the planning stage does not need any communication facilities and does not have to be completed in a certain amount of time, it is critical to include real-time control for reliable and secure communications that produce control signals relatively fast.

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

#### 2.5.1 Grid Parallel Mode

The microgrid will most often operate in grid-connected mode. In this mode, the proposed 3.5 MW CHP unit, proposed 200 kW solar PV array, and existing 50 kW solar PV array will operate continuously, supplying energy to microgrid-connected facilities and, potentially, other loads within the Town of Mount Kisco. The microgrid design does not include diesel backup generators.

If the larger grid experiences an emergency while the microgrid is connected, the parallel mode control scheme allows for the export of a predetermined amount of active and reactive power from microgrid DERs. By injecting power into the larger grid, the microgrid may be able to balance frequency and voltage to avert an outage. If the 3.5 MW CHP unit has sufficient excess capacity, it will ramp up generation as necessary to fulfill the power requirement.

#### 2.5.2 Intentional Islanded Mode

The proposed energy management and control scheme will balance generation with microgrid demand and maintain adequate frequency, voltage, and power flow across the microgrid network in islanded mode (as described in Section 2.7.3). Islanded mode can be intentionally used during forecasted Con Ed grid outages or disturbances to maintain electricity supply for microgrid facilities—the system will manage the generation from the CHP unit and solar arrays to match aggregate demand in real time. Because the output of the solar arrays cannot be controlled and the design does not include natural gas or diesel backup generators, the CHP unit alone will provide flexible real-time response. Refer to the simplified one-line diagram in Figure 3 for a detailed device representation showing both existing and proposed generation assets and their utility interconnection points.

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

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

### 2.6.1 Electrical Infrastructure

The local utility, Con Ed, owns the existing electrical infrastructure in the Town of Mount Kisco. Electricity will enter the microgrid area from the existing Con Ed feeders on Moore Ave. Power will first pass through the proposed PME at the hospital (SW9 on Figure 3), proceed through two proposed switches (SW7 and SW8 on Figure 3), and then continue to the rest of the Con Ed grid. New distribution lines will begin near SW1 and SW2 and will connect these switches (and associated loads) to the PME and ATS at the hospital. The PME and ATS will connect the new lines to the existing buried Con Ed lines that currently serve the hospital. A new medium voltage electric distribution line will connect the Boys and Girls Club to one of the proposed lines. The following tables (Table 7 to Table 9) describe the microgrid components and are referenced throughout the document and in the One Line below.

Automated switching equipment distributed throughout the microgrid will enable different routings of power flows and the isolation/bypass of certain areas as needed. Mount Kisco’s one-line diagram is shown below in Figure 3.

The Con Ed distribution grid in Mount Kisco consists of medium-voltage lines (13.2 kilovolt (kV)). All loads have their own transformers to step incoming power down to low voltage.

**Table 7. Mount Kisco Distributed Switches Description**

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

Name	Description	New/Upgrade
<b>SW1</b>	Automatic switch for feeder isolation	Upgrade
<b>SW2</b>	Automatic switch for feeder isolation	Upgrade
<b>SW3</b>	Automatic switch for load shedding and Microgrid sequence control	New
<b>SW4</b>	Automatic switch for load shedding and Microgrid sequence control	New
<b>SW5</b>	Inverter internal breaker	New
<b>SW6</b>	Generator breaker	New
<b>SW7</b>	Automatic switch for load shedding and Microgrid sequence control	New
<b>SW8</b>	Automatic switch for load shedding and Microgrid sequence control	New
<b>SW9</b>	Automatic switch for load shedding and Microgrid sequence control	New
<b>SW10</b>	Automatic switch for feeder isolation	New
<b>SW11</b>	Inverter internal breaker	Upgrade

**Table 8. Mount Kisco’s Network Switch Description**

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

Name	Description	Status	Address
NS1	Near Switch 1 for communication	Proposed	Refer to Eqp. Layout
NS2	Near Switch 2 for communication	Proposed	Refer to Eqp. Layout
NS3	Near Switch 3 and Switch 4 for communication	Proposed	Refer to Eqp. Layout
NS4	Near DER1 and DER2 for communication	Proposed	Refer to Eqp. Layout
NS5	Near Switches 7, 8, and 9 for communication	Proposed	Refer to Eqp. Layout
NS6	Near DER3 for communication	Proposed	Refer to Eqp. Layout
NS7	Near EMS and workstations for communication	Proposed	Refer to Eqp. Layout

**Table 9. Mount Kisco’s Server Description**

Table describes the workstation and servers, their status as proposed, and their addresses. Because there are no Mount Kisco government buildings included in the microgrid and the ownership structure is uncertain, the Project Team has assumed that the servers will be placed in a safe, enclosed building on hospital land. The placement of the microgrid servers and workstation may change as the ownership structure is decided.

Name	Description	Status	Address
Workstation	Operator/Engineer workstation	Proposed	400 Main St
Server1	Primary EMS and SCADA	Proposed	400 Main St
Server2	Secondary EMS and SCADA	Proposed	400 Main St

**Figure 3. Mount Kisco One-Line Diagram**

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

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2.6.2 Points of Interconnection and Additional Investments in Utility Infrastructure

The proposed components and interconnection points for the Mount Kisco community microgrid are listed in Table 10. The PCC between the main grid and the microgrid will be located at the hospital PME (SW9 in Figure 3).

The microgrid will rely on automated isolation switches across the feeders to segment loads, which is required for precise microgrid control and reliability. This segmentation is critical to provide voltage and frequency control within the millisecond response intervals required for maintaining a stable microgrid and serving multiple, non-contiguous loads using distributed generators.

**Table 10. List of Components**

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

Device	Quantity	Purpose/Functionality
<b>Microgrid Control System Protocol Converter (Siemens SICAM PAS or equivalent)</b>	1 Primary 1 Back-up	Protocol Converter responsible for operating the microgrid’s field devices via protocol IEC-61850.
<b>Microgrid Control Center (Siemens MGMS or equivalent)</b>	1	Provides data trending, forecasting, and advanced control of generation, loads and SCADA interface, interface to NYISO for potential economic dispatch.
<b>Automated Pole Mount Circuit Breaker/Switch (Siemens 7SC80 relay or equivalent)</b>	2	Upgraded breakers/switches at 2 distribution overhead switches. Isolate feeders from Microgrid
<b>Automated Underground Circuit Breaker/Switch (Siemens 7SJ85 relay or equivalent, multi module control)</b>	2	New multi module relays at Pad Mounted/underground distribution switches. One relay can protect and control multiple switches/breakers at each PME. Isolates the downstream loads and generation from the Microgrid
<b>Generation Controls (OEM CAT, Cummins, etc.)</b>	1	Serves as the primary resource for coordinating the paralleling load matching of spinning generation.
<b>PV Inverter Controller (OEM Fronius or equivalent)</b>	2	Controls PV output and sends data to main microgrid controller for forecasting.
<b>Network Switch (RuggedCom or equivalent)</b>	7	Located at IEDs and controllers for network connection, allowing remote monitoring and control.

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

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

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

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

#### 2.6.4 Thermal Infrastructure

The proposed CHP unit requires a steady supply of natural gas to operate. At a minimum, the CHP unit will require 3-5 pounds per square inch gauge (psig) pressure at its intake. The existing 6 inch high-pressure natural gas pipe at the hospital will provide adequate fuel volume and pressure (at least 40 psig) throughout the year.

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

This section provides a more detailed description of the microgrid's modes of operation. The microgrid control system (MCS) will include an EMS and a SCADA based control center (see Figure 4), hereafter collectively referred to as the main microgrid controller. Distributed intelligent electronic devices (IEDs) will communicate with the main microgrid controller over the local Transmission Control Protocol/Internet Protocol (TCP/IP) network. In grid-parallel mode, the microgrid will synchronize frequency and voltage magnitude with the larger grid and will have the potential to export excess electricity to Con Ed. 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 2.7.4) 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 Con Ed grid (described in Section 2.7.5).

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

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

- SOA software platform – The SOA platform facilitates the monitoring and control of included power devices and control systems.
- Redundant Array of Independent Disks (RAID) 5 servers (including 1 primary, 1 backup) for the MCS – The MCS will include an EMS and a SCADA based control center, and will optimize the operation of the microgrid. This includes determining which critical loads will be supplied, integrating PV output into the energy portfolio (including high resolution solar forecasting), and controlling the charge/discharge of energy storage wherever applicable. The system combines information on power quality, utilization, and capacity in real time, which allows the community and control algorithms to balance electricity supply with microgrid demand.
- Historian database server – Historian database collects and logs data from various devices on the network.
- Applications server (one or more) – Depending on the software and hardware vendors' preference, application servers may be used for numerous purposes. Common uses for an

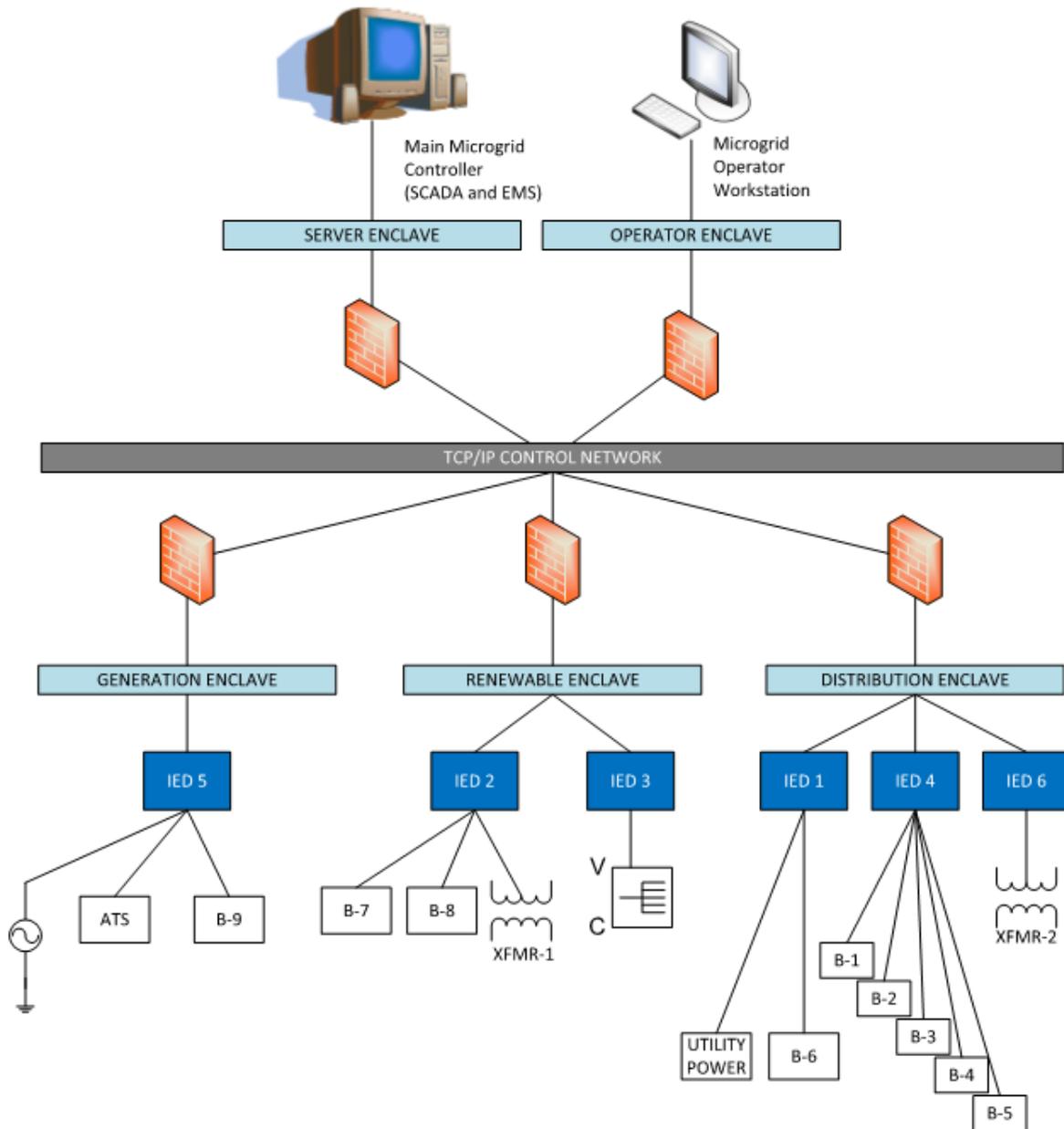
application server include, but are not limited to, backup and recovery, antivirus, security updates, databases, a web server, or use as some other software depending on how the SCADA and EMS vendors configure their platform.

- Operator workstations for SCADA and EMS – Workstation computers, sometimes called thin-clients, allow operators to view real-time data and control the microgrid from the SCADA control room or a remote location. Users must have proper access rights and permissions to operate workstation computers.
- Intelligent Electronic Device distribution switches: Automated pole mount circuit breaker/switch (Siemens 7SC80 relay or equivalent) – The microprocessor based logic controllers in the field (also referred to as IEDs) are programmed to act on predetermined set points. They can also be manually overridden by the MCS or a human operator. The control system host servers continuously poll these logic controllers for data using discrete or analog signals. Resulting data is processed by the IEDs connected to control elements.
- Pad Mount Equipment (PME) (Siemens 7SJ85 multi breaker control relay or equivalent) – The PME, which includes two switches and two fuses, is updated via remote control relay.
- Automatic Transfer Switch (Siemens 7SJ85 multi breaker control relay or equivalent) – The ATS is capable of current sensing and multi breaker control and is equipped with remote control relay. Programmed logic will control switching to an available hot feeder, with one designated as the preferred feeder. Current sensing on both feeders facilitates the initiation of emergency island mode.
- PV Inverter Controller (OEM Fronius or equivalent) – This component will control PV output and send data to the MCS for forecasting.

Use of the listed hardware, software, and resources must be synchronized to maintain stable and reliable operation. There are three main categories of microgrid control systems: fully centralized control, fully decentralized control, and hierarchical control. Hierarchical control, which is the most common approach, consists of a central controller that communicates generation or demand set points to distributed controllers. The central controller and the local generation and demand controllers operate on different time scales—the central controller usually computes the set points on a minute scale whereas local generation and demand controllers operate on millisecond or faster scales. The inherent fast dynamics and switching transients in an islanded microgrid make the microgrid system prone to instability—microgrid control systems are similar to transmission control systems, but they lack the system-wide mechanical and electrical inertia that can filter out fast dynamics. The Project Team has concluded that a hierarchical control system is the most appropriate approach for the Mount Kisco microgrid.

**Figure 4. Diagram of Representative Microgrid Control System Hierarchy**

The following network diagram illustrates a conceptual microgrid control network with a generator, breakers, transformers, an ATS, IEDs (which could be actuators, Meters, Accumulators, or Programmable Logic Controllers), a renewable energy source, and the Main Microgrid Controller with SCADA and Energy Management System (EMS) server and client workstation node.



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.

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

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

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 CHP unit is capable of providing ancillary services to Con Ed's grid to enhance the reliability of the system. It can provide reactive power and frequency response services on demand, but providing reactive power support may diminish the rotating generator's ability to generate real power.

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

### 2.7.3 Islanded Mode Control

The transition to island mode can be either unintentional or intentional. Unintentional islanding is essentially the main microgrid controller's programmed response to an outage at the level of the distribution or transmission system. An outage at the distribution system level can occur within or outside the microgrid, and the microgrid islanding scheme must be able to handle either situation. MCS relays at the PCC will recognize low voltage, and the appropriate switches will open automatically (disconnecting the microgrid from the larger grid). Any existing on-line generation will be isolated and ramped down via generation breakers. All microgrid loads and distribution switches will then be switched open via designated circuit breakers and relays to prepare for local generation startup. Using the CHP unit's black-start capabilities, the MCS will

commence island mode operation. The main generator will ramp up to 60 Hz and prepare to supply each of the microgrid loads in sequence. After the CHP unit is on-line and power flow through the microgrid is stable, the main microgrid controller will synchronize output from the solar arrays (voltage and frequency) and bring them on-line. In steady state, their phases will be different, just as they are during grid-connected steady state operation.

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

- The Con Ed grid has an expected outage that could potentially affect transmission power to Mount Kisco substations.
- The Con Ed grid needs to perform network maintenance work, thereby isolating loads in the Mount Kisco area.
- The Con Ed grid anticipates a certain level of hot pockets at the Mount Kisco substations.

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.

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

### **Energy Management in Islanded Mode**

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. The CHP unit is currently the microgrid's only connected spinning generator, but the microgrid may expand in the future to include backup generators or new generators.
- Generators that trip off unexpectedly during microgrid operation.
- Switchgear that fails to operate.
- Switchgear that fails to report status.

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

#### 2.7.4 Black Start

The proposed CHP unit will be equipped with black start capabilities. If the Mount Kisco grid unexpectedly loses power, the main microgrid controller will initiate island mode by orchestrating the predefined black start sequence (see Appendix). The microgrid then begins the unintentional transition to island mode. A DC auxiliary support system is an essential part of the CHP unit's black start capabilities. The battery system must have enough power to start the generator multiple times in case it fails to start the first time.

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

1. PCC breaker opens.
2. All active generation is disconnected.
3. The main microgrid controller waits a pre-set amount of time (approximately 30 seconds) in case Con Ed 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 based on the available generation and a predetermined load priority order.

The MCS will manage any contingencies that arise during the black-start operation (e.g., breakers do not respond to trip commands and the microgrid does not properly disconnect from the larger grid). Lower priority loads will be energized only if sufficient capacity can be guaranteed. If the CHP unit does not start as expected during a utility outage, the MCS is equipped with contingency algorithms to appropriately manage the situation. If possible, the main microgrid controller will still isolate the microgrid, but only critical loads will be satisfied.

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

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

#### 2.7.5 Resynchronization to Con Ed Power

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

While operating in island mode, the system will constantly monitor the status of the utility feeder at the PCC and determine when appropriate levels of current and voltage have been restored. When power is restored, the main microgrid controller will disconnect the solar arrays and synchronize output from the CHP unit with the utility service through the utility circuit breaker. Before the microgrid system starts paralleling with the utility, it will balance local generation and load so as not to exceed either minimum or maximum export limits or time durations set forth in the utility interconnection agreement. When microgrid power flow has been synchronized to the larger grid, the main microgrid controller will bring the solar arrays back on-line.

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

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

The existing information technology (IT) and telecommunication infrastructure at Mount Kisco 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 Hospital, 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 as discussed in Section 2.7.4. 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](#)

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

### [2.8.2 IT Infrastructure and Microgrid Integration](#)

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

### 2.8.3 Network Resiliency

The data transmitted throughout the proposed Mount Kisco microgrid will be encrypted, but several additional intrusion protection measures can easily be implemented. One simple and inexpensive method is to disable any 65,535 TCP ports not being used to make the microgrid system work. Depending on final configuration, only a few TCP ports will need to be active. More TCP ports will need to be active if the available enterprise-level or remote monitoring outside Mount Kisco's private domain will be utilized.

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

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.

Because the logic controllers will be located at or near loads, the distributed equipment will take the IT system to the "edge" of the Mount Kisco 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 Mount Kisco network. Every network attached device has a unique, unchanging media access control 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.

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

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

### **Conclusions**

In conclusion, the project is technically feasible. However, two significant items remain in order for Mount Kisco's microgrid to become a reality. First, the utility (Con Ed) needs to cooperate with the proposed interconnection and electrical distribution, and the Northern Westchester Hospital needs to agree to host the proposed CHP and new solar array. However, the hospital has considerable incentive to support the project because the CHP would provide cheap thermal energy and would reduce the use of existing natural gas boilers. While a firm contractual

commitment awaits further discussion and negotiations, they have expressed a strong interest in the project. Second, generation assets and microgrid components must be available for maintenance at all times. The team is working with the facilities to ensure that they will allow a third party to service the generation assets and microgrid components located on their land. The Project Team expects these operational challenges to be resolved by the time of construction.

The microgrid design proposes two new medium-voltage lines that will connect the hospital to the Boys and Girls Club, the Mount Kisco Medical Group, and the Diamond Properties office building at 100 South Bedford Road. Existing natural gas and thermal infrastructure in the Town will support continuous operation of the CHP unit, but the hospital may have to extend steam piping (depending on the CHP unit's final location).

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

Preliminary analyses indicate that by selling electricity at Con Ed's average supply price and steam at the average price for natural gas-generated steam per million British Thermal Units (MMBTU), private investors will realize a positive return on investment from the CHP system. Even higher returns could be realized if the project were to sell power directly to the facilities under a long-term PPA.

This feasibility study does not consider the possibility of Con Ed 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. However, the overall project return may be slightly negative without NYSERDA NY Prize Phase III funding because the design requires approximately 5,500 feet of new distribution lines. Additional incentives will provide critical support to the project. As of this writing the NYSERDA CHP Performance and NY Sun Programs exist and if they are still offered at the time of construction SPV investors would be eligible for approximately \$2 million in incentives from the Program, \$560,000 from the Federal Investment Tax Credit (ITC),<sup>24</sup> and \$105,000 from the NY Sun Program.

An alternative operating regime would be to treat the entire microgrid as a single, behind-the-meter entity at all times. Operating the microgrid as a behind-the-meter entity would improve project economics and provide expanded opportunities for DR and load support that are not available revenue streams in the model that is currently proposed. This operational structure would require the consent and support of Con Ed, as they would be losing significant loads from their system, and is not considered in the revenues and costs presented in this deliverable. Please see Section 3.1.5 for further explanation of the demand response considerations and Section 3.2.1 for an expanded discussion of the business model concepts.

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<sup>24</sup> 10% of the installed cost of the CHP and 30% of the installed cost of the solar array; <http://energy.gov/savings/business-energy-investment-tax-credit-itc>

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

The Mount Kisco microgrid will include five facilities: Northern Westchester Hospital, the staff housing facility at the hospital, the Boys & Girls Club of Northern Westchester (hereafter BGC), Mount Kisco Medical Group (hereafter MKMG), and Diamond Properties. One SPV will own and operate the CHP and microgrid components/control infrastructure and the hospital will own the PV array. It is assumed that private investors and Mount Kisco will purchase shares in the SPV. Con Ed will contribute useful expertise to the day-to-day operation of the microgrid if they elect to be the operator, otherwise a third party operator will work in close cooperation with the utility to operate the system on a daily basis. Private investors and Mount Kisco will provide the majority of the capital outlay required for this project.

The hospital will provide critical services (as defined by NYSERDA) to the Town during emergency situations. Although the remaining facilities do not provide critical services, they can serve as shelters during emergencies, and the MKMG can provide additional healthcare services. None of the proposed facilities that will be connected to the microgrid currently own available backup generators, so the CHP and solar arrays will serve as the primary power sources for all five facilities during an outage. The hospital has extensive diesel backup, however emergency code dictates that it cannot be intertied with the microgrid. The design requires extensive new lines, but there is minimal need for new steam infrastructure because the CHP system will be located on-site at the hospital. The project will affect several groups of stakeholders in the Mount Kisco community that are not physically connected to the microgrid; the benefits and challenges to these stakeholders are discussed further in this section.

#### 3.1.1 Microgrid Customers and Investors

Two generators will provide power to the Mount Kisco microgrid: a 3.5 MW natural gas-fired CHP system and a 200 kW solar array. The microgrid will enter island mode when it detects an outage or disturbance on the larger Con Ed system. The microgrid will also have the technical ability to enter island mode for economic reasons (to participate in DR programs), but is unlikely to do so regularly. See Section 3.5 for further discussion. In their day-to-day operations, most of the connected facilities serve the Mount Kisco community, and will make their services available to a larger group of stakeholders during emergency situation.

The Table 11 below identifies each of the direct microgrid customers and the scenarios during which they will purchase electricity and steam from the microgrid.

**Table 11. 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
Northern Westchester Hospital	400 Main St	Healthcare	Yes	Yes	Both
Hospital Staff Housing	400 Main St	Healthcare	No	No	Both
Boys & Girls Club	351 Main St	Commercial	No	No	Both
Mount Kisco Medical Group	90 S Bedford Rd	Healthcare	No	No	Both
Diamond Properties	100 S Bedford Rd	Commercial	No	No	Both

Cash flows from electricity and thermal energy sales will consistently cover variable costs and yield positive operating revenues. The NYSERDA CHP Performance Program if offered in the future could offset approximately 40% of the capital cost of the CHP system, while together the Federal ITC and NY Sun Program could recover around 60% of the capital cost of the solar array. However, the project requires considerable investment in new distribution lines (around 5,500 feet), which will cost \$330,000 for overhead lines.<sup>25</sup> Assuming the availability of these current incentives and rebates, the project is net positive. However, should the project not receive the aforementioned rebates, the project will rely on NYSERDA NY Prize Phase III funding in order to be a reliable investment for the Town and private investors.

3.1.2 Benefits and Costs to Other Stakeholders

Prospective stakeholders in the Mount Kisco microgrid extend beyond direct investors and facilities to include other Con Ed customers, existing generation asset owners, and residents of the areas surrounding Mount Kisco. Direct benefits will accrue to the Town, 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.

During an emergency power outage, the microgrid will maintain power to a hospital, medical center, and the Boys & Girls Club, all of which are accessible and available to residents both inside and outside the Town. The hospital and medical center will provide healthcare and shelter to residents of the Town and surrounding communities in the event of a long-term grid outage, while the BGC can provide shelter and basic life support (water, heat, first aid, etc.).

New distributed energy resource assets will defer steam boiler investments for the hospital. The CHP system’s cogenerated thermal energy (approximately 2900 MMBTU per month) will replace steam produced by existing natural gas-fired boilers at the hospital and will render the Hospital’s upcoming investments in new boilers unnecessary. The CHP system and the solar arrays together possess a maximum generation capacity of 3.7 MW, which is 3.5 MW of

<sup>25</sup> \$540/ft for underground lines—Travers Dennis, Con Ed.

continuous load reduction for the larger Con Ed grid from the CHP during both peak demand events and normal periods of operation and 200 kW of variable support from the PV array.

Although no facilities currently possess backup generators that will be incorporated into the microgrid's DER mix, interconnecting backup generators will be possible in the future. The hospital does possess significant diesel backup generation, however it cannot be tied into the microgrid as it is required to remain directly connected to the hospital for emergency situations.

### 3.1.3 Purchasing Relationship

The SPV will own the CHP and microgrid infrastructure (including control equipment, distributed intelligent electronic devices, and new distribution lines). Long-term ownership of the CHP will remain with the SPV as it drives the value proposition of the project and any lease to own arrangement with the hospital may negatively affect the overall project economics.

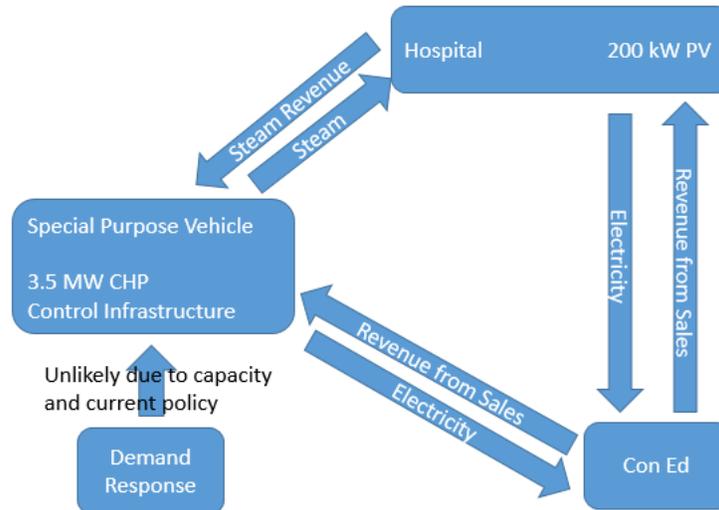
The hospital will own and operate the PV. If serving in an operational capacity, Con Ed will leverage its energy domain expertise to operate and maintain the microgrid components and controls. The SPV owners will sell electricity from the CHP system to Con Ed under a buy-back agreement or other long-term power purchase agreement; solar energy will be valued at the average commercial rate according to a net metering agreement between the hospital and Con Ed. Depending on the local demand for electricity and baseline generator output, the CHP system may be able to sell ancillary services on the NYISO frequency regulation or reserve markets. However, the minimum required capacity for participation in most NYISO ancillary service markets is 1 MW, which represents approximately 30% of the generator's maximum output. The Project Team expects minimal participation in NYISO ancillary service markets, as programs that require less than 1 MW of capacity (such as spinning and non-spinning reserves) do not provide competitive payments to participants. Reserving capacity for participation is not economical, as steam and electricity sales provide more value to the project than do intermittent ancillary service payments. Solar energy produced by the proposed arrays will be valued at the local commercial rate pursuant to a net metering agreement with Con Ed.<sup>26</sup> Figure 5 and Figure 6 provide visual representation of the purchasing relationship during normal and islanded operations.

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<sup>26</sup> This electricity is valued at the local commercial retail rate.

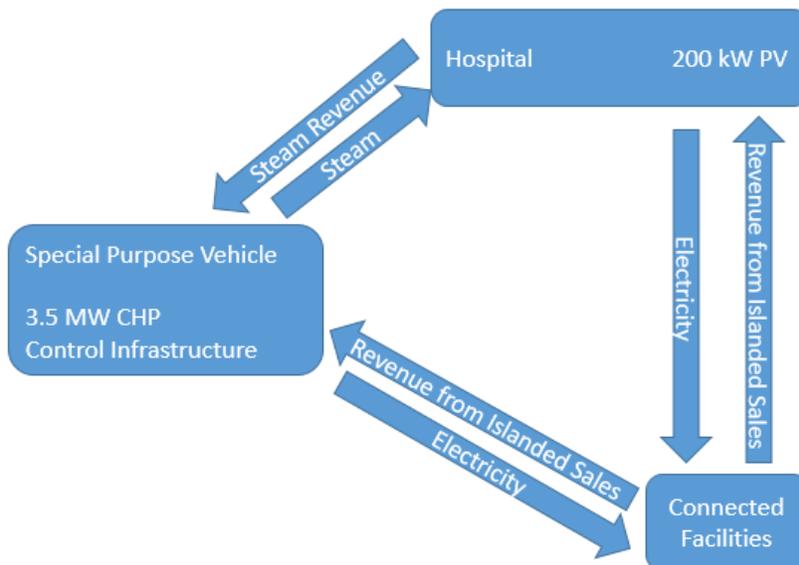
**Figure 5. Normal Operation Purchasing Relationship**

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



**Figure 6. Islanded Operation Purchasing Relationship**

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



3.1.4 Solicitation and Registration

The Town and utility will work with identified facilities 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 completed by the Project Team and virtually 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 Con Ed will follow existing contractual and purchase relationships. Electricity sales from proposed generation assets will follow a new buy-back 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 and thermal energy, and they may produce extra revenue from participation in ancillary service or DR programs.

Proposed generation assets include a 3.5 MW natural gas-fired CHP system and a 200 kW solar PV array, plus the existing 50 kW PV array at the Boys and Girls Club. Together these DERs will provide up to 3.75 MW of electricity for the microgrid and the larger Mount Kisco community. Con Ed will distribute the purchased electricity in load agnostic fashion across its grid.

The CHP system will sell approximately 2,900 MMBTU of steam to the hospital every month. This supply of cogenerated steam will replace the thermal energy currently produced by on-site natural gas-fired boilers and will render some future investments in replacement boilers unnecessary for the hospital. Cogenerated steam will replace a future capital investment of around \$40,000.<sup>27</sup> However, the CHP will not provide enough thermal energy for all of the Hospital's demand. Limited operation of existing natural gas boilers will continue as needed.

Although the CHP system will not have sufficient capacity available to participate in most NYISO ancillary services markets, as discussed above, the microgrid may be able to participate in Con Ed DR programs by entering island mode during peak demand events.

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

The microgrid will provide value to the Mount Kisco, private investors, Con Ed, direct participants, and the larger State of New York. The proposed CHP system and solar array will reduce the Town's reliance on higher-emission peaking assets during peak demand events 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.

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<sup>27</sup> \$40,000 = ~2500 MMBTU/month \* \$17/MMBTU/month. Estimate of \$17 MMBTU/month pro-rated from commercially available Weil-McLain EG Steam Boiler.

### 3.2.1 Business Model

Mount Kisco is well positioned to adopt an ownership model that couples the CHP and microgrid infrastructure into the SPV, along with hospital ownership of the co-located PV. Revenue streams from electricity and thermal energy sales will accrue to SPV investors and will cover variable generation costs. Private investors will likely finance this project with a mixture of outside debt and equity. Pending required approvals, the Town of Mount Kisco may issue bonds to raise capital, and the Town should qualify for a relatively low interest rate on issued debt given its high credit rating (Section 3.5.2). In Mount Kisco, the SPV ownership model provides the greatest benefits to the utility and customer base within the Town, ensuring that revenues and costs are relatively in balance.

Given the capital expenditures required for the CHP and microgrid infrastructure, private investors are expected to own the majority of the SPV. As an entity with considerable utility expertise, it is proposed Con Ed will either retain responsibility for the day-to-day operation of the microgrid or work closely with a third party operator for enhanced system transparency. Finally, as a municipal entity with a good credit rating, the Town of Mount Kisco will provide relatively inexpensive capital to supplement initial capital expenditures for DERs and microgrid equipment. Because the Town is not expected to own a majority share in the SPV, it is exposed to relatively low risk.

Table 12 below provides an overview of the Mount Kisco microgrid project, including an analysis of project strengths, weaknesses, opportunities, and threats (SWOT).

**Table 12. Mount Kisco Microgrid SWOT**

Table includes a discussion of the Strengths, Weaknesses, Opportunities, and Threats (SWOT) associated with the Mount Kisco microgrid project.

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Evenly distributes cost burden so no single actor is responsible for the full project cost</li> <li>• Provides value to investors by selling electricity at the local utility supply charge and thermal energy at a competitive rate</li> <li>• Qualifies for several existing incentive programs, such as the NYSERDA CHP Performance Program, Federal ITC, and NY Sun Program</li> <li>• Connects a full-service hospital to emergency power, maintaining community access to life-saving equipment and services during emergency outages</li> <li>• Aligns interests of the Town (and community), Con Ed, connected facilities, and private investors in seeing the microgrid succeed</li> <li>• Leverages Con Ed’s expertise to facilitate load aggregation, following, voltage regulation, and other necessary daily operations</li> <li>• Solar array can participate in a Con Ed net metering program wherein its electricity is credited at the retail rather than wholesale rate</li> </ul>	<ul style="list-style-type: none"> <li>• Overhead distribution lines will cost approximately \$350,000. New lines are required due to the structure of Con Ed feeders</li> <li>• Project ROI depends on the capital cost of microgrid infrastructure and may need NY Prize Phase III funding to make a positive net present value (NPV) business case</li> <li>• Long-term purchase agreements between DER owners and Con Ed are required to ensure value for DER investors. These are assumed but not guaranteed</li> <li>• No backup generators will be connected to the microgrid</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Serves as a replicable template (most NY communities are served by IOUs) and encourages coordination between local government, private investors, and utility</li> <li>• Experiments with new methods of rate calculation, with the opportunity to revolutionize the role of utilities in electricity generation, distribution, and consumption in New York State</li> <li>• Demonstrates the feasibility of reducing load on the larger grid with distributed energy resources</li> <li>• Expands the microgrid to include nearby critical and important facilities</li> <li>• Potential for Qualifying Facility designation and operation under novel business model (see section 3.2.5 for detailed discussion)</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in regulatory requirements could impact the proposed business model and stakeholder goals—for example, if utilities are permitted to own generation assets in the future, Con Ed may wish to purchase a larger stake in DERs</li> <li>• If natural gas prices increase, it will significantly raise the microgrid’s marginal cost of producing electricity, which may prompt a re-negotiation of Con Ed’s purchasing price</li> <li>• Incentives such as the Federal Business Investment Tax Credit and CHP Performance Program may expire or exhaust funding</li> </ul>

While there are several valuable strengths and opportunities associated with the single ownership model, there are also weaknesses and threats that must be addressed. These weaknesses are discussed below.

- **Financial** – DER owners will seek a long-term PPA, or some other form of long-term custom purchase agreement, with Con Ed or directly with the facilities, to guarantee steady future revenue streams. If the microgrid sells power to Con Ed, the utility will likely negotiate for a custom procurement model based on fuel source, generator location,

and generator size. As long as the agreement reliably guarantees fair compensation for generator output over the project lifespan, DER owners must be content with flexible compensation rates and low levels of risk. Second, although electricity and thermal energy sales will recover initial investments in DERs, they may not recover the entirety of infrastructure capital costs. This weakness is offset by NY Prize Phase III funding. If received, NY Prize funding makes the project a more financially attractive investment. Finally, the current design does not include backup generators to be incorporated into the microgrid. The aggregate peak demand from connected facilities was approximately 2.9 MW in 2014. With a reliable 3.5 MW of electricity from the CHP system and a potential 250 kW of supplemental energy from the two solar arrays, the proposed electricity supply should be sufficient for the microgrid's energy needs. However, if aggregate electricity demand grows in future years, the facilities may have to invest in backup generators, small-scale DR programs, or energy efficiency upgrades to ensure a reliable power supply.

- **Regulatory** – Utilities in New York State cannot own generation assets unless they can demonstrate why full vertical integration provides value to their customers. The State of New York wishes to avoid monopolies that could raise electricity prices without a corresponding improvement in service. However, this regulatory landscape may change as the state transitions from large power plants distributing electricity over an unwieldy macrogrid to distributed energy resources assets connected to smart microgrids. If the regulatory landscape shifts, utilities may wish to own their own distributed energy resource assets in the future.

Further, current State, NYISO, and utility incentives, such as DR, do not anticipate nor are they currently structured to incentive microgrids. For instance, current Con Ed DR programs are lucrative; if the Mount Kisco microgrid qualified it could receive more than \$300,000 per year in DR payments for removing loads. However, as discussed above, islanding the microgrid to shed the loads also sheds generation and provides no net benefit to Con Ed or NYISO, so this revenue is not currently included in calculations. Moving forward, regulatory policy should address the treatment of microgrids in DR programs, as policies do not account for the particulars of microgrid operation.

- **Incentives** – The commercial viability of the Mount Kisco microgrid currently depends on the NYSERDA CHP Performance Program and the Federal ITC, which together offset around 50% of initial investment costs. These programs are both slated to expire on December 30, 2016, and the CHP Performance Program may exhaust available funds before then. Within the NY Prize timeline, microgrid construction is unlikely to be complete by the end of 2016, so the project depends on the renewal of these incentive programs their replacement by similar programs. If neither program is available at the time of construction, the project may still be commercially feasible with NYSERDA NY Prize Phase III funding.

### 3.2.2 Replicability and Scalability

The Mount Kisco 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 Con Ed 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.* The proposed business model does not present a barrier to project replicability, but the reliance on incentive programs for commercial viability limits the specific replicability of this design (the CHP Performance Program has limited funding, for instance). See Section 3.5.1 for details.

Because most municipalities in NY State follow an electricity model wherein the local IOU distributes power purchased from large generation assets, this project's organizational structure as proposed is easily replicable. Further, the Project Team believes that the Mount Kisco microgrid may petition for a declaratory ruling as a Qualifying Facility, which will improve operational flexibility and open the project to potentially more lucrative economic arrangements (see Section 3.2.5 for further discussion). The combined benefits of inexpensive capital from municipalities and local expertise from the utility will promote close cooperation between previously separated stakeholders and encourage the adoption of the single ownership model. The project's replicability expands the potential market for resulting innovations to include a large part of New York State. As such, this project presents a valuable opportunity for NYSERDA to examine the changing role of the IOU in energy generation and distribution.

*Scalability.* The microgrid is scalable, however given that it connects several feeders, increasing the footprint requires a more complex understanding than simply adding intermediate facilities along the relevant feeder lines. The Mount Kisco microgrid does not rely on AMI meters to remotely disconnect loads that fall within the utility line breakers, meaning that any expansion will have to either consider the physical realities of partitioning new power lines from the larger grid or introduce AMI remote disconnect capability to all loads between utility line breakers. Additionally, because the proposed generation assets will operate at nearly full capacity throughout the year and there are no backup generators included in the design, new generation assets are a prerequisite to expanding the microgrid in the future. Expansion provides an opportunity to add more critical facilities to the microgrid, including a nearby gas station, pharmacy, and additional medical facilities.

### 3.2.3 Benefits, Costs and Value

The microgrid will provide both direct and indirect benefits to a wide range of stakeholders (as described in Section 3.2.3). 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, customers will see stabilized electricity prices (from reduced demand and the concomitant reduced congestion costs to Con Ed when prices on the spot market are high), and the community will have access to healthcare and shelter during emergency grid outages. Preliminary analysis indicates cash flows from electricity sales, steam sales, and incentive programs will cover variable generation costs. However, depending on final infrastructure costs, project cash flows may not fully recover initial investment costs. In this case, the project’s commercial feasibility will depend on NY Prize Phase III funding. Projected costs and benefits are discussed in Table 13 through Table 18.

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. Table 13 below provides an overview of the benefits and costs to members of the SPVs, direct microgrid customers, citizens of Mount Kisco and surrounding municipalities, and the State of New York.

**Table 13. Benefits, Costs, and Value Proposition to SPV Owners**

Table describes the benefits, costs, and value proposition to SPV owners.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<p><b>SPV investors</b></p>	<ul style="list-style-type: none"> <li>- Investors will receive cash flows from electricity and steam sales from the CHP system</li> <li>- NYSERDA CHP Performance Program will offset ~40% of the cost of the CHP system</li> <li>- Entering island mode during peak demand events could qualify the microgrid for lucrative Con Ed DR programs. However, Con Ed is unlikely to accept “islanding” as eligible load reduction</li> <li>- NY Prize Phase III funding could recover up to \$5 MM of initial project costs</li> </ul>	<ul style="list-style-type: none"> <li>- Initial capital outlay for DERs will be significant. The 3 MW CHP will cost approximately \$4.8 MM<sup>28</sup></li> <li>- Initial capital outlay for infrastructure may have a drastic impact on commercial feasibility</li> <li>- Ongoing maintenance of DERs</li> </ul>	<ul style="list-style-type: none"> <li>- Baseline operation of CHP unit provides breakeven cash flows. These cash flows may be supplemented by strategic participation in DR programs and/or ancillary services markets</li> <li>- Improved energy resilience and reduced reliance on high-emission peaking assets make the Mount Kisco microgrid an attractive investment to the Town, private investors, and utility</li> <li>- CHP Performance Rebate will offset up to \$2.2 MM in capital costs</li> <li>- Inclusion in the microgrid should provide generation asset owners with a reliable energy market for excess generation</li> </ul>

<sup>28</sup> CHP Capital Cost: Pro-rated from Siemens estimate for 2.5 MW CHP  
 Solar array Capital Cost: Pro-rated from Siemens estimate for 2 MW Solar PV

**Table 14. Benefits, Costs, and Value Proposition to Consolidated Edison, Inc.**

Table describes the benefits, costs, and value proposition to Con Ed.

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

**Table 15. Benefits, Costs, and Value Proposition to the Town of Mount Kisco**

Table describes the benefits, costs, and value proposition to Mount Kisco.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>Town of Mount Kisco</b>	<ul style="list-style-type: none"> <li>- The microgrid will provide a resilient and redundant energy supply to critical services</li> <li>- Meet NY state energy goals by encouraging DER construction and improving energy resilience</li> <li>- In the future, municipal government facilities could be connected to the microgrid</li> <li>- Further integration as a smart community</li> <li>- Reduced emissions during peak demand events</li> </ul>	<ul style="list-style-type: none"> <li>- When the microgrid enters island mode due to a larger grid outage, customers will pay a slightly higher price for electricity than they would for electricity from the larger grid. This cost is offset by enhanced reliability and power quality</li> </ul>	<ul style="list-style-type: none"> <li>- Critical and important services will keep the lights on during outages, allowing the Town of Mount Kisco to be a point of relief for local citizens and surrounding areas</li> <li>- The microgrid project will serve as a catalyst for customers becoming more engaged in energy service opportunities and will inspire residential investment in DER assets, such as solar PV and battery storage, as citizens see benefits associated with avoiding peak demand hours, producing enough electricity to be independent from the larger grid, and selling electricity in a local market</li> <li>- Generating electricity with solar PV arrays and a natural gas-fired CHP system will offset high-emission peaking assets during peak demand events</li> </ul>

**Table 16. Benefits, Costs, and Value Proposition to Connected Facilities**

Table describes the benefits, costs, and value proposition to connected facilities.

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>Connected Facilities</b>	<ul style="list-style-type: none"> <li>- Resilient and redundant energy supply to operations—power outages cost commercial and residential customers ~\$40-60/kWh and ~\$5-8/kWh, respectively<sup>29</sup></li> <li>- Access to a local market for distributed energy generation makes investments in small DERs more attractive to connected facilities</li> </ul>	<ul style="list-style-type: none"> <li>- Slightly higher electricity prices during island mode</li> <li>- Connection fees as part of connecting to the microgrid</li> </ul>	<ul style="list-style-type: none"> <li>- Maintain operations during emergency outages and provide valuable critical services to the Mount Kisco community</li> <li>- Potential for partnerships and a local market for excess generation will encourage industrial stakeholders to build large-scale generation assets</li> <li>- Local market for excess energy makes investments in small DERs (such as solar panels) profitable for connected facilities</li> <li>- The hospital will purchase steam from the CHP at a competitive market rate; this thermal energy supply makes the upcoming replacement of natural gas boilers unnecessary (replacements could cost the hospital upwards of \$40,000)</li> </ul>

**Table 17. Benefits, Costs, and Value Proposition to the Larger Community**

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

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
<b>Community at Large</b>	<ul style="list-style-type: none"> <li>- Access to a wide range of critical and important services during grid outages</li> <li>- Potential for inclusion if the microgrid footprint expands in the future</li> </ul>	<ul style="list-style-type: none"> <li>- Because the larger community will not be connected to the microgrid, this stakeholder group will not bear any significant costs</li> </ul>	<ul style="list-style-type: none"> <li>- Inclusion of critical and publically accessible medical facilities and shelter for times of emergency</li> <li>- Future expansion of the microgrid could bring more facilities into the design; however, the Town of Mount Kisco will likely need to install widespread advanced metering infrastructure (AMI) to make this feasible</li> </ul>

<sup>29</sup> PG&E; cited from <http://www3.epa.gov/chp/basic/benefits.html>

**Table 18. Benefits, Costs, and Value Proposition to New York State**

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

Beneficiary	Description of Benefits	Description of Costs	Value Proposition
New York State	<ul style="list-style-type: none"> <li>- DER assets will offset high-emission peaking assets during peak demand events</li> <li>- Cash flows will provide tangible evidence of microgrid project’s commercial viability</li> <li>- Indirect benefits (such as outages averted) will demonstrate the benefits of microgrids paired with DER assets to citizens across the state and reduce load on the larger grid</li> <li>- Each microgrid accelerates NY state’s transition from old macrogrid technology to newer, smarter, smaller technologies</li> </ul>	<ul style="list-style-type: none"> <li>- Depending on financing plans, the growth of microgrid popularity, and increased use of natural gas-fired generators, the state may need to develop additional plans for expanding natural gas infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>- By reducing peak load on the larger grid, every microgrid’s DER assets will reduce the state’s use of coal-fired and oil-fired plants during peak demand events, thus reducing GHG emissions and achieving NY State energy goals</li> <li>- Successful construction and operation of a microgrid will demonstrate the tangible value of microgrid projects as investments</li> <li>- Indirect benefits associated with microgrids will encourage and inspire citizens to strive for DERs in their own communities</li> </ul>

3.2.4 Demonstration of State Policy

The proposed microgrid coordinates with REV by providing a utility-maintained power distribution platform for locally owned DER assets. The ownership model has the potential to be extremely successful by leveraging outside capital as well as local utility expertise and is highly replicable. This project could therefore serve as a valuable example of an innovative, profitable relationship between IOUs, municipalities, and private investors.

The CHP generator will rarely have sufficient standby generating capacity available to participate in DR programs. As discussed in Section 3.5.1, disconnecting the entire microgrid during peak events is unlikely to qualify for Con Ed DR programs. However, the Project Team believes there is an opportunity for NYSERDA to work with the NY PSC to help provide clarity to the DSPs as to providing DR programs specific to community microgrids that will monetize the value of reducing system-level congestion at peak times. Additionally, 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.

The microgrid presents an excellent opportunity to further expand future renewable energy generation and immediately improve the town’s resilience to extreme weather events. Paired with energy efficiency programs, generation assets in Mount Kisco could shave a substantial electricity load from the larger grid during peak demand events when congestion costs are highest.

Distributed renewable generation assets greatly improve resilience and reliability of local energy supply in extreme weather situations, and encourages citizens within the community to invest in local energy generation and distribution. Coupled with the community’s investments in LEDs and other energy efficiency measures, Mount Kisco’s microgrid and DER assets will immediately reduce the town’s reliance on high-emission peaking assets during peak demand events and provide a platform for expanding the town’s clean DERs capability in the future.

### 3.2.5 REV Concordance

The Project Team believes that the proposed Mount Kisco microgrid will be eligible as a Qualifying Facility (QF) as described under Public Service Law §§ 2(2-d), and could operate a “behind-the-meter” project that is in line with the long term intent of the REV proceedings. Slight changes to existing Qualifying Facility designations will greatly help achieve a “grid of grids” concept in the future. While many microgrids, including Mount Kisco, may already be eligible for QF designation, uncertainty about any given project’s regulatory disposition drives up costs. The team believes energy costs in New York State, and the current condition of the electricity infrastructure in the State, are ripe for an economically efficient expansion of a system of microgrids, however they remain an elusive proposition without alterations in policy that formally and proactively promote favorable regulation of community microgrids.

Further, investor owned utilities (IOUs) are not currently incentivized to allow large swaths of their customer base to move off of their network. The facilities included in the microgrid proposal represent hundreds of thousands of dollars in transmission and distribution charges to Con Ed each year above and beyond the cost of the electricity itself. At a state level, this could easily sum to many millions of dollars of revenue not earned by IOUs. Nevertheless, behind the meter operation would improve the operation of the NYISO system by optimizing load and generation matching and, if implemented at a large scale, significantly reduce congestion on major transmission infrastructure. As more microgrids populate the region, Con Ed is well positioned to serve as the distributed system platform in its service territory to integrate multiple microgrids, aggregate excess generation capacity, and redistribute services to voltage or watt deficient microgrids, municipal grids, and load pockets. With a critical mass of microgrids or other individually managed load pockets, investor owned utilities will be needed to constantly manage and balance the grid and will yield income on wheeling and the transactions necessary to facilitate such operation. Thus, more clearly articulated regulations will help the propagation of community microgrids while providing a role for utilities in ongoing management of this fundamentally new system of electricity management.

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

The Project Team includes Con Ed, the local Mount Kisco 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 steam demand and discuss other aspects of the project development. The Project Team has also spoken to additional medical facilities that may be interested in joining the project.

3.3.2 Project Team

The Mount Kisco microgrid project is a collaboration between the public sector, led by the Town of Mount Kisco, and the private sector, led by Con Ed 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 the Town of Mount Kisco has strong interest in improving its energy reliability and expanding its clean energy generation capacity. Tables 19 and 20 below provide information about the Project Team.

**Table 19. Project Team**

Table provides background on Booz Allen Hamilton, Siemens AG, Power Analytics, and Con Ed.

<b>Booz Allen Hamilton</b>	<b>Headquarters: McLean, VA</b>	<b>Annual Revenue: \$5.5 B</b>	<b>Employees: 22,700</b>
<b>History and Product Portfolio:</b> Booz Allen was founded in 1914. In the ten decades since its founding, Booz Allen has assisted a broad spectrum of government, industry, and not-for-profit clients including the American Red Cross, all branches of the Department of Defense, the Chrysler Corporation, NASA, and the Internal Revenue Service. Booz Allen’s energy business includes helping clients analyze and understand their energy use and develop energy strategies, recommending technology solutions to achieve their energy goals, and executing both self- and 3 <sup>rd</sup> party funded projects including energy efficiency, renewable energy, and smart grids.			
<b>Siemens AG</b>	<b>Headquarters: Munich, Germany; U.S. Headquarters: Washington, DC</b>	<b>Annual Revenue: €71.9 B</b>	<b>Employees: 343,000</b>
<b>History and Product Portfolio:</b> Siemens AG was founded in 1847 and is now one of the world’s largest technology companies. Siemens AG specializes in electronics and electrical engineering, operating in the industry, energy, healthcare, infrastructure, and cities sectors. Siemens AG develops and manufactures products, designs and installs complex systems and projects, and tailors a wide range of solutions for individual requirements. The Siemens Microgrid Team develops comprehensive solutions leveraging the strength of Siemens’ portfolio – from generation sources such as gas, wind, and solar, to transmission & distribution products, to control software solutions and services.			
<b>Power Analytics</b>	<b>Headquarters: San Diego, CA</b>	<b>Annual Revenue: \$10-15M</b>	<b>Employees: 50</b>
<b>History and Product Portfolio:</b> Founded 25 years ago, Power Analytics is a privately-held small business that develops and supports electrical power system design, simulation, and analytics software. The Company’s worldwide operations include sales, distribution, and support offices located throughout North America, South America, Europe, Asia, and Africa and Australia.			
<b>Consolidated Edison, Inc.</b>	<b>Headquarters: New York, NY</b>	<b>Annual Revenue: \$13 B</b>	<b>Employees: 14,500</b>
<b>History and Product Portfolio:</b> For more than 180 years, Consolidated Edison has served the world’s most dynamic and demanding marketplace—metropolitan New York. Con Ed provides electric service to approximately 3.3 million customers and gas service to approximately 1.1 million customers in New York City and Westchester County. The company also provides steam service in certain parts of Manhattan. Con Ed receives yearly operating revenues of approximately \$13 BN and owns assets totaling approximately \$44 BN.			

**Table 20. Project Team Roles and Responsibilities**

Table outlines the 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
<b>Consolidated Edison, Inc.</b>	The utility’s expertise will be essential in planning microgrid construction, and the utility should commit to assisting ongoing operation and maintenance of the microgrid.	Con Ed will provide a share of the initial capital outlay that corresponds to whichever hardware and software requirements will be required by the utility.	Con Ed may help operate and maintain 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. Con Ed may also purchase electricity from the CHP system and distribute it to customers in Mount Kisco.
<b>Town of Mount Kisco</b>	The Town may purchase minority shares in the SPV. It will serve as the main conduit to representatives of the critical and important facilities and other interests in the Town. This effort is spearheaded by the Town Mayor, who is responsible for local outreach.	As the liaison, the Town will coordinate with all local and state parties as needed. The Town will also provide a share of the capital outlay that corresponds to its ownership of the SPV.	As the liaison, the Town will coordinate with all local, regional, and state parties as required. The Town will also provide a share of necessary services and capital to maintain the microgrid that correspond with its ownership share of the SPV.
<b>Booz Allen</b>	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.
<b>Siemens</b>	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.
<b>Power Analytics</b>	Power Analytics is the partner for energy software solutions. The PA team, in conjunction with Siemens and Booz Allen, is responsible for the design of the SCADA and system software components and controls.	Power Analytics will lead the installation of control and energy management software following hardware installation and in concert with Siemens.	Provide IT systems support; may play an active role in system management through the EnergyNet software platform.

Team Member	Roles and Responsibilities		
	Project Development	Construction	Operation
<b>Suppliers</b>	There are no suppliers required during this development phase, however project partners and suppliers Siemens and Power Analytics are closely involved in feasibility and design portions of the project. BAH is in touch with several additional suppliers of hardware and software including Duke Energy, Con Ed Solutions, Enel Green Power, Anbaric Transmission, Bloom, and Energize.	Siemens or another engineering and technology firm will be the hardware supplier, including switches and other physical controls. Power Analytics or another software company will be the EMS and SCADA provider, responsible for software and server components.	The installer of the hardware and software will continue to provide maintenance and advisory services as require to ensure proper and efficient functioning of their components. The software provider will work in cooperation with Con Ed to assess the best approach to daily operations of the software system.
<b>Financiers/Investors</b>	Outside finance advisors will be leveraged to assist the potential Mount Kisco bond offering and creation of the Special Purpose Vehicle. The SPV will be created during the project development phase. Investors will provide capital for stakes in the SPV. Investors may include any of the entities mentioned in the row above as well as private investors not mentioned as part of the Project Team.	Outside financial advisors will be retained to assist the bond offering and drawdown of funds. Debt and equity investors will supply the cash required to complete the construction and installation of generation assets and microgrid controls.	Outside financial advisors will be retained to assist with any issues in bond repayment that may arise. Generation asset owners will realize revenues from the sale of electricity and thermal resources. Microgrid system owners will realize revenues from the microgrid tariff, and Con Ed may realize T&D depending on final financial agreements.
<b>Legal/Regulatory Advisors</b>	Legal and regulatory advice is housed both within Booz Allen and through project partner Pace Climate and Energy Center. 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, Con Ed, and any investor counsel required.	Legal and regulatory will be the responsibility of the Town, the utility, and any investors in the Special Purpose Vehicle

3.3.3 Financial Strength

The principal shareholders in the microgrid project are the DER owners (private investors) and the Town of Mount Kisco. Private investors that do not publish financial statements are not discussed in this section.

Moody’s Investor Service gave the Town of Mount Kisco’s \$9.9 million general obligation bonds (sold in July 2015) a long-term credit rating of Aa2 (its third highest ranking) and has published a positive opinion on the City’s future credit outlook. An obligation rated as “Aa” indicates that the obligation is “judged to be of high quality and [is] subject to very low credit risk”. Moody’s credit rating reflects the Town’s moderately-sized tax base, above-average wealth levels, ample reserve position, and manageable debt burden. The Town will therefore

qualify for relatively low interest rates should it choose to finance the microgrid project with debt.

### **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 Supervisory Control and Data Acquisition (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 Operation

Investor owned utilities generally prefer to operate systems integrated into their existing infrastructure. Con Ed, as the project operator, would ease the transition of the system between island and grid parallel mode. However, absent direct Con Ed operational control of the microgrid, competitive energy services firms such as Con Ed Solutions or Constellation can also provide this service in collaboration with Con Ed. All SPV investors will contribute funds to operate and maintain microgrid infrastructure and generation assets. All members of the SPV will be responsible for the continued and successful operation of the component pieces of the grid, including software, switches, servers, generation, and meters, but they will have ongoing assistance from the Booz Allen Team. 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. For more information on how the system will operate see Section 2.5.

Con Ed will purchase electricity from the SPV and distribute this energy across their grid. The facilities will continue to be billed for electricity via the regular Con Ed billing mechanism and cycle. Con Ed's revenue should be sufficient to cover the supply cost of electricity (from the DERs) as well as Con Ed-imposed delivery and capacity charges. Additional fees may be imposed upon microgrid participants as a percentage of their tariff. 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, this will be no more than 1% of the connection tariff.

#### 3.4.2 Barriers to Completion

The barriers to constructing and operating the microgrid are primarily financial. The high capital costs and relatively long payback make the investment a difficult one—new distribution lines alone could cost up to \$3 million (if they are placed underground). Assuming the DERs will sell electricity to Con Ed at their current supply charge, the microgrid will produce positive net

income from year to year. However, after discounting future cash flows, annual net income does not provide sufficient revenue for a stand-alone positive NPV business case.<sup>30</sup>

### 3.4.3 Permitting

The Mount Kisco microgrid may require certain permits and permissions depending on the ultimate design choices. Distributed energy resource assets will require zoning variances or approvals as accessory uses because they are currently not permitted on hospital property (see section 3.6 for more details). Mount Kisco is not in any EPA criteria pollutant nonattainment zones; however, the CHP unit will require air quality permits pursuant to the Clean Air Act.

## 3.5 Financial Viability (Sub Task 3.5)

The distributed energy resource assets included in the microgrid design will produce revenue streams from electricity sales to Con Ed under buy-back tariff agreements (or other custom procurement models), thermal energy sales to the hospital, and net metered credits from the PV. These assets will require significant initial capital outlay as well as annual operation and maintenance costs. The Project Team expects that microgrid infrastructure in Mount Kisco will require considerable investment and will play a major role in final project NPV. The entire SPV will qualify for the NYSERDA CHP Performance Program and the NY Sun Program, while only the SPV's private investors will qualify for the Federal ITC unless the tax equity is sold (the Town is not eligible for this incentive). The Town of Mount Kisco may issue municipal bonds to finance its relatively minor share in proposed DERs and microgrid infrastructure, pending any approval process within the municipality. 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 21. The revenues will sum to approximately \$2.4 million per year, which will exceed the yearly generation costs (estimated to be around \$1.9 million per year). If new distribution lines must be buried underground, the commercial viability of the Mount Kisco microgrid project will depend heavily on NY Prize Phase III funding. See Table 21 for the savings and revenues and Table 22 for the capital and operating costs.

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<sup>30</sup> The Booz Allen Team forecasts the break-even sales price of electricity to be ~\$0.102/kWh when new distribution lines are installed underground and ~\$0.089/kWh when new lines are installed overhead. These forecasts do not include NY Prize Phase III funding or revenue from participation in Con Ed Demand Response programs. NY Prize Phase III funding would recover capital costs and upgrade the project to a net-positive financial investment.

**Table 21. Savings and Revenues**

Table describes expected revenues & savings directly associated with operation of the microgrid and its DER assets.

Description of Savings and Revenues	Savings or Revenue	Relative Magnitude	Fixed or variable
Electricity sales from 3.5 MW CHP system during grid connected mode <sup>31</sup>	Revenue	~\$1,900,000/yr	Variable
Steam sales from 3.5 MW CHP system	Revenue	~\$530,000/yr	Variable
Electricity value from 200 kW solar PV array (Net Metering) during G-C mode	Savings	~\$28,000/yr	Variable
<b>Total Revenue</b>		<b>\$2.4 MM/yr</b>	Variable

**Table 22. Capital and Operating Costs**

Table describes the expected costs from construction and operation of the microgrid.

Description of Costs	CapEx or OpEx	Relative Magnitude	Fixed or Variable
3.5 MW CHP system	Capital	~\$5,600,000	Fixed
200 kW Solar PV array	Capital	~\$350,000	Fixed
Microgrid Control Systems	Capital	~\$350,000	Fixed
Distributed Equipment	Capital	~\$45,000	Fixed
IT Equipment (Wireless stations and cabling)	Capital	~\$60,000	Fixed
New distribution lines <sup>32</sup>	Capital	\$330,000 (overhead) \$3 MM (underground)	Fixed
<b>Total CapEx</b>		<b>\$6.7 MM (overhead wires)</b>	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
<b>Total Planning and Design</b>		<b>\$1,000,000</b>	Fixed
3.5 MW CHP System Fuel	Operating	~\$1,660,000/yr	Variable
3.5 MW CHP System Maintenance	Operating	~\$260,000/yr	Variable
125 kW Solar PV Maintenance	Operating	~\$4,000/yr	Fixed
<b>Total OpEx</b>		<b>\$1.9 MM/yr</b>	Variable

The proposed microgrid will qualify for three incentive programs: the Federal ITC, NYSERDA CHP Performance Program, and NY Sun Program. The ITC and CHP Rebate are set to expire at the end of 2016; without these, the project will be financially challenged. Together the programs will recover around 50% of the total DER capital cost (although only private investors are

<sup>31</sup> The Booz Allen Team calculated Con Ed's supply charge for electricity to be approximately \$0.0729/kWh in Zone I (Dunwoodie). This is the assumed price for grid-connected sales from the CHP system.

<sup>32</sup> Based on per foot new line construction costs from Con Ed for overhead and underground.

eligible for the Federal ITC). 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) and capacity payments for participation in Con Ed DR programs. See Table 23 for a list of available incentive programs.

The microgrid could also theoretically enter island mode when electricity prices on the spot market rise above the DERs’ marginal cost of producing electricity. Con Ed offers several flexible billing plans that could accommodate this capability. For example, “business customers” are eligible for hourly pricing. Under this billing plan, the hourly price of electricity follows the NYISO-regulated wholesale market for electricity (specifically the hourly Location Based Marginal Price, or LBMP). Under the “voluntary time-of-use” billing plan, customers pay different rates during peak and off-peak hours—peak hour prices during the summer months can rise as high as \$0.1899/kWh.<sup>33</sup> By subscribing to this program and entering island mode during peak summer month hours, microgrid-connected facilities could save more than 50% on electricity bills. However, participation in these programs requires coordination and agreement from all microgrid-connected facilities (the system cannot partially enter island mode), and it is unclear how rate manipulation would affect the price Con Ed will pay for CHP-generated electricity. These uncertainties prevented the Project Team from including potential savings in the feasibility study.

**Table 23. 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	Preferred
NYSERDA NY Prize Phase III	~\$5,000,000	Preferred (required if lines must be buried)
NYSERDA CHP Performance Program	~\$2,200,000	Preferred
NY Sun Program	~\$105,000	Preferred
Federal ITC (for CHP)	~\$560,000	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 community and outside financing providing the required 25% cost share. The Town of Mount Kisco 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

<sup>33</sup> <http://www.ConEd.com/customercentral/energyresvoluntary.asp>

information from the PSC, and firm financing for the construction of the project (described below).

The various investors will leverage Phase III funding from NYSERDA to complete the construction phase and will supplement with capital from any municipal bonds, long-term debt, and private equity. Phase III NY Prize funding, which will provide up to \$5 million for the purchase and installation of microgrid and DER equipment, will cover 50% of the total capital.<sup>34</sup> The balance of capital financing will come from third party sources.

Pending required approvals, the Town of Mount Kisco is willing to consider the issuance of municipal bonds to finance their relatively minor share in the project. Issues to be addressed during the negotiations related to the bond terms are:

- 1) Limits of the basic security
- 2) Flow-of-funds structure
- 3) Rate (or user-charge) covenant
- 4) Priority of revenue claims
- 5) Additional-bonds tests
- 6) Other relevant covenants

The bonds would be backed by the Town's share of revenues generated during the operation of the microgrid. Financing obligations will depend on the Town's share in the various DERs and infrastructure, the amount of NYSERDA NY Prize funding received, and the magnitude of future operation and maintenance costs. Specific market conditions at the time of issuance will determine the interest rate and repayment schedule. Generation will be sited on hospital land.

The operational phase will be characterized by positive revenue streams and a gradual pay-down of principal and interest. Structured as a typical infrastructure project, the microgrid revenue model will be built for a 20-year period (mirroring the expected lifespan of microgrid infrastructure and generation assets). The project is expected to generate sufficient cash flows to cover debt service payments and maintenance costs of microgrid infrastructure and generation assets.

### **3.6 Legal Viability (Sub Task 3.6)**

Like any infrastructure project that involves the development of public and private land, the Mount Kisco 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 Ownership and Access**

Legal considerations will include access limitations, franchising, zoning, and permitting. A single SPV, plus the hospital, will own and operate proposed DERs and microgrid infrastructure.

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<sup>34</sup> Total capital costs are \$6.2 MM including overhead lines.

Microgrid equipment will be installed on town-owned land, while generators will be installed at the hospital. Property rights and access limitations will not be a concern for microgrid infrastructure, but the hospital may need to address these issues for both the CHP system and solar array. The data network that supports the microgrid logic units and controllers is owned by the Town of Mount Kisco—access to this network will not represent a significant barrier to project completion.

### 3.6.2 Regulatory Considerations

#### *State and Utility Regulation*

The SPV should be exempt from being treated as an electric corporation if it meets the criteria for a “qualifying facility” under the terms of PSL §2. To be considered a qualifying facility, a microgrid must utilize qualifying forms of generation (co-generation, hydroelectric power, or alternative energy including solar), include no more than 80 MW of generation capability, serve a qualifying number of users, and connect facilities that are located “at or near” generating facilities. The Mount Kisco microgrid will include one 200 kW solar PV array and one 3.5 MW CHP, will not generate more than 80 MW of power, and will connect facilities located near generators.<sup>35</sup> So long as the microgrid owners petition the PSC for a declaratory ruling that the proposed users (connected facilities) do not run counter to the PSC’s interpretation of PSL §2, the Project Team expects that the microgrid infrastructure SPV will meet the “qualifying facility” criteria and thus would be exempt from burdensome PSC regulation.<sup>36</sup>

#### *Local Regulation*

All entities that require the use of public ways (i.e., for transmission or distribution facilities) must be granted permission by the presiding municipal authority in the form of a franchise or some lesser consent, depending on the scope of the usage. The cities, towns, and villages of New York have specific statutory authority to grant franchises. As provided by N.Y. Vil. Law § 4-412, every Village Board of Trustees is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city.<sup>37</sup> “Use” encompasses occupying public rights-of-way and operation of the provider’s built infrastructure to provide the public service.<sup>38</sup>

Electric generation is not currently a permitted use in any of the relevant zoning districts in Mount Kisco (hospital, recreation, and general office), and siting the CHP would require either an exemption as an accessory use or a zoning variance. The authority for each resides with the Town Zoning Board of Appeals; however, there is no clear path to either an accessory use determination or a zoning variance. If electric generation were added as a specially permitted use

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<sup>35</sup> The test for “near” has been held by the PSC to be approximately two miles. This project proposes generation and loads approximately 1/3 mile apart, well within two miles.

<sup>36</sup> Burrstone provides precedent for such a ruling.

<sup>37</sup> N.Y. Vil. Law § 4-412.

<sup>38</sup> See, e.g., “Contract of April 7, 1887 between Hess et al. Commissioners & Consolidated Telegraph & Electrical Subway Co.” (Con Tel and Electrical Subway Company Agreements 1886-1891.pdf).

in each of the districts in which microgrid customers have been proposed, it would create a regulatory path forward while allowing the Zoning Board of Appeals to maintain some essential controls over the character and uses of affected neighborhoods.

### *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 CHP system in Mount Kisco 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.

New York state has enacted amendments to Environmental Conservation Law Articles 19 (Air Pollution Control) and 70 (Uniform Procedures), and DEC amended regulations 6NYCRR Parts, per the 1990 Amendments to the Clean Air Act. With this demonstration of authority, DEC received delegation of the Title V operating permit program from the US Environmental Protection Agency (EPA). Title V Permits are required for all facilities with air emissions greater than major stationary source thresholds. New York's air pollution control permitting program combines the federal air operating permitting program with long-standing features of the state program.

The primary rules for applications are found in 6NYCRR:

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

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

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

The microgrid project will include five facilities from the Town of Mount Kisco: Northern Westchester Hospital, the Northern Westchester Hospital Staff Housing facility, the Mount

Kisco Medical Group, the Boys & Girls Club of Northern Westchester, and Diamond Properties. Of these facilities, the hospital is considered a critical facility (as defined by NYSERDA). The project will follow an ownership model wherein a Special Purpose Vehicle (SPV) owns the CHP and microgrid infrastructure and the hospital owns the PV. Private investors and the Town may purchase shares in this SPV. The SPV will effectively tie the project's costs and benefits into one value stream, but it risks being considered an "electric corporation" under NY PSC law. However, as discussed in Section 3.2.5, the microgrid meets several of the PSC's exemption criteria and therefore could be treated as a Qualifying Facility. This section further describes policy recommendations that may smooth the process of Qualifying Facility designation and the promotion of REV.

The proposed microgrid's commercial feasibility may depend on NY Prize Phase III funding. Its design includes two new DERs to be located at the Hospital: a 3.5 MW CHP system and a 200 kW solar array. The Project Team forecasts yearly revenues of approximately \$2.4 million from the generators, which should reliably cover yearly generator operation and maintenance costs (forecasted to be approximately \$1.9 million per year). However, new distribution lines could add up to \$3 million to total initial capital costs. Revenue from generator operation will not be sufficient to cover this elevated capital cost, so the project may require extra subsidies (i.e., NYSERDA NY Prize funding) to fully recover initial investment costs.

In addition to revenues from electricity sales, the microgrid will provide indirect financial and non-financial benefits to Mount Kisco citizens, SPV shareholders, Con Ed, and the larger Westchester 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 Mount Kisco, providing citizens with access to pharmacies, gas, and groceries in outage situations.

Permitting and regulatory challenges should be reasonably straightforward, although the hospital will need to seek zoning variances or accessory use determinations in order to install the CHP system and solar PV array. The primary regulatory hurdles will be obtaining permits for the CHP system under the Clean Air Act and obtaining zoning permission for the siting of the generation.

The estimates and value propositions in this document are predicated on several assumptions. First, investors must have sufficient interest in the microgrid project to provide capital for construction of the DERs and microgrid infrastructure, and the operator will facilitate smooth day-to-day operations of the microgrid by purchasing a minority share in the SPV. Second, the solar array will value electricity at the average local commercial retail rate through a Net Metering Agreement with Con Ed. Finally, Con Ed will purchase electricity generated by the CHP system at the utility's average supply price of electricity.

## 4. Cost Benefit Analysis

To achieve the next step of the feasibility study, the Project Team has carefully assembled the necessary data to perform an independent cost-benefit analysis of the microgrid project. Much of the data used for this analysis comes from concrete cost, load, and other relevant data; the Project Team addressed any data gaps by using estimates from similar projects or industry standards.

This deliverable is made up of seven sections in addition to the introduction and conclusion:

- **Section 1** analyzes the *facilities connected to the microgrid* and their energy needs.
- **Section 2** discusses the *attributes of existing and proposed distributed energy resources*, including factors such as nameplate capacity and expected annual energy production.
- **Section 3**, analyzes *potential ancillary services sales and the value of deferring transmission capacity investments*.
- **Section 4** reviews the *overall costs* associated with construction and installation of the microgrid as well as the fuel, operation, and maintenance costs required over the lifetime of the microgrid.
- **Sections 5 and 6** discuss the *community benefits* of maintaining power during a grid-wide outage and outline the costs associated with operating the microgrid in island mode.
- **Section 7** presents the Industrial Economics *benefit-cost analysis report and associated Project Team commentary*.

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

The Mount Kisco microgrid will include five facilities from various rate classes and economic sectors. NYSERDA designates three primary rate classes based on type of facility and annual electricity consumption: residential, small commercial (less than 50 MWh per year), and large commercial (greater than 50 MWh per year). See Table 24 for basic statistics on each facility's energy usage. All three of the proposed microgrid facilities belong to the large commercial rate class requiring approximately 16,987 MWh of electricity per year. Additionally the average aggregate demand in 2014 was 1.938 MW and rose as high as 3.64 MW.

There are three kinds of facilities in the microgrid: health, recreational, commercial. The health facilities represent the largest electricity loads with Northern Westchester Hospital and Mount Kisco Medical Group comprising 80% and 10% of the microgrid's total annual electricity usage, respectively. The recreation facility is the Boys and Girls Club of Northern Westchester which consumes approximately 3.5% of the microgrid's total annual usage. The commercial facility is a Diamond Properties office building that consumes approximately 6.5% of the microgrid's total annual usage.

The combination of existing and proposed generation assets included in the microgrid design will be capable of meeting 100% of average aggregate facility energy usage during a major power outage, but may approach their generation limits if several large facilities simultaneously reach peak energy use. Some of the facilities do not operate 24 hours a day, such as the Boys and

Girls Club and the Diamond Properties office building, and will only operate 18 hours per day during grid-connected mode. However some critical facilities that normally operate less than 24 hours per day may need to operate continuously in emergency island-mode situations. For example, Boys and Girls Club normally requires electricity for lighting, electrical appliances, and heating/cooling during the daytime hours, but could serve as a community shelter in emergencies. This will extend its electricity usage window from 18 hours per day to 24 hours per day. For information on each facility's average daily operation during a major power outage, see Table 24.

**Table 24. Facility and Customer Detail Benefit<sup>39</sup>**

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

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<sup>39</sup> Load data was provided to Booz Allen by Con Ed.

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

The microgrid design incorporates distributed energy resources, including one existing solar PV array, one proposed CHP unit, and one proposed solar PV array. The proposed CHP unit and combine solar PV arrays will produce an average of 2.575 MW of electricity throughout the year.<sup>40</sup>

The CHP system has a nameplate capacity of 3.5 MW and will operate nearly continuously. Assuming a capacity factor of 85%, the CHP unit will produce approximately 26,061 megawatt hours (MWh) of electricity over the course of the year. If a major power outage occurs, the CHP unit will produce an average of 71.4 MWh of electricity per day, which would provide over 100% of the microgrid's average daily demand. Assuming a heat rate of 9.5 MMBTU per MWh,<sup>41</sup> the CHP unit will incur a fuel cost of approximately \$53/MWh.<sup>42</sup>

Limited by weather conditions, natural day-night cycles, and assuming a capacity factor of 14% the 0.2 MW and 0.05 MW solar PV arrays are expected to produce a combined 306 MWh per year. Because many outages are caused by severe weather events, solar panels cannot be relied upon to provide energy during emergency outages without supplementary battery storage. However, on average, the solar arrays will produce a combined 0.838 MWh of electricity per day, which represents approximately 2% of average daily electricity demand. Maintenance costs for the solar array will be around \$5,000 per year,<sup>43</sup> which means the marginal cost of producing solar electricity will be about \$34/MWh.<sup>44</sup>

See Table 25 for a detailed list of all proposed and existing distributed energy resources in Mount Kisco.

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<sup>40</sup> **NG generator capacity factor:** 85% (EPA estimate for 10 MW generator, <http://www3.epa.gov/chp/documents/faq.pdf>)

**Solar array capacity factor:** 14% (NREL PV Watts Calculator)

<sup>41</sup> 2013 EIA average for natural gas fired Gas Turbine ([http://www.eia.gov/electricity/annual/html/epa\\_08\\_02.html](http://www.eia.gov/electricity/annual/html/epa_08_02.html))

<sup>42</sup> **Price of natural gas:** \$5.74 per Mcf (average CHGE supply price from 2013-2015)

<sup>43</sup> **Annual fixed O&M cost:** \$20/kW per year (NREL, [http://www.nrel.gov/analysis/tech\\_lcoe\\_re\\_cost\\_est.html](http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html))

<sup>44</sup> **Capital cost:** \$2,400/kw (Siemens estimate)

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

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

**Table 25. Distributed Energy Resources**

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

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Expected Daily Production During Major Power Outage (MWh)	Potential Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
							System fuel	Units of MMBTUs
DER1 - CHP System	Northern Westchester Hospital	Natural Gas	3.5	26,061	71.4	84	9.26 Mcf	9.5 MMBTUs
DER2 - Solar PV Array	Northern Westchester Hospital	Sunlight	0.2	245.28	0.67	1.6 <sup>45</sup>	N/A	N/A
DER3 - Existing Solar PV Array	Boys and Girls Club	Sunlight	0.05	61.32	0.168	0.4 <sup>8</sup>	N/A	N/A

<sup>45</sup> Assumes 10 hours of production (daylight) at 80% of capacity.

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

#### 4.3.1 Peak Load Support

The microgrid’s proposed generation assets will operate nearly continuously throughout the year, providing a constant level of load support to the greater grid. Although continuous operation will limit the CHP unit’s ramp-up capability during peak demand events, it will also maximize revenue for owner of the microgrid. See Table 26 for the maximum generation capacities of the proposed and existing DERs.

The proposed solar arrays will be at their most productive on days with peak solar irradiance when peak demand events are common, thus providing peak load support when it is most needed. They will provide around 0.035 MW (including capacity factors) of load support on average over the course of a year. However, their generation depends on weather conditions and time of day, therefore solar arrays are not a reliable source of peak load support.

**Table 26. Distributed Energy Resource Peak Load Support**

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

Distributed Energy Resource Name	Facility Name	Available Capacity (MW)	Does distributed energy resource currently provide peak load support?
DER1 - CHP System	Northern Westchester Hospital	Maximum of 3.5	No
DER2 - Solar PV Array	Northern Westchester Hospital	Maximum of 0.2	No
DER3 - Existing Solar PV Array	Boys and Girls Club	Maximum of 0.05	Yes

#### 4.3.2 Demand Response

DR programs require facilities to curtail load or expand generation using generators or battery storage in response to forecasted or real-time peak demand events on the larger grid. Entering island mode is the primary method for a microgrid to reduce load on the larger grid and thus participate in DR programs. The microgrid-connected assets and loads will be able to disconnect from the larger grid as a single point. Because the microgrid will only enter island mode during emergency outages, its ability to participate in DR programs is limited to reducing energy usage or expanding energy generation on the level of individual generators or loads. The Project Team is currently assuming a high baseline level of operation for the CHP system and therefore negligible participation in DR programs. Additionally, the solar arrays’ variable production prevents reliable participation in DR programs.

#### 4.3.3 Deferral of Transmission/Distribution Requirements

The 2.575 MW of average local generation produced by the DERs will slightly reduce the amount of electricity imported from the larger NYISO and Con Ed power lines. Although these power lines will last up to one hundred years if well maintained,<sup>46</sup> they can only transmit a

<sup>46</sup> Professor John Kassakian, MIT: <http://engineering.mit.edu/ask/how-do-electricity-transmission-lines-withstand-lifetime-exposure-elements>.

limited amount of power. As demand for electricity in Mount Kisco increases, the lines may need to be supplemented to handle additional load.

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

#### 4.3.4 Ancillary Service

None of the existing and proposed generation resources in Mount Kisco will participate in ancillary services markets. Although the CHP system 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 28% of the CHP unit's maximum output. If the CHP system runs at projected levels, it will never have the minimum regulation capacity available.

Although the CHP unit will not participate in paid NYISO ancillary service programs, it will provide many of the same ancillary services to the local Mount Kisco grid. For example, the CHP will provide frequency regulation as a by-product of its operation. The Mount Kisco 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.

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

Northern Westchester Hospital will be a steady and reliable customer for all of the steam generated by the CHP facility. At normal levels of operation, the CHP unit will produce approximately 3,080 MMBTUs of steam per month. This will meet approximately 36% of the Hospital's average monthly thermal energy demand, which is around 8,606 MMBTUs.<sup>47</sup> By purchasing steam from the CHP unit, Northwestern Westchester Hospital will replace around 36,960 MMBTUs of natural gas with co-generated steam every year.

#### 4.3.6 Environmental Regulation for Emission

The microgrid's generation assets will drive a net 2,772 MTCO<sub>2</sub>e (metric tons CO<sub>2</sub> equivalent) increase in GHG emissions in Mount Kisco as compared to the New York State energy asset mix. The proposed generation assets will produce approximately 26,367 MWh of electricity per year. The proposed CHP unit will emit approximately 14,304 MTCO<sub>2</sub>e per year,<sup>48</sup> while the solar arrays emit none. The current New York State energy asset mix would emit approximately 9,570 MTCO<sub>2</sub>e to produce the same amount of electricity<sup>49</sup> and natural gas-fired boilers would

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<sup>47</sup> Data supplied by the Con Edison.

<sup>48</sup> **CHP System Emissions Rate:** 0.51 MTCO<sub>2</sub>e/MWh (assuming 117 lb CO<sub>2</sub>e per MMBTU; EIA, <http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11>)

<sup>49</sup> Assuming an asset mix of 15% coal, 31% natural gas, 6% oil, 17% hydro, 29% nuclear, 1% wind, 1% sustainably managed biomass, and 1% "other fuel". This adds up to around 0.36 MTCO<sub>2</sub>e/MWh. Info from EPA ([http://www3.epa.gov/statelocalclimate/documents/pdf/background\\_paper\\_3-31-2011.pdf](http://www3.epa.gov/statelocalclimate/documents/pdf/background_paper_3-31-2011.pdf))

emit around 1,961 MTCO<sub>2</sub>e to produce the same amount of thermal energy.<sup>50</sup> The microgrid’s generation assets will therefore result in a net increase in emissions by 2,772 MTCO<sub>2</sub>e.

The microgrid’s generation assets will not need to purchase emissions permits to operate and will not exceed current New York State emissions limits for generators of their size. The New York State overall emissions limit was 64.3 MMTCO<sub>2</sub>e in 2014, and will begin decreasing in the near future. The state sells an “allowance” for each ton of CO<sub>2</sub>e emitted in excess of the limit at allowance auctions, but does not require assets under 25 MW to purchase allowances. The CHP unit is defined as a “small boiler” by NYS Department of Environmental Conservation (NYS DEC) limits (fuel input of 10-25 MMBTU/hour). The NYS DEC is currently developing output-based emissions limits for distributed energy resource assets. These limits on SO<sub>2</sub>, NO<sub>x</sub>, and particulate matter (to be captured in 6 NYCRR Part 222) should be published in late 2015 or early 2016. The main source of emissions regulations for small boilers is currently the EPA 40 CFR part 60, subpart JJJJJ—however, this law does not include gas-fired boilers.

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

Table 27 catalogs the CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and Particulate Matter (PM) emissions rates for the CHP system.

**Table 27. Emission Rates**

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

Distributed Energy Resource Name	Location	Emissions Type	Emissions Per MWh (Metric Tons/MWh)
DER1 - CHP System	Northern Westchester Hospital	CO <sub>2</sub>	0.553
		SO <sub>2</sub>	0.0000067 <sup>51</sup>
		NO <sub>x</sub>	0.00055 <sup>52</sup>

## 4.4 Project Costs (Sub Task 4.4)

### 4.4.1 Project Capital Cost

The microgrid design requires the following new pieces of equipment at the substation and across the rest of the microgrid:

- A control system to provide one point of control for operating the microgrid and synthesizing real-time electricity data from the connected facilities.

<sup>50</sup> Average emissions rate for natural gas boilers: 0.053 MTCO<sub>2</sub>e/MMBTU. Info from EIA (117 lb CO<sub>2</sub> per MMBTU; <http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11>).

<sup>51</sup> CHP calculator, EPA

<sup>52</sup> EPA, <http://www3.epa.gov/chp/documents/faq.pdf>

- Intelligent Electronic Devices to interface with the 44 kV utility breaker at the substation as well as the smaller 13.2 kV distribution feeders.
- Automated breakers installed throughout Mount Kisco to allow the microgrid to isolate and maintain power to the microgrid connected facilities.
- Grid-paralleling switchgear to synchronize each generator’s output to the system’s frequency.

The total installed capital cost of the distributed equipment is estimated to be \$581,000, \$17,000 for the IT infrastructure and \$330,000 for overhead powerline installation.<sup>53</sup> The Project Team estimates the CHP system and solar PV array will carry an installed cost of \$7,000,000 and \$480,000, respectively.<sup>54</sup> This brings the total installed capital cost \$8.41 million. If the powerlines were to be installed underground, the capital cost would increase to \$11.07 million, not including interconnection fees and site surveys. Additionally the estimated capital cost does not account for any financial incentives or tax credits that may lower the overall cost of the microgrid. See Tables 28 and 29 below for estimated installed costs for each microgrid component.

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

Table 28 details capital cost of the distributed equipment includes the microgrid control system and centralized generation controls that will allow the operator and electronic controllers to manage the entire microgrid.

**Table 28. Distributed Equipment Capital Cost**

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

Distributed Equipment Capital Costs				
Capital Component	Quantity	Installed Cost (\$ (+/- 30%))	Component Lifespan (Years)	Purpose/Functionality
Microgrid Control System (Siemens SICAM PAS or equivalent)	1 Primary 1 Back-up	\$50,000	7 - 8	Control system responsible for operating the microgrid sequencing and data concentration under all operating modes.
Microgrid Control Center (Siemens MGMS or equivalent)	1	\$300,000	20	Provides data trending, forecasting, and advanced control of generation, loads and AMI/SCADA interface, interface to NYISO for potential economic dispatch.

<sup>53</sup> Cost estimate provided by Travers Dennis - Con Ed

<sup>54</sup> **CHP Capital Cost:** \$2,000/kW (Siemens CHP system estimate)

**Solar PV Capital Cost:** \$2,400/kw (Siemens Solar PV estimate)

Distributed Equipment Capital Costs				
Capital Component	Quantity	Installed Cost (\$) (+/- 30%)	Component Lifespan (Years)	Purpose/Functionality
Automated Pole Mount Circuit Breaker/Switch (Siemens 7SC80 relay or equivalent)	4 new 2 upgrade	\$100,000 \$10,000	20	Upgraded breakers/switches at 2 distribution overhead switches. Isolate feeders from Microgrid
Automated Underground Circuit Breaker/Switch (Siemens 7SJ85 relay or equivalent, multi module control)	2	\$20,000	20	New multi module relays at pad mounted/underground distribution switches. One relay can protect and control multiple switches/breakers at each PME. Isolates the downstream loads and generation from the microgrid
Generation Controls (OEM CAT, Cummins, etc.)	1	\$4,000	20	Serves as the primary resource for coordinating the paralleling load matching of spinning generation.
PV Inverter Controller (OEM Fronius or equivalent)	2	\$8,000	20	Controls PV output and sends data to SCADA and EMS for forecasting.
WiMax Base Station	1	\$8,000	20	Located near microgrid control cabinet. Communicates wirelessly with WiMax subscriber units for remote control and monitoring of breakers and switches. Should be installed at high location.
WiMax Subscriber Units	6	\$12,000	20	Each subscriber unit can communicate back to the WiMax base station for SCADA monitoring and control or remote relay to relay GOOSE messaging.
WiMax configuration and testing	1	\$23,000	-	The configuration and testing of the WiMax hardware
Installation Costs	-	\$46,000	-	Installation of capital components in the microgrid

**Table 29. Capital Cost of Proposed Generation Units**

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

Proposed Generation Units				
Capital Component	Quantity	Installed Cost (\$) (+/- 30%)	Component Lifespan (Years)	Purpose/Functionality
3.5 MW CHP System	1	\$7,000,000	20	Generation of electricity
0.2 MW PV System	1	\$480,000	30	Generation of electricity

The microgrid IT infrastructure will also require Cat-5e Ethernet for communication between distribution switches, generation switchgear, PV inverters, and network switches. The design uses Cat-5e cabling, including RJ-45 connectors at \$0.61 per cable.<sup>55</sup> The total installation cost of cabling is approximately \$5.65 per foot.<sup>56</sup> The Project Team will use the existing cabling infrastructure to install the communications cables, thereby avoiding the high costs of trenching the proposed lines. The estimated total cost for the microgrid IT infrastructure is around \$17,000.<sup>57</sup>

In addition to the microgrid IT infrastructure, the microgrid will need new distribution lines in order to connect the DERs to the microgrid supported facilities. The Project Team has determined the approximate cost of building these new lines is \$330,000 for an overhead installation or \$2.99 million for underground installation.<sup>58</sup>

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 30 below.

<sup>55</sup> Commercially available RJ-45 connectors, \$0.30 per connector.

<sup>56</sup> **Installation costs for Cat5e:** \$5.45/ft. **Component cost for Cat5e:** \$0.14/ft (commercially available).

<sup>57</sup> The Project Team estimated ~1,955 feet of Cat5e will be necessary.

<sup>58</sup> The Project Team has determined that approximately 5,540 feet of new line is required at the cost of \$60/ft for overhead installation and \$540/ft for underground installation according to Travers Dennis at Con Ed.

**Table 30. Initial Planning and Design Cost**

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

Initial Planning and Design Costs (\$) <sup>59</sup>	Cost Components
\$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
<b>\$1,000,000</b>	<b>Total Planning and Design Costs</b>

4.4.3 Operations and Maintenance Cost

The proposed DERs will incur fixed O&M costs, including fixed annual service contracts.

Annual service for the proposed CHP unit will cost approximately \$365,000. <sup>60</sup> The microgrid owner will also incur \$5,000 per year in total costs for annual fixed system service agreements for the solar PV array and backup generators. <sup>61</sup>

The DER assets will also incur variable O&M costs that fluctuate based on output. These include fuel and maintenance costs outside of scheduled annual servicing. First, the CHP system will require capital for fuel, consumable chemicals, and other operating expenses. The average price of natural gas is \$5.74/Mcf, which translates to an average fuel cost of \$53/MWh for the CHP unit.

The solar PV arrays will not require fuel to operate, and it should not require service outside of the normally scheduled down-time. Normally scheduled down-time should cost approximately \$20/kW per year. <sup>62</sup>

Annual service for all non-DER microgrid components will cost approximately \$70,000 per year. <sup>63</sup>

Table 31 outlines all fixed operations and maintenance (O&M) costs associated with normal operation of the DERs.

<sup>59</sup> Estimates developed by Booz Allen Project Team and industry experts.

<sup>60</sup> **CHP O&M:** \$0.01/kWh. (US DOE Industrial Technologies Program).

<sup>61</sup> \$5,000 for solar PV array (\$20/kW per year), \$4.60/kW per year for backup diesel generators (Electric Power Research Institute, “Costs of Utility Distributed Generators, 1-10 MW”) and \$1,500 for CHP system (Pete Torres, Prime Power; yearly service for small scale natural gas generator).

<sup>62</sup> NREL (projects \$0/kWh variable maintenance costs): [http://www.nrel.gov/analysis/tech\\_lcoe\\_re\\_cost\\_est.html](http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html)

<sup>63</sup> **O&M for non-DER microgrid components:** \$70,000/year (Siemens).

**Table 31. Fixed Operating and Maintenance Cost**

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

Fixed O&M Costs (\$/year)	Cost Components
~ 365,000	CHP system Service Agreement – Annual costs of maintenance and servicing of unit
~ \$5,000 (total)	Solar PV System Service Agreements – Annual costs of maintenance and servicing of unit
\$70,000	Non-DER Microgrid Components Service Agreement - Annual costs of maintenance and servicing of components

4.4.4 Distributed Energy Resource Replenishing Fuel Time

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

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

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

4.5.1 Backup Generation Cost during a Power Outage

All microgrid generation assets will serve as backup generation in the event of an extended power outage. The CHP system will be the most reliable and productive of the DERs, providing an average of 2.975 MW to the microgrid at any given time. Because the CHP system will use natural gas via pipeline as fuel, disruptions to its fuel source are unlikely. The CHP system can generate a maximum of 84 MWh per day, using approximately 777 Mcf (798 MMBTU) of natural gas. The CHP system will not require startup or connection costs in order to run during island mode and should not incur any daily variable costs other than fuel.

The solar array will be available for backup generation during a power outage, but its production is too inconsistent for it to qualify as a true backup generator. Extreme weather is responsible for many emergency outages in New York State, and such weather will greatly reduce the output of the solar panels. However, when high state-wide electricity demand on the most irradiated days of summer causes outages, the solar panels will be at their most productive and could provide up to 0.25 MW of load support to the Mount Kisco microgrid. Table 32 shows all of the costs associated with operating the DERs during a power outage, including fuel and variable O&M costs.

**Table 32. Cost of Generation during a Power Outage**

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

Location	Distributed Energy Resource	Energy Source	Nameplate Capacity (MW)	Expected Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/ Day)	Fuel Consumption per Day		One-Time Operating Costs (\$)	Ongoing Operating Costs per day – Fuel and variable O&M
						Quantity	Unit		
Northern Westchester Hospital	DER1 - CHP System	Natural Gas	3.5	100%	84	777	Mcf	N/A	\$5,500 <sup>64</sup>
Northern Westchester Hospital	DER2 - Solar PV Array	Sunlight	0.2	14%	0.672 <sup>65</sup>	N/A	N/A	N/A	\$11
Boys and Girls Club	DER3 - Existing Solar PV Array	Sunlight	0.05	14%	0.168 <sup>66</sup>	N/A	N/A	N/A	\$2.75

<sup>64</sup> = Daily fuel cost during an outage (Mcf/day) + (Yearly O&M/365).

<sup>65</sup> This output assumes that the PV arrays are still operational after an emergency event.

<sup>66</sup> Ibid.

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

There are no costs associated with switching the microgrid to island mode during a power outage other than the operational costs already accounted for Table 32. Please refer to Table 32 for one-time and ongoing costs of microgrid generation per day. The proposed microgrid has the capacity to support all the connected facilities. Facilities not connected to the microgrid will experience power outages and may need emergency services depending on the severity of the emergency event. Any other cost incurred during a wide spread power outage will be related to the emergency power (i.e. portable generators) rather than electricity generation costs.

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

Most of the facilities to be connected to the microgrid are medical facilities that serve the community of Mount Kisco and the surrounding area (such as the Northern Westchester Hospital and the Mount Kisco Medical Group). Others, like the Boys and Girls Club, serve a smaller population for most of the year, but provide critical services to the entire population during emergency situations.

Backup power supplied by the microgrid should provide 100% of each facility's electricity demand during outage situations. However, if backup power from the microgrid is not available, the critical services provided by these facilities will be severely hampered. Some critical services do not require electricity (e.g. driving a police car to the scene of a crime), while others are completely dependent on a stable power supply (e.g. some municipal buildings or local water sanitizing operations). Based on the portfolio of services that each facility provides and the electricity dependency of each service, Table 33 provides an estimate of how effectively each facility can perform its normal services without electricity.

**Table 33. Critical Services Supported**

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

Facility Name	Population Served by This Facility	Percentage Loss in Service During a Power Outage <sup>67</sup>	
		When Backup Power is Available	When Backup Power is Not Available
Northern Westchester Hospital and Staff Housing	11,100	0%	> 90%
Boys and Girls Club	~2,000 <sup>68</sup>	0%	> 50%
Mount Kisco Medical Group	~ 9,500 <sup>69</sup>	0%	> 75%
Diamond Properties Office Building	600 <sup>70</sup>	0%	> 75%

**4.7 Industrial Economics Benefit-Cost Analysis Report**

As follows is a direct cost-benefit analysis deliverable from Industrial Economics (IEc). IEc was hired by NYSERDA to conduct a benefit-cost analysis of each feasibility study. The benefit-cost analysis of the Mount Kisco microgrid was delivered to the Project Team on February 22, 2016.

4.7.1 Overview

As part of NYSERDA’s NY Prize community microgrid competition, the Town of Mount Kisco has proposed development of a microgrid that would serve four facilities located in close proximity to one another along Main Street and South Bedford Road:

- Northern Westchester Hospital and staff housing, a full service, not-for-profit hospital with 245 beds and over 700 physicians.<sup>71</sup>

<sup>67</sup> Booz Allen estimated % loss based on energy demands and services provided for Emergency Services, Municipal Services, Health Services, and Education Services based on previous research by NIH and CDC (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1497795/>; <http://www.ncbi.nlm.nih.gov/pubmed/15898487>; <http://emergency.cdc.gov/disasters/poweroutage/needtoknow.asp>)

<sup>68</sup> Boys and Girls Club of North Westchester website (<http://www.bgcnw.com/mission-who-we-are/>)

<sup>69</sup> Total of 95 doctors, with 500+ doctors in the Group (<http://www.mkmg.com/directory/locations/show/mount-kisco-campus-90-south-bedford-road>) and approximately 100 patients per doctor (<http://www.lohud.com/story/money/business/2015/06/01/mount-kisco-medical-layoffs/28311385/>)

<sup>70</sup> Average worker per square foot is ~ 150 sf (<http://www.naiop.org/en/E-Library/Perspectives/Changes-in-Average-Square-Foot-per-Worker.aspx>) and the building is approximate 89,000 sf with 640 car spaces (<http://dpmgt.com/project/100-south-bedford-road/>)

<sup>71</sup> <http://nwhc.net/about-us>

- Mount Kisco Medical Group, including Mount Kisco Medical Group Pediatrics, a multi-specialty medical group with 95 physicians.
- Boys and Girls Club of Northern Westchester, a not-for-profit organization providing educational and recreational programs for local youth.
- Diamond Properties Office Building, a commercial real estate investment and management company.

The microgrid would be powered by two new distributed energy resources: a 3.5 MW natural gas CHP system and a 200 kW PV array, both of which would be located at Northern Westchester Hospital. In addition, the microgrid would incorporate a 50 kW PV array currently installed at the Boys and Girls Club.<sup>72</sup> The town anticipates that the natural gas CHP system and both PV systems would produce electricity for the grid during periods of normal operation. The system as designed would have sufficient generating capacity to meet average demand for electricity from the four facilities during a major outage, though not to support peak usage at all of the facilities. 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

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<sup>72</sup> Because the 50 kW PV array at the Boys and Girls Club is already installed and operating, the energy it generates and the capacity it provides are not treated as benefits of the microgrid.

support. Of note, the model analyzes a discrete operating scenario specified by the user; it does not identify an optimal project design or operating strategy.

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.<sup>73</sup> It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.<sup>74</sup>

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<sup>73</sup> The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO<sub>2</sub> emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>2.5</sub>, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

<sup>74</sup> The New York State Department of Public Service (DPS) requires utilities delivering electricity in New York State to collect and regularly submit information regarding electric service interruptions. The reporting system specifies 10 cause categories: major storms; tree contacts; overloads; operating errors; equipment failures; accidents; prearranged interruptions; customers equipment; lightning; and unknown (there are an additional seven cause codes used exclusively for Consolidated Edison's underground network system). Reliability metrics can be calculated in two ways: including all outages, which indicates the actual experience of a utility's customers; and excluding outages caused by major storms, which is more indicative of the frequency and duration of outages within the utility's control. In estimating the reliability benefits of a microgrid, the BCA employs metrics that exclude outages caused by major storms. The BCA classifies outages caused by major storms or other events beyond a utility's control as "major power outages," and evaluates the benefits of avoiding such outages separately.

4.7.3 Results

Table 34 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 14.9 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

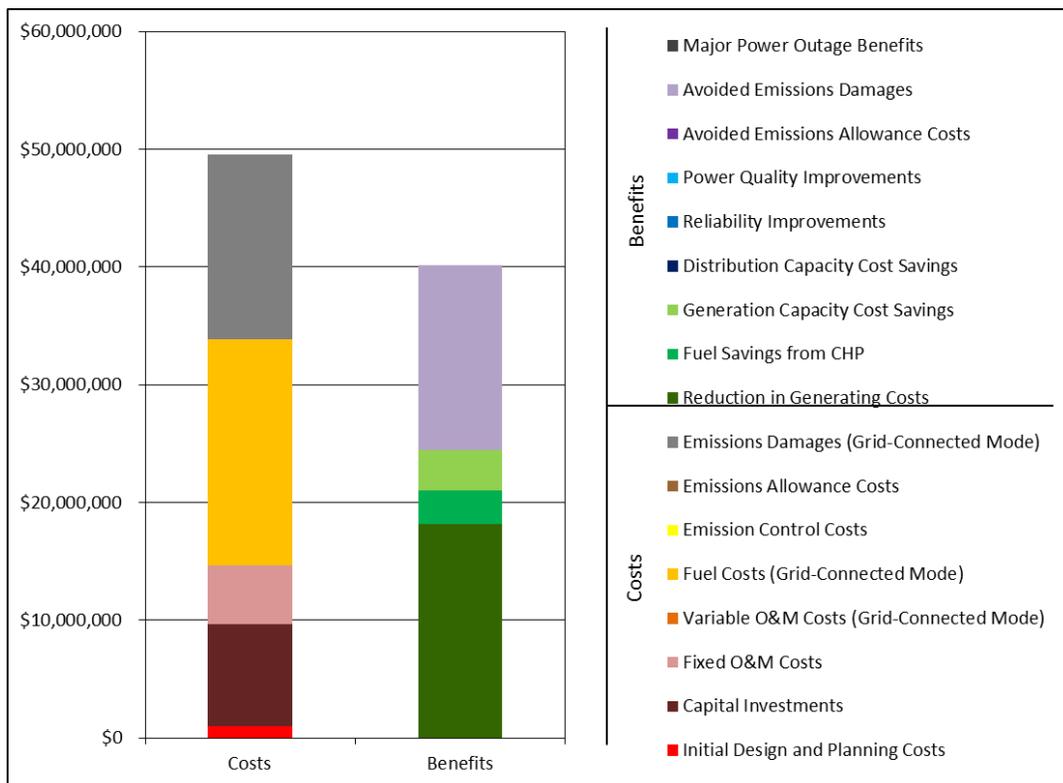
**Table 34. BCA Results (Assuming 7 Percent Discount Rate)**

ECONOMIC MEASURE	EXPECTED DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 14.9 DAYS/YEAR
Net Benefits - Present Value	-\$9,380,000	\$59,300
Benefit-Cost Ratio	0.8	1.0
Internal Rate of Return	-6.3%	7.3%

**Scenario 1**

Figure 7 and Table 35 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 35. Detailed BCA Results, Scenario 1**  
**(No Major Power Outages; 7 Percent Discount Rate)**

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
<b>Costs</b>		
Initial Design and Planning	\$1,000,000	\$88,200
Capital Investments	\$8,660,000	\$750,000
Fixed O&M	\$4,990,000	\$440,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$19,200,000	\$1,690,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$15,700,000	\$1,020,000
<b>Total Costs</b>	<b>\$49,500,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$18,100,000	\$1,600,000
Fuel Savings from CHP	\$2,860,000	\$253,000
Generation Capacity Cost Savings	\$3,430,000	\$303,000
Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$42,700	\$3,780
Power Quality Improvements	\$0	\$0
Avoided Emissions Allowance Costs	\$8,920	\$787
Avoided Emissions Damages	\$15,700,000	\$1,020,000
Major Power Outage Benefits	\$0	\$0
<b>Total Benefits</b>	<b>\$40,100,000</b>	
<b>Net Benefits</b>	<b>-\$9,380,000</b>	
<b>Benefit/Cost Ratio</b>	<b>0.8</b>	
<b>Internal Rate of Return</b>	<b>-6.3%</b>	

### *Fixed Costs*

The BCA relies on information provided by the Project Team to estimate the fixed costs of developing the microgrid. The Project Team's best estimate of initial design and planning costs is approximately \$1.0 million. The present value of the project's capital costs is estimated at approximately \$8.7 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 3.5 MW natural gas unit and 200 kW PV array; 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 approximately \$440,000. The present value of these O&M costs over a 20-year operating period is approximately \$5.0 million.

### *Variable Costs*

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's primary generator. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the Project Team and projections of fuel costs from New York's State Energy Plan (SEP), adjusted to reflect recent market prices.<sup>75</sup> The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately \$19.2 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the Project Team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the new natural gas CHP system are estimated at approximately \$1.0 million annually. The majority of these damages are attributable to emissions of CO<sub>2</sub>. Over a 20-year operating period, the present value of emissions damages is estimated at approximately \$15.7 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 Mount Kisco'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 \$18.1 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. Cost savings would also result from fuel savings due to the CHP system, relative to the current boiler heating system at the Northern Westchester Hospital; the BCA estimates the present value of fuel savings over the 20-year operating period to be approximately \$2.9 million. The reduction in demand for electricity from bulk energy suppliers would also reduce emissions of CO<sub>2</sub> and particulate matter from these sources, and produce a shift in demand for SO<sub>2</sub> and NO<sub>x</sub> emissions allowances.<sup>76</sup> Likewise, the reduction in demand for heating fuel at the hospital would reduce emissions damages. Over the 20-year operating period, the present value of these benefits is estimated at approximately \$15.7 million.

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<sup>75</sup> The model adjusts the State Energy Plan's natural gas and diesel price projections using fuel-specific multipliers that are based on the average commercial natural gas price in New York State in October 2015 (the most recent month for which data were available) and the average West Texas Intermediate price of crude oil in 2015, as reported by the Energy Information Administration. The model applies the same price multiplier in each year of the analysis.

<sup>76</sup> Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model values emissions of CO<sub>2</sub> using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.] Because emissions of SO<sub>2</sub> and NO<sub>x</sub> from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.<sup>77</sup> Based on standard capacity factors for solar and natural gas generators, the Project Team estimates the incremental impact of the project on demand for generating capacity to be approximately 3.003 MW 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 \$3.4 million over a 20-year operating period.

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

### ***Reliability Benefits***

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately \$3,800 per year, with a present value of approximately \$43,000 over a 20-year operating period. This estimate was developed using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:<sup>78</sup>

- System Average Interruption Frequency Index – 0.11 events per year.
- Customer Average Interruption Duration Index – 181.2 minutes.<sup>79</sup>

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

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<sup>77</sup> Impacts on transmission capacity are implicitly incorporated into the model's estimates of avoided generation costs and generation capacity cost savings. As estimated by NYISO, generation costs and generating capacity costs vary by location to reflect costs imposed by location-specific transmission constraints.

<sup>78</sup> [www.icecalculator.com](http://www.icecalculator.com).

<sup>79</sup> The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Consolidated Edison.

rate for backup generators.<sup>80</sup> It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

### *Summary*

The analysis of Scenario 1 yields a benefit/cost ratio of 0.8; i.e., the estimate of project benefits is approximately 80 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

### **Scenario 2**

#### ***Benefits in the Event of a Major Power Outage***

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.<sup>81,82</sup>

As noted above, the Town of Mount Kisco’s microgrid project would serve four facilities: the Northern Westchester Hospital and staff housing; the Boys and Girls Club of Northern Westchester; the Mount Kisco Medical Group, including the Pediatrics Building; and a Diamond Properties office building. The project’s consultants indicate that at present, none of these facilities is equipped with a backup generator. Instead, each of the facilities would maintain some level of normal operations during a major outage by bringing in portable generators, at a cost of approximately \$17,200 per day for the hospital, \$3,200 per day for the medical group, \$1,700 per day for the Boys and Girls Club, and \$4,600 per day for the commercial office building. In the

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<sup>80</sup> <http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1>.

<sup>81</sup> The methodology used to estimate the value of lost services was developed by the Federal Emergency Management Agency (FEMA) for use in administering its Hazard Mitigation Grant Program. See: FEMA Benefit-Cost Analysis Re-Engineering (BCAR): Development of Standard Economic Values, Version 4.0. May 2011.

<sup>82</sup> As with the analysis of reliability benefits, the analysis of major power outage benefits assumes that development of a microgrid would insulate the facilities the project would serve from all outages. The distribution network within the microgrid is unlikely to be wholly invulnerable to service interruptions. All else equal, this will lead the BCA to overstate the benefits the project would provide.

absence of backup power – i.e., if the backup generators failed and no replacements were available – all four facilities would experience at least a 50 percent loss in service capabilities.

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

- The Northern Westchester Hospital would rely on a portable generator, experiencing no loss in service capabilities while this unit is in operation. If the portable generator fails, the hospital would experience a 90 percent or greater loss of service.
- The Mount Kisco Medical Group and the Diamond Properties Office Building would also each rely on portable generators, experiencing no loss in service capabilities while these units are in operation. If either portable generator failed, the host facility would experience a 75 percent or greater loss of service.
- The Boys and Girls Club would also rely on a portable generator, experiencing no loss in service while this unit is in operation. If the portable generator fails, the Boys and Girls Club would experience a 50 percent or greater loss of service.
- In all four cases, the supply of fuel necessary to operate the backup generator would be maintained indefinitely.
- At each facility, there is a 15 percent chance that the backup generator would fail.

The economic consequences of a major power outage also depend on the value of the services the facilities of interest provide. The analysis calculates the impact of a loss in the town's hospital services using standard FEMA values for the value of statistical life, the increase in emergency room visits during a natural disaster, and the impact of increased travel time to emergency medical services on death rates.<sup>83</sup> The impact of a service interruption at other facilities is based on application of the ICE Calculator, which yields the following estimates of the cost of a total loss of service:

- For the Mount Kisco Medical Center, approximately \$120,000 per day.
- For the Boys and Girls Club, approximately \$80,000 per day.<sup>84</sup>
- For the Diamond Properties Office Building, approximately \$50,000 per day.

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<sup>83</sup> The hospital facility also includes staff housing. This methodology does not account for the cost of on-site residential buildings losing power during a major outage and therefore may underestimate the benefits of maintaining operations at the facility.

<sup>84</sup> If its operations are maintained during a major power outage, the Boys and Girls Club could, in theory, be used as a staging area for first responders. In that case, the ICE Calculator's estimate would likely underestimate the value of lost service at this facility.

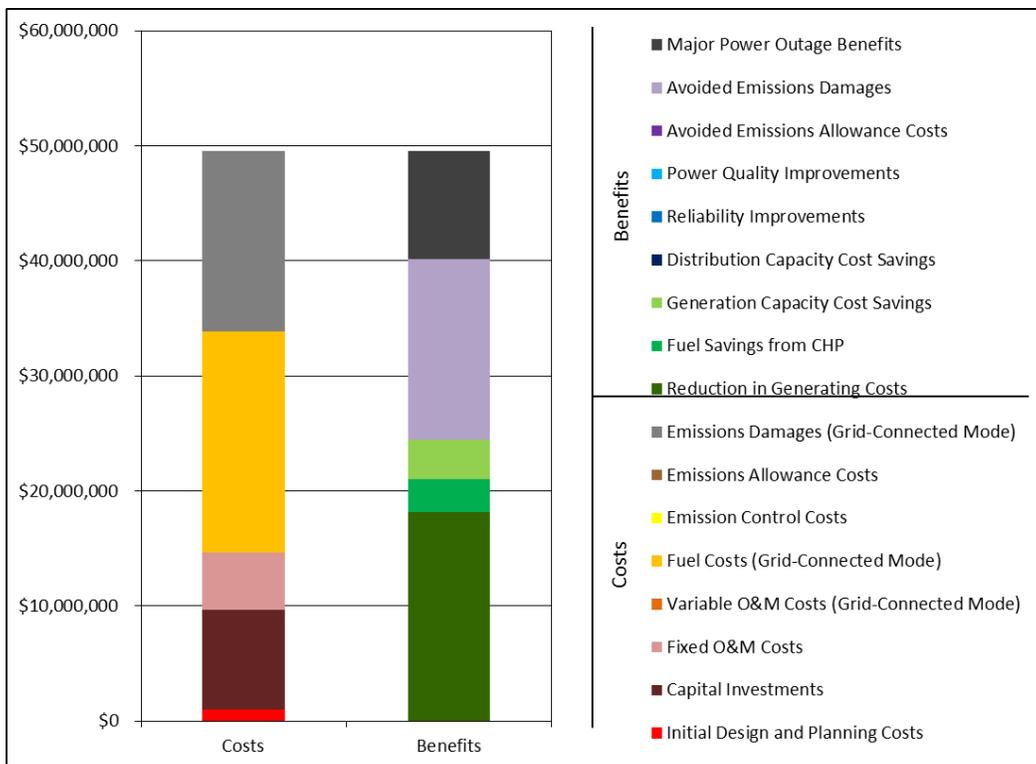
Based on these values, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the four facilities is approximately \$57,000 per day.<sup>85</sup>

**Summary**

Figure 8 and Table 36 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 14.9 days per year without power. If the annual duration of the outages the microgrid prevents is less than this total, the project’s costs are projected to exceed its benefits.

**Figure 8. Present Value Results, Scenario 2**

**(Major Power Outages Averaging 14.9 Days/Year; 7 Percent Discount Rate)**



<sup>85</sup> This value takes into account the availability of portable generators in the event of an outage, which significantly reduces the probability that the facilities listed above would experience a complete loss of service.

**Table 36. Detailed BCA Results, Scenario 2**  
**(Major Power Outages Averaging 14.9 Days/Year; 7 Percent Discount Rate)**

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
<b>Costs</b>		
Initial Design and Planning	\$1,000,000	\$88,200
Capital Investments	\$8,660,000	\$750,000
Fixed O&M	\$4,990,000	\$440,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$19,200,000	\$1,690,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$15,700,000	\$1,020,000
<b>Total Costs</b>	<b>\$49,500,000</b>	
<b>Benefits</b>		
Reduction in Generating Costs	\$18,100,000	\$1,600,000
Fuel Savings from CHP	\$2,860,000	\$253,000
Generation Capacity Cost Savings	\$3,430,000	\$303,000
Transmission & Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$42,700	\$3,780
Power Quality Improvements	\$0	\$0
Avoided Emissions Allowance Costs	\$8,920	\$787
Avoided Emissions Damages	\$15,700,000	\$1,020,000
Major Power Outage Benefits	\$9,440,000	\$848,000
<b>Total Benefits</b>	<b>\$49,600,000</b>	
<b>Net Benefits</b>	<b>\$59,300</b>	
<b>Benefit/Cost Ratio</b>	<b>1.0</b>	
<b>Internal Rate of Return</b>	<b>7.3%</b>	

The Project Team assumed an electricity sales price of \$0.073 per kWh in Mount Kisco. This is the supply cost for Con Ed, the average amount spent by Con Ed 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 Con Ed grid. In Mount Kisco, the Dunwoodie LBMP is \$39.16 per MWh<sup>86</sup>, or \$0.039 per kWh, a more than 45% reduction in price from the supply cost. The benefits allowed for capacity cost reductions do not

<sup>86</sup> Average according to IEc cost-benefit model.

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.

## 5. Summary and Conclusions

This section concludes with the Project Team’s lessons learned, benefits analysis and conclusion and path forward based on all four of the previous work streams summarized above. The lessons learned from the Mount Kisco microgrid feasibility study are divided into two parts. The first part in Section 5.1 highlights Mount Kisco-specific issues to be addressed moving forward. The second part in Sections 5.1.1 and 5.1.2 addresses statewide issues, replicability, and the perspectives of many stakeholder groups. These lessons learned may be generalized and applied across the State and other NY Prize communities.

### 5.1 Mount Kisco Lessons Learned

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

The Mount Kisco microgrid proposal consists of significant medical facilities, including the primary hospital and trauma center for northern Westchester County. The diversity of the ambulatory and inpatient medical facilities provides emergency services to a substantially larger population than microgrids that lack a large, regional medical facility. Moreover, the Northern Westchester Hospital is the largest load in the microgrid and early, consistent communication with the staff proved invaluable for accurately characterizing the facility and determining the possibilities for generator locations and types. This dialogue yielded provisional support for the Project Team’s desired siting of the generation assets in the most efficient locations available; for instance, placing the CHP unit in the hospital boiler room allows it to intertie directly into the facility’s steam infrastructure while also protecting the generator from all weather and external elements.

Mount Kisco citizens are also very keen on enhancing community sustainability, along with the Town and the formal energy and sustainability committees. For example, Diamond Properties who owns and manages numerous facilities around the area, including multiple facilities within the footprint of the microgrid, is also the owner of the largest solar array in Westchester County. Vocal proponents in the business community, such as Mr. Diamond, fill a critical role in outreach to local residents and other business leaders, gaining buy-in and support for larger scale initiatives such as a community microgrid. While Booz Allen is well equipped to conduct community outreach and engage local residents on the merits of the microgrid, respected community members have instant credibility and stature to promote investments like these.

In comparison to working with a municipal utility, working with the investor-owned Con Ed was a more time-intensive process. As a utility with a large footprint, customer base, and

transmission and distribution (T&D) network, Con Ed has many issues to manage that require its attention, among which microgrids and NY Prize were just one. However in this case, Con Ed was receptive to the possibility of connecting multiple feeders to create a microgrid design, understanding there were insufficient critical facilities on a single feeder in Mount Kisco to make an appealing microgrid. The result is a technically feasible microgrid that meets NYSERDA's critical facility requirements. A NY Prize Phase II award would require more extensive conversations with Con Ed 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.

#### 5.1.1 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 Mount Kisco, the design proposal largely addresses constraints in the existing electrical infrastructure. There are insufficient critical and important loads on the same feeder in Mount Kisco, necessitating new distribution lines to connect the desired facilities. The new connections will link multiple feeders, and while the expense and technical effort to do so is significant, it will allow for more flexible operation of the microgrid. Thus, while connecting several facilities at the end of multiple feeders is expensive (or, if available, multiple critical facilities at the end of a single feeder), it allows for economic and operational islanding that would be unavailable if there were disconnected downstream loads.

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 for an islanded microgrid. In contrast, natural gas-fired generation provides a high reliability baseload, is relatively clean and efficient, and allows for cogenerated steam sales if there is a proximate off-taker. Mount Kisco is fortunate to have the requisite natural gas infrastructure as well as a conveniently located steam off-taker at the hospital.

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

Project financial structures are also important to consider. Revenue from these projects is driven almost exclusively by the sale of electricity and, if available, steam; however, the microgrid

control components may require a million dollars or more of capital investment. Ownership structures that separate cost drivers from the revenue streams may be difficult propositions, as the microgrid controls owners would have little opportunity to recoup their investment. This is especially true for privately owned microgrids in locations with reliable power supplies where islanding would be infrequent. In these cases, municipal ownership of the generation and infrastructure would be the most effective. The exception is if the entire microgrid can be developed “behind the meter.” While it remains to be seen if utilities will allow this to transpire, a fully behind-the-meter solution in an area with moderate to high electricity prices would likely be a more advantageous financial proposition for connected facilities, as well as for generation and controls owners. Moreover, ancillary services have the potential to provide positive revenue for community microgrids; however, they are hard to qualify for because they require high levels of reserve capacity for most programs, and the payments are somewhat small relative to the electricity that could be generated and sold with an at-capacity generator.

*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. Demand response 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. While the nature of DR payments in such situations is not clear, the Project Team suggests explicit guidance from the Public Service Commission (PSC) and the various utilities regarding their respective policies. Due to this lack of clarity, DR revenue has generally been excluded from the Project Team’s revenue analysis.

Lastly, local community involvement is an important contributor to microgrid design success. Though even the most robust community engagement may not overcome highly unfavorable infrastructure, it is nonetheless imperative for steady forward progress. In Mount Kisco, support from the utility for this effort has been robust and the community has been exceptionally engaged. In other communities, as in Mount Kisco, the Project Team has been in close and frequent contact with administrators, elected officials, and non-governmental community representatives; this type of engagement is necessary to not only build support among prospective facilities but also to engage on ownership models, generation options, and other considerations that will directly affect the feasibility of the proposal. The engagement and commitment from the community is instrumental to the Project Team’s ability to make recommendations that are acceptable and reasonable to the community. 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. Mount Kisco’s microgrid is not an AMI remote disconnect based design; however, the utility of AMI is evident in other projects in the Project Team’s portfolio. Lastly, the larger the microgrid grows, the more switches and controls are need to be installed, connected, and maintained for smooth islanding and grid-reconnect processes. In the aggregate, such infrastructure is costly and does not provide many direct returns. Utilities are also likely to push back if the microgrid grows to occupy significant portions of their infrastructure. To that end, the Project Team has worked diligently with the local utilities to find acceptable footprints that meet the goals of NYSERDA and respect the operational concerns of the utilities.

#### 5.1.2 Stakeholder Lessons Learned

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

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

Investor-owned-utilities in the Project Team’s portfolio, including Con Ed in Mount Kisco, were uniformly against allowing a third party operational control of utility-owned infrastructure. This view is understandable, however it engenders a particularly difficult situation if the utility does not support the microgrid development. In such situations, the microgrid will generally be forced

to construct duplicate infrastructure, with is both prohibitively expensive and against the spirit of the NY Prize. In general, utilities which support the integration of their infrastructure to the extent technically possible allow for more expansive microgrid possibilities.

*Academics.* Academic considerations in microgrid development may center around three areas. First, research into a relatively small grid systems with multiple generators (some spinning, some inverter-based), temporally and spatially variable loads, and multidirectional power flows may inform better designs and more efficient placement of generation and controls relative to loads. The second is optimizing financial structures for collections of distributed energy resources and control infrastructure. To-date, most microgrids in the United States have been campus-style developments in which the grid serves a single institution and can be easily segregated from the macrogrid. Community microgrids consisting of multi-party owned facilities and generation are a new concept, and literature on how best to own and operate such developments is not yet robust. Lastly, and related to financial structures, is the idea of how a “grid of grids” would be managed and structured to provide optimal operational support and the right mix of incentives to encourage customer and utility buy-in.

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

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

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. 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.

Lastly, this project and many others would reap significant benefits from NYSERDA incentive programs, in particular the CHP performance program. The upfront and early year benefits from the incentives lend important economic support, however the long term disposition of the programs is uncertain. Though some projects may remain viable absent the incentives, Mt. Kisco included, many others will not and will pass from positive to negative economics with the sunset of the incentives.

## 5.2 Benefits Analysis

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

### 5.2.1 Environmental Benefits

New York State's normal energy portfolio is very clean, with primary energy sources being hydropower and nuclear. Therefore, having a microgrid powered by a natural gas-fired CHP will increase the overall emissions per kilowatt hour (kWh). However, the natural gas CHP is cleaner than many peaking assets, which come online when statewide demand is high, and is significantly cleaner than the existing diesel backup at the hospital. In Mount Kisco, cogenerated steam will replace stand-alone natural gas-fired boilers, increasing the overall efficiency of the steam production. 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 Mount Kisco

Critical and important facilities in the Town of Mount Kisco 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 CHP unit will also offset higher-emission peaking assets during peak demand events. The additional electricity supply will also obviate the need for the hospital to run its diesel generators whenever there is a grid interruption, reducing local emissions. The Project Team met with the community in-person on February 9<sup>th</sup> and February 29<sup>th</sup>, 2016 to provide a summary of the project analysis and a recommend approach for a path ahead.

### 5.2.3 Benefits to Residents in and around Mount Kisco

Residents of Mount Kisco and in all of northern Westchester County 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 Mount Kisco and nearby surrounding communities will have access to healthcare, shelter and

other services in the event of an outage. In the future, the microgrid could be expanded to connect more facilities.

#### 5.2.4 Benefits to Healthcare Customers

The Northern Westchester Hospital will benefit from the reliability and resilience of the microgrid. The microgrid will allow the hospital to operate at near full capacity during a grid outage and will reduce their reliance on relatively more expensive diesel backup generation. Moreover, the hospital will be able to reduce operational wear and tear on its existing steam boilers as it switches to CHP generated steam for much of its load.

#### 5.2.5 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 Mount Kisco 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 Mount Kisco microgrid is feasible. Previous task deliverables have detailed the capabilities of the microgrid, its primary technical design, the commercial, financial, and legal viability of the project, and the costs and benefits of the microgrid. The microgrid meets all of the NYSERDA required capabilities and most of its preferred capabilities.

Major challenges include working with Con Ed regarding the proposed interconnections and new distribution infrastructure, and working with the hospital to site both the CHP and solar PV, as well as secure an off-take agreement for the steam. A failure to address any one of these conditions would make it difficult to develop and operate the microgrid as it is currently proposed. With positive adjudication, the microgrid stands to be a case study in collaborative operation and the drivers of microgrid profitability.

The proposed Mount Kisco microgrid is replicable and scalable, and it provides a proof of concept for a CHP-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.

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 on the overall grid, 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 distributed energy resource assets. The utility will see increased revenues and grid performance, customers will see stabilized electricity and steam 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 provided by Con Ed. They are included in this feasibility study to show which facilities have highest and lowest load demands at different times of the day. Analyzing these load demand curves has allowed the team to develop a better overall understanding of the generation capacity needed to sustain the microgrid. Con Ed does not provide interval data for loads less than 500 kW, so the Project Team used a simulator to profile typical 24-hour load curves for these facilities.

**ONE LINES AND LOAD PROFILES REDACTED PER NDA WITH CONSOLIDATED  
EDISON**