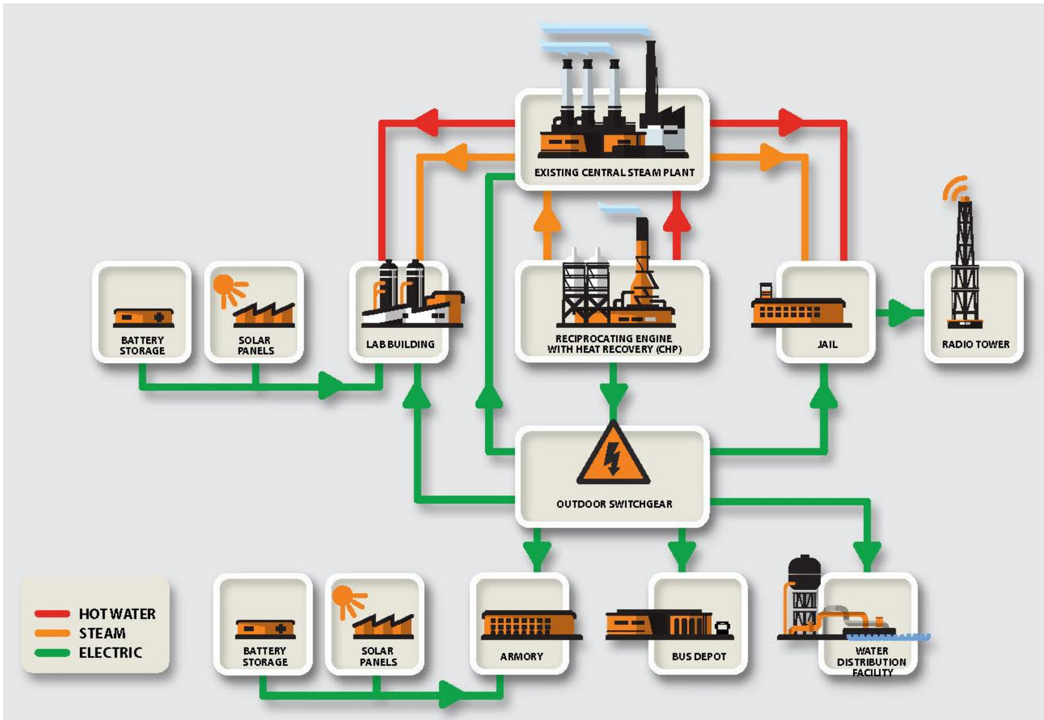
35 - Town of Valhalla

September 2016

Notice



NYSERDA NY Prize RFP 3044
Stage 1 Feasibility Assessment

Valhalla Community Microgrid Feasibility Study
Westchester County Public Utility Service
Project Number 67218

Task 5
Final Written Document
(Volume 1)

September, 2016

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Introduction

Project No. 67218
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Executive Summary

As part of NYSERDA's NY Prize community microgrid competition, Westchester County has proposed development of a microgrid for its hamlet of Valhalla to enhance the resiliency of electric service for 25 facilities in Westchester County in an area that is highly susceptible to flooding from both the Hudson River and Long Island Sound. The facilities to be served by the microgrid include multiple hospital buildings, a water distribution facility, and multiple large academic and public sector facilities.

As described on NYSERDA's website, "Microgrids are defined by the U.S. Department of Energy as a group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single, controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode." Microgrids that are localized, small-scale groupings of generating sources, storage systems, and loads are currently one of the biggest drivers of change in the electric power market. A major contributor to their rising popularity is their ability to easily integrate distributed generation sources such as combined heat and power (CHP), solar or wind. They also offer increased energy reliability and security, and carry a large economic cost saving opportunity. Microgrids have been installed at various universities, medical campuses, and military facilities.

As part of this microgrid competition, a feasibility study was developed to look at the technical, commercial and financial feasibility for implementing a microgrid. The regulatory challenges and socio-economic benefits of a community microgrid were also assessed. To concentrate the team's focus on specific microgrid implementation details for this specific geographic area, the study was divided into the four tasks outlined below:

1. Development of Microgrid Capabilities
2. Development of Preliminary Technical Design Costs and Configurations
3. Assessment of Microgrid's Commercial and Financial Feasibility
4. Development of Information for a Benefit Cost Analysis

The proposed microgrid would combine 22 distributed energy resources (DERs), including a new 8 MW natural gas-fired combined heat and power (CHP) system; two new rooftop solar photovoltaic (PV) arrays with a combined nameplate capacity of 500 kW; 17 existing diesel generators with a combined nameplate capacity of 5.32 MW; an existing 400 kW natural gas generator; and a new battery storage system located at the CHP plant. Of these, the CHP generator and two PV arrays would generate electricity under normal operating conditions, while the existing diesel and gas-fired generators would supplement production only during major power outages. The system would have sufficient generating capacity to meet average demand for electricity from all included facilities during a major outage. The microgrid will also be capable of providing frequency regulation, reactive power support, and black start support to the grid if required.

In addition, to assist with completion of the project's NY Prize Stage 1 feasibility study, IEc on behalf of NYSERDA, conducted a screening-level analysis of the microgird's potential costs and benefits. Their analysis suggests that if no major power outages occur over the microgrid's assumed 20-year operating life, the project's costs would slightly exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to exceed approximately 0.3 days per year.

However, after reviewing IEc's Benefit Cost Analysis (BCA) report and all of the input entries in its calculations the Valhalla Team disagrees with some of the input values that were utilized and has been reviewed with IEc for resolution. Input values were changed in the Valhalla Team BCA (see Appendices C.3 and C.4) for the following items: fuel costs and fuel cost escalation. With these revisions, the Valhalla Team Benefit Cost Analysis is more in line with the team's expectation that project benefits outweigh costs over the assumed 20-year operating life. In addition, the internal rate of return for the microgrid increases with the duration of a major outage. In addition, it should be noted that gas rates and electric rates local to the Valhalla area make this a favorable project.

For consistency with other NY Prize participants, this Final Report includes the detailed information provided by IEc.

Project Scope

The Valhalla Community Microgrid (VCM) study assessed the feasibility of a community microgrid to serve Westchester County's Valhalla Complex. Fifty-seven buildings located on the campus and several potential members in the surrounding area were evaluated for their suitability to be members of the community microgrid. The evaluation criteria included looking at the critical nature of the facility, thermal and electrical demands, close proximity to other suitable facilities, and compatibility with existing infrastructure. This application is sponsored directly by the County of Westchester.

The VCM incorporates a diverse mix of critical infrastructure and public facilities which will benefit greatly from CHP and Microgrid applications. These benefits include lower energy costs from savings available through local generation, energy savings due to the combined effect of generating electricity and steam in one application, increased reliability and resiliency, and a reduced carbon footprint.

The VCM will maintain critical loads with power provided from DERs, will adjust other loads, and will shed non-critical demands. It is also well-suited to match intermittent low-carbon renewable sources with a wide range of demand requirements. This combination of reduced losses and lower energy costs will also encourage business growth and provide new jobs that benefit the local, regional, and state economy.

Annual energy demand and use assessment for the VCM is provided below for the entire campus. The energy information was gathered from 2009 through 2015.

- Annual Electric Usage – 71,000,000 kWh/year
- Annual Electric Average Demand – 13.4MW
- Annual Steam Usage – 465,000 MMBTU
- The coincidence of heat/fuel and electricity usage will be determined from additional site/building/operations information

The VCM will benefit the environment through reduced CO2 emissions by combining energy generation in single package utilizing low emission fossil fuels with CHP capabilities and shifting towards renewable energy sources. Technologies like CHP can significantly reduce carbon emissions as proven in the widely publicized NYU study on Sustainability Progress from 2013. Using smart energy management, demand can be shifted to carbon-free generation such as solar to produce or store power. When an event shuts down the main grid, the VCM will provide a secure back-up energy source to maintain operations at several critical infrastructure facilities.

The VCM will have a Point of Common Connection (PCC) with the utility grid allowing it to import or export electricity as commercial or technical conditions dictate. The VCM will reduce the current stress on Con Edison's peak demands in the area. Both the Valhalla campus and Water District #3 Eastview Distribution Chamber are mission-critical and essential for community operations. Con Edison will benefit from potential "islanding" at a time of critical operations in case of a major weather event on the scale of Superstorm Sandy or an extreme heat wave.

Project Background

Westchester County's Valhalla campus is located in the suburbs of New York City roughly 30 miles north of Manhattan. The area has been struck by many severe weather events including ice storms, blizzards, hurricanes, and flooding over the last 20 years. Each storm has had increasingly deleterious effects on the local community causing power outages, road closures, and disruptions to daily lives of the local businesses and citizens. The goal of the microgrid is to provide and maintain power and heat in the form of steam to critical facilities. Islanding these facilities and maintaining power is critical during a power outage for the 1 million residents of Westchester County. The facilities include communication assets for the U.S. Department of Homeland Security which protects tens of millions of residents in the greater New York City area.

In keeping with the New York State energy plan, Reforming the Energy Vision (REV), the VCM will be a self-sustaining, independent local energy system. It will be designed to utilize a variety of Distributed Energy Resources (DERs) including both renewable and non-renewable energy sources. These DERs will be diversified energy components including natural gas-fired turbine (combined heat and power generation-CHP), photovoltaic solar (rooftop, ground mount, or carport), and battery storage. The three major components of Generation, Storage and Demand Response will be bundled into a controlled network, which may or may not be connected to the utility grid provided by our partners, Consolidated Edison (ConEd) and New York Power Authority (NYPA).

In addition to New York's REV, this project supports the goals of the Westchester County Economic Development Strategy for workforce development. Building the microgrid will be a major construction project that provides new jobs in the short-term. For the long-term, renewable energy deployment will ensure a more stable power system which provides job security and business continuity during emergencies. The VCM also advances goals of the Mid-Hudson Regional Economic Development Council Strategic Plan and the Cleaner, Greener Community Sustainability Plan. By decreasing the cost and improving the reliability of power, the VCM serves as a model project which addresses a key cost of doing business in Westchester Country.

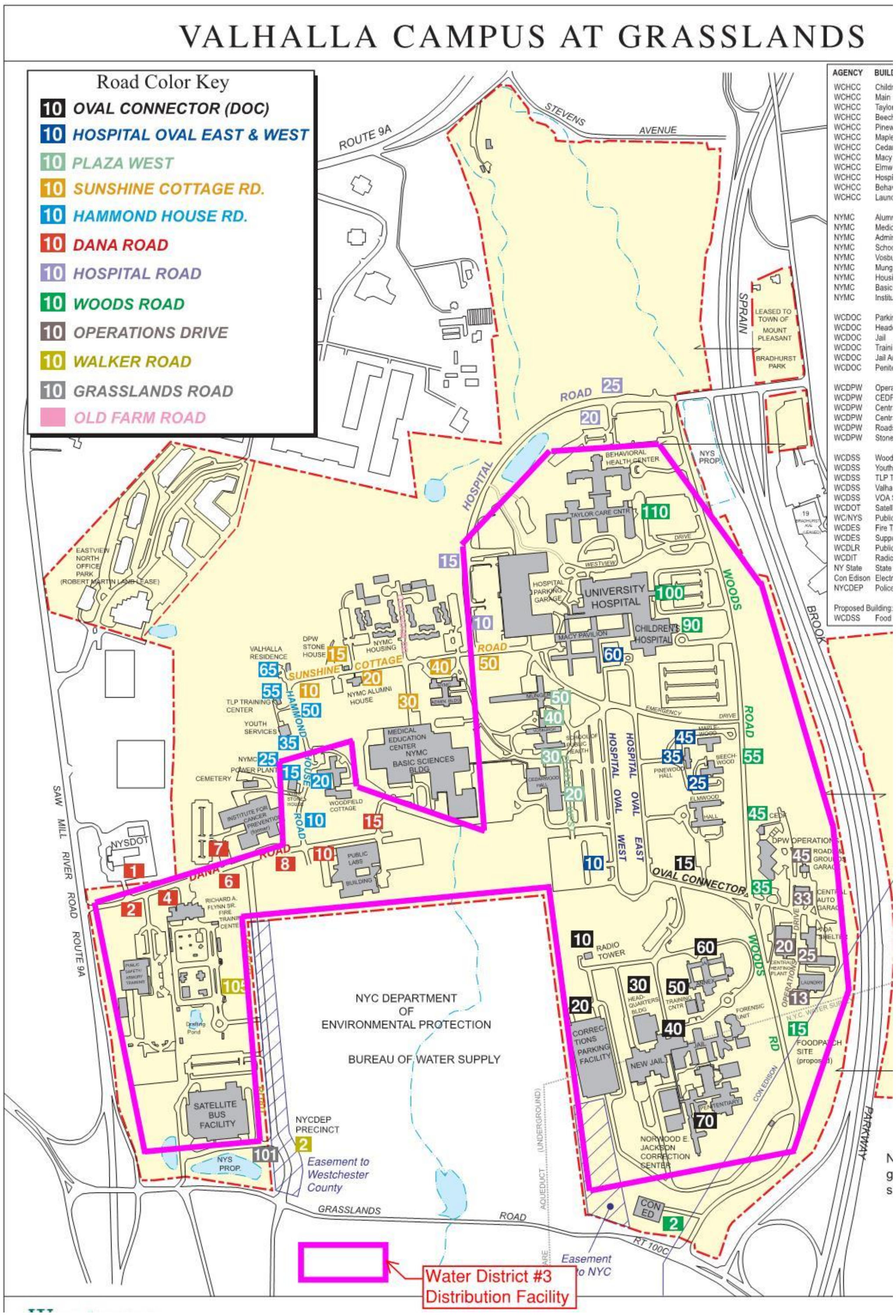


Figure 1: Members of the Valhalla Community Microgrid (VCM)

Development of Microgrid Capabilities

Critical Facilities Served

Various tenants and agencies that reside on the Valhalla campus. Specifically, a private corporation, the Westchester County Health Care Corporation (WCHCC), has a 95 year lease from the County for 100 acres of property largely bounded by Hospital Road and Woods Road. This is tantamount to outright ownership of the land and the approximately twelve buildings contained therein. These structures (University Hospital, Children's Hospital, Cedarwood Hall, Ruth Taylor Care Center, Behavioral Health Center, etc.) are all independently operated and maintained by the WCHCC. In fact, the WCHCC is on the verge of constructing another building on the parcel, Ambulatory Surgery Center, totally at their own expense. Said building will be supplied in the same manner as the others they "own", with both thermal and electrical energy from the County's central plants (estimated load increase is included in the proposed microgrid). The Volunteers of America (VOA), another independent entity, is a religious and social service organization having a long term building and property lease from the County. They provide assistance to seniors, needy families, veterans and persons with disabilities, as well as operating a homeless shelter. Again, they purchase steam and electricity from the County's distribution facilities. Similarly, the New York Medical College (NYMC) has a sixty year lease from the County for buildings and pertinent land. Their Alumni House, Administration Building (Sunshine Cottage), Clinical Sciences Pavilion, School of Public Health are all maintained and virtually owned by the NYMC. While these buildings have their own independent, privately maintained, heating sources, they are County customers regarding electrical power. Finally, the new Westchester Water District No. 3 treatment and pump station is nearing the construction stage, and is a regional water authority, funded by separate tax warrants from the villages of Briarcliff Manor, Sleepy Hollow and Tarrytown. This structure will have a self-contained heating system, but will buy electricity from the County.

The end users of electricity are the various tenants and agency that reside at the campus purchase their electricity from Westchester County. It is evident that the very infrastructure that a large and therefore efficient Microgrid powerplant would require (centralized production of heat and electricity), already exists at this subject location. That is, a network for the distribution of thermal and electrical energy, combined with suitable back-up power supplies commensurate with the critical nature of the serviced facilities. Both, the existing Con Edison feeder system and the County operated steam boiler plant are capable of producing enough power for the specified buildings. Operation of the Microgrid CHP unit(s) could be folded into the existing steam boiler plant which is currently manned 24/7 by County personnel. To further demonstrate resilience, the various buildings and structures have large standby electric power generators already in place.

The VCM contains several critical facilities, the WCHCC, the Westchester County Radio Tower (WCRT), the Westchester County Public Labs (WCPL), Westchester County Bus Depot (WCBD), and Westchester County Water District #3 (WD3).

The WCHCC is affiliated with the New York Medical College and is listed as the University Hospital located at 100 Woods Rd. Westchester Medical Center has approximately 28,000 visits a year to their emergency room and has over 650 patient beds to treat various ailments.

In the event of a disaster or emergency, the Westchester County Radio Tower provides an essential means for communicating and disseminating information via commercial and government radio waves.

The Westchester County Public Labs provide a range of scientific testing solutions in the fields of criminal evidence and public health. This facility provides testing for emergency response, bio-defense, and related incidents as a member of the nationwide CDC Laboratory Response Network for the seven (7) surrounding counties in the lower Hudson Valley.

The Westchester County Cerrato Bus Facility provides maintenance, storage and dispatching for Westchester County's Bee-line bus services. During emergencies, up to 110 buses (as well as their drivers) can be directed to stand-by at this bus facility. They are dispatched to pick up or transport emergency personnel as needed, provide additional service during power outages or road closures, and assist in evacuating large numbers of people from disaster areas.

The Westchester County Water District #3 Distribution Chamber provides pre-treated (both chemical and ultraviolet) water, which is then further treated and distributed as potable water by the Westchester County villages of Tarrytown, Sleepy Hollow, and Briarcliff Manor. WD3 is separate and distinct from typical County government and is funded by, and acts on behalf of the municipalities it solely supports. The Valhalla campus is an additional member of WD3, and there is a planned expansion of the Distribution Chamber to build a pumping station which serves the whole campus (WD3 Eastview Pumping Station).

These buildings will be tied to the reliable electric service provided by the VCM. In addition, steam from the new CHP unit will provide thermal energy throughout the campus to the existing steam users.

Primary Generation Source and Diesel Generators

The primary generation source capacity will not be totally diesel fueled generators. The proposed microgrid will be designed to utilize a variety of Distributed Energy Resources (DERs) from both renewable and non-renewable energy sources. These DERs will be diversified energy components including CHP (natural gas-fired turbine), roof mounted solar photovoltaic panels, battery storage, and diesel fueled generators. Primary generation will include CHP, solar PV panels, and battery storage. Diesel fueled generators will be utilized to meet peak electrical demand that is in excess of the primary generation when the microgrid is operating in islanded mode only. Below is Table 1 listing all of the proposed DERs:

Table 1: Proposed VCM DERs

No.	DER	Capacity	Other
1	New CHP Unit 1	8MW	125psi steam (unfired) 36.37klb/hr, 125psi steam with duct burners 159.53klb/hr, natural gas, Fuel Consumption: 9.955 MMBTU/MWh
2	New DG Unit 1 - Battery Storage	1.0MWh	
3	New PV Unit 1	250kW	availability factor - 15%
4	New PV Unit 2	250kW	availability factor - 15%
5	Existing DG Unit 1	175kW	diesel-fired, Fuel Consumption: 210 gals/day
6	Existing DG Unit 2	150kW	diesel-fired, Fuel Consumption: 185 gals/day
7	Existing DG Unit 3	40kW	diesel-fired, Fuel Consumption: 57.6 gals/day
8	Existing DG Unit 4	100kW	diesel-fired, Fuel Consumption: 128 gals/day
9	Existing DG Unit 5	400kW	diesel-fired, Fuel Consumption: 458 gals/day
10	Existing DG Unit 6	425kW	diesel-fired, Fuel Consumption: 486 gals/day
11	Existing DG Unit 7	500kW	diesel-fired, Fuel Consumption: 584 gals/day
12	Existing DG Unit 8	100kW	diesel-fired, Fuel Consumption: 128 gals/day
13	Existing DG Unit 9	100kW	natural gas-fired, Fuel Consumption: 1157 therms/day
14	Existing DG Unit 10	750kW	diesel-fired, Fuel Consumption: 871 gals/day
15	Existing DG Unit 11	30kW	diesel-fired, Fuel Consumption: 46 gals/day
16	Existing DG Unit 12	300kW	diesel-fired, Fuel Consumption: 336 gals/day
17	Existing DG Unit 13	500kW	diesel-fired, Fuel Consumption: 584 gals/day
18	Existing DG Unit 14	500kW	diesel-fired, Fuel Consumption: 584 gals/day
19	Existing DG Unit 15	300kW	diesel-fired, Fuel Consumption: 336 gals/day
20	Existing DG Unit 16	250kW	diesel-fired, Fuel Consumption: 286 gals/day
21	Existing DG Unit 17	300kW	diesel-fired, Fuel Consumption: 336 gals/day
22	Existing DG Unit 18	500kW	diesel-fired, Fuel Consumption: 584 gals/day

The current electrical sources for existing facilities are Con Edison's electrical grid with backup diesel generation, in case of emergencies such as loss of grid power. The primary source of heat and hot water is from a centralized Steam Plant with a network of underground pipes. The Steam Plant utilizes natural gas as its primary fuel, with fuel oil as a backup.

Over 75% of the critical and active facilities included in the proposed microgrid have backup diesel generation at this time. These facilities utilize the backup diesel generators in emergencies only and they currently do not cover the facilities' entire peak demand. The proposed microgrid DERs (CHP, PV, battery storage and existing diesel-fired generators) will rectify this situation and will have sufficient capacities to cover the peak demand of the site. However, not all facilities are operated 24 hours a day, 7 days a week nor are critical facilities, therefore load shedding would be deployed during emergency situations to lower the energy demand. By load shedding the microgrid will be able to maintain a longer event duration with the onsite fuel storage. This will allow the goal of providing a power source capable of providing the facilities with 24/7 operation and power supply for a minimum of one week achievable. None of these facilities currently participate in any demand response programs with NYPA or Con Edison. However, participation in a demand response program may alter the tiered rating of all site generators. The Environmental Protection Agency (EPA) emissions standards provide a tiered timing structure of emission allowances based on the systems' engine horsepower rating and its status as an emergency or non-emergency generator. This will be further investigated and evaluated at a later design stage.

Combination of Technology for Grid Connect and Islanding

A combination of generation resources will provide power in both grid-connected and islanded mode. The primary generation source will include CHP, solar PV panels, and battery storage. During normal operation (grid-connected mode), the utility will be utilized to meet the peak electrical demand (or the load in excess of the on-site primary power generation). However in islanded mode only, the existing diesel fueled generators will be utilized to meet peak electrical demand.

Formation of an Intentional Island and Restoration to Grid

The proposed microgrid design will be able to form an intentional island. The appropriate disconnecting means as well as protection and control system will be implemented to allow the owner to intentionally form an island if the owner decides to initiate this for reasons related to weather, homeland security, economics, or other natural or man-made events. Intentional islanding will be achieved manually by making sure the 43 Selector Switch in the Remote Control Panel of the 15kV Switchgear inside the Central Electrical Distribution Facility (CEDF) on the Valhalla campus is set to local. 15kV Breakers 101, 102, 103, and 104 will then be opened to disconnect the utility from the campus (refer to the simplified one-line diagram shown in Appendix A.1). In addition, islanded mode shall be selected within the master microgrid controller which will automatically cycle through a preset checklist of items to verify and set parameters including adjusting the relay settings group for the 15kV distribution feeder breakers.

For unplanned islanded operation, IEEE standard 1547 requires automatic detection and disconnection of all DERs within a maximum of two seconds. Rapid islanding detection enables circuit breakers which connect the DERs to the main utility grid to be tripped and allows for resynchronization at a later time when conditions permit.

Upon restoration to grid, the reverse process would be undertaken. The breakers 101, 102, 103, and 104 will be closed only if the appropriate synchronizing steps were taken. The detailed procedure for intentional islanding and restoration will be developed during the design phase of this project.

The microgrid will include an operation and maintenance service contract with a proposed equipment provider. The equipment provider through their networked control environment will monitor and operate the system on a 24-hour basis. These services are currently supplied in New York State for utilities such as National Grid and NYSEG and throughout the US to major utilities such as Duke Energy.

Compliance with Manufacturer's Maintenance Requirements and 24/7 Power Utilization

The microgrid will include an operation and maintenance service contract with a proposed equipment provider. The equipment provider through their networked control environment will monitor and operate the system on a 24-hour basis. These services are currently supplied in New York State for utilities such as National Grid and NYSEG and throughout the US to major utilities such as Duke Energy.

In addition, the CHP unit will be furnished with a service agreement from the manufacturer that will provide personnel to periodically maintain and service the equipment. The agreement will include refurbishment of the machine at periodic intervals.

The microgrid will include a CHP (natural gas-fired turbine with a firm supply of natural gas), photovoltaic generating system, with battery storage, that will allow for capabilities to provide power 24 hours per day and seven days per week.

Two-way Communication with Control Center

An existing communication path is already in place between the Valhalla campus and Con Ed at the CEDF building on campus. To enable to a two-way communication path throughout the campus, a master microgrid controller will be utililzed which will be designed to manage and control distributed power generation plants and loads that use renewable and non-renewable energy resources. Communication to the generation plants as well as loads is achieved using various communication protocols, including bi-directional communications for control and one-way communication for system monitoring and reporting as shown in Appendix A.4 with the IT Infrastructure. The master controller will be connected to each building and DER control node via a redundant communication path. All high level communication protocols used by the microgrid controller will be based on either standard Ethernet TCP/IP or UDP and the expectation is that it will communicate with existing SCADA/BMS systems at the Valhalla campus buildings and Water District #3. Westchester County, as the owner or its service provider, will have access and control of all data and set points.

Customer Diversity

The rate class of each of the facilities included in the microgrid are large Commercial/Industrial (>50 annual MWh). The proposed microgrid will not include any type of housing. However, it will include water services, academic facilities, public sector facilities, hospital facilities, and a jail complex. These include 25 varied-use facilities.

Total site peak electrical demand is 13.4MW.

The detailed data below represents the average total energy consumed per year for each facility on the Valhalla campus in MWh (data taken from 2009 to 2015):

- Macy NW (SE-4)/Macy NW (SE-4A)/Macy SW (SE-5): Total 3,439.35 MWh
- Maplewood/Beechwood Halls (SE-7): 651.79 MWh
- Children's Hospital (SE-8): 8,915.55 MWh

- Behavioral Health/Taylor Care (SE-9): 4,483.43 MWh
- WC Corrections East (SE-10): 1,885.69 MWh
- WC Jail Annex (SE-11): 1,073.11 MWh
- WC Corrections West (SE-12): 14,220.45 MWh
- WC Swgr/Operating Bldg (SE-14): 353.91 MWh
- WC Central Heating Plant (SE-15): 1,643.71 MWh
- Woodfield Cottage (SE-16): 521.37 MWh
- Elmwood Hall (SE-17): 1,284.57 MWh
- Cedarwood Hall (SE-18): 1,424.92 MWh
- WC Bus Facility (SE-19): 2,284.05 MWh
- Stonehouse (SE-20): 564.96 MWh
- NYMC Sunshine Cottage (SE-21): 491.60 MWh
- NYMC Munger Pavilion (SE-22): 234.76 MWh
- NYMC Vosburgh Pavilion (SE-23): 1,257.79 MWh
- Hospital Chiller Plant (SE-24): 2,888.87 MWh
- Hospital SB#1 (SE-25): 8,129.38 MWh
- Hospital SB#2 (SE-26): 9,914.90 MWh
- Public Health (SE-27): 6,201.92 MWh
- WC DPS/Fire Training Center (SE-28): 2,125.19 MWh
- Water District #3 Distribution Facility: 2,102.40 MWh

<u>Uninterruptible Fuel Supply or One Week On-site</u>

The fuel supply provided for power generation will be uninterruptible. The proposed microgrid will provide a diverse local energy generation mix including a natural gas-fired CHP with a firm supply of natural gas combined with renewable energy photovoltaic panels and battery storage which will act as the primary generation. Existing on-site diesel fueled generators will be available to meet peak electrical demand in islanded mode. All of the existing diesel fueled generators have storage tanks containing fuel for two to twenty days of continuous use. An additional fuel oil storage tank to supplement the existing diesel-fired generators will not be required to ensure a minimum of one week of fuel supply is available if load shedding is implemented during islanded mode.

<u>Black Start Capability</u>

The proposed CHP plant will be composed of a natural gas-fired turbine. We anticipate the gas supply to be firm which will limit the possibility of a loss of fuel supply. However, in case a black start is required, Westchester County has two portable 500kW diesel fueled generators. These portable generators would be relocated to the CHP plant in order to black start the unit. The CHP's switchgear will be designed for connecting portable generators for black start capability. In addition, all of the existing diesel-fired gensets are capable of providing black start.

Advanced, Innovative Technologies

Microgrid logic controllers, smart meters, and the energy storage will be utilized within the design. The dual purpose of utilizing the battery storage for black start capabilities and electrical demand management will be further evaluated in the next stage of microgrid study.

Active Network Control

The master microgrid logic controller, with its software, will optimize the electrical supply and demand through its active network control system. Customer interaction with the microgrid will be available through microgrid master controller in conjunction with the slave controllers at each DER. The microgrid master controller will provide all controls and information in a central location. The entire system will be designed with smart devices so that all microgrid utilization metrics and controls are available to the end user, Westchester County. Please refer to Appendix A.4 for a diagram of the IT infrastructure.

Energy Efficiency and Demand Response Options

Energy efficiency and demand response will be an integral component of the proposed microgrid. The use of a CHP unit will greatly add to the efficiency of electrical and thermal generation by combining these generation sources into one unit. Demand response will be utilized in conjunction with smart meters and hourly energy usage collected building by building to provide energy reduction measures that are customized for each facility which will include load shedding by turning off lighting, air conditioning, pumps, and other non-essential equipment during periods of high electrical demand. At this time fixing the the steam leaks would be a part of the energy efficiency measures. Since our microgrid will be encompassing many buildings, it would be the intent to provide smart meters and provide the knowledge to the tenants of each building of their real-time energy usage for them to take the appropriate energy savings measurements to save money.

System Integration

The existing configuration at the Valhalla campus has four (4) 15kV Con Ed feeders terminating at Westchester County's Central Electrical Distrubtion Facility (CEDF) where Westchester County is the purchaser of electricity (supply through NYPA; distribution through Con Edison) and from there electricity is distributed through a 15kV network that is operated and maintained by the County. The existing campus has an underground 15kV electrical distribution as well as a 125psi high pressure steam distribution network already in place. As such, the primary infrastructure or backbone of the microgrid is already established. Distributed energy resources will be added to provide generation sources to the existing infrastructure. The thermal energy will be distributed via the existing 125psi high pressure steam network. The steam will be stepped down to 15psi at each of the buildings where it will be utilized for heat and also converted to hot water.

Coordination with Reforming the Energy Vision (REV)

The proposed microgrid not only provides the Valhalla campus and surrounding area with reliable and local generation but supports New York State REV initiatives. With the addition of smart meters and a cloud-based control system, Westchester County and its users will have a better understanding of their energy usage, not just at the end of the month or end of the year, but on a day to day and hour to hour basis allowing the campus to make a more informed choice to their energy usage. Information is the basis of good energy management! In addition, the planned use of PV panels and energy storage will be bringing renewable energy sources to the campus and contribute to a reduction in carbon emissions.

Cost-Benefit Analysis and Private Investment

The system will create low cost power and will save an estimated $3.5M dollars per year in energy savings. This will have a tremendous benefit to the County and the tax payers as this money can be diverted. The new system will be more reliable and will contain a stronger infrastructure.

NYPA and Westchester County are public entities and cannot accept private capital. Either NYPA or the County will provide funding for the project.

Clean Power Supply Sources

With the introduction of a CHP system, this will provide a much more efficient use of the site's fuel source to provide combined electrical and thermal generation which is a large improvement over the national average of approximately 50% for these services when separately provided. Along with CHP, the solar PV plant and battery storage will provide a renewable energy source that will reduce the site's carbon emissions and minimize environmental impacts. By combining the heat and power generation it's estimated that this CHP project will avoid yearly emissions of greenhouse gases by 30,500 tons of carbon dioxide as per Table 2 below (calculations developed per EPA's Combined Heat and Power Emissions Calculator):

Table 2: CHP Unit Reduction of Carbon Footprint

Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	37.39	17.84	46.87	27.32	42%
SO_2 (tons/year)	-	0.67	0.27	0.95	100%
CO_2 (tons/year)	69,664	45,352	54,790	30,479	30%
CH_4 (tons/year)	1.31	1.568	1.03	1.287	49%
N_2O (tons/year)	0.13	0.180	0.10	0.152	54%
Total GHGs (CO_2e tons/year)	69,732	45,441	54,844	30,553	30%
Fuel Consumption (MMBtu/year)	1,191,848	773,550	937,384	519,086	30%
Equal to the annual GHG emissions from this many passenger vehicles:				5,842	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				2,916	

Community Benefits

The proposed microgrid will tie into Westchester County's "Sustainable Westchester, Inc." initiative. Sustainable Westchester is a consortium of Westchester County local governments that facilitates effective sustainability initiatives, engages community stakeholders, and shares tools, resources, and incentives to create healthier, vibrant and attractive communities, now and in the future. The Valhalla microgrid will be an important pilot project that models the benefits and various applications of a community microgrid to encourage future, even larger projects in Westchester County.

The use of CHP, photovoltaic panels and battery storage will be utilized in order to gain a mix of generation that reduces the carbon footprint and delivers energy savings to the community. In addition, the microgrid will provide value to various parties affiliated with the project. The microgrid's capital expenditure payback is expected to be ten years. At which time the annual savings of $4.2 million is expected to be passed onto the end user in lower electric bills. The community will see its property value increase in direct proportion to the reliability and resiliency added to its electric grid. Based on feedback during a working session with Con Edison, they do not see any impacts to their system if the microgrid was implemented. The utility may defer long range plans to upgrade equipment within this particular load pocket. Suppliers will benefit from the experience of participating in this microgrid while building their resume and deploying new innovative technologies. NY State will benefit from gaining knowledge of implementing a successful deployment of a microgrid as well as moving towards meeting REV goals. In addition, its estimated that approximately 1,400 temporary and permanent jobs will be created based on the estimated 20-year lifecycle of the microgrid including engineering, construction, testing, maintenance, and operations personnel.

Customer Interaction with Grid

Westchester County, as the owner of the microgrid, will be collecting a large amount of electrical and thermal energy usage information. They will be able to pass this information along to building tenants and other occupants on campus for their use. Energy usage could be minimized through consolidating building space, alter work schedules, adjust thermostats, utilize shades and blinds to control direct sunlight into buildings, and other communication and educational initiatives to show how behaviors affect energy usage . This will be empowering the tenants to make more informed decisions on how they utilize energy for their business needs.

Develop Preliminary Technical Design Costs and Configuration

Microgrid operation description

The proposed microgrid will be capable of operating during normal (grid-connected mode) and emergency (islanded mode) conditions. During normal operation, the microgrid and its onsite renewable and natural-gas fired generation sources (CHP, PV, and battery storage) will operate in dispatchable mode and follow the load while providing electrical and thermal energy. Energy in excess of the 8.1MW provided by the microgrid will be provided by the connected utility. During emergency operation, the microgrid and its onsite renewable and natural-gas fired generation sources will change the output control of the generators from a dispatch power mode to a frequency mode while following the load and providing electrical and thermal energy. Energy in excess of the 8.1MW provided by the microgrid CHP, PV, and battery storage sources will be provided by the onsite diesel-fire generators (which will require modification to the existing control scheme for the onsite diesel generators.) The microgrid master controller will be actively monitoring and adjusting the generating sources in order to maintain voltage and frequency stability. The main control of this microgrid will be a master/slave control scheme where the CHP unit will act as the master DER and the other DERs will be slaves. The master microgrid controller will utilize the CHP unit to set the reference voltage and frequency. The other DERs will be adjusted to inject active and reactive power to maintain voltage magnitude and frequency. The master/slave control scheme is reliant on the fact that the microgrid has enough storage capability to inject the power required for stabilization. In emergency mode (or islanded), the microgrid may not have enough generation resources or storage capacity to maintain the voltage and frequency at which time a load shedding scheme will be initiated by the master microgrid controller to lower the peak demand load on the system. A load shedding scheme listing the largest, most disruptive loads to the smallest, least disruptive load will be complied and prioritized based on the critical nature of these loads on campus. The load shedding signal will be dispatched from the master microgrid controller to the control nodes at each of the buildings and will slowly shed large loads that are not critical to the campus' operation until voltage and frequency stabilization is established. The detailed procedure for load shedding will be developed during the design phase of this project.

See Appendix A simplified equipment layout and one-line diagrams for the proposed microgrid. New infrastructure is indicated by dark, black lines. Existing infrastructure is indicated by light, gray lines.

Electrical and Thermal Load Characteristics

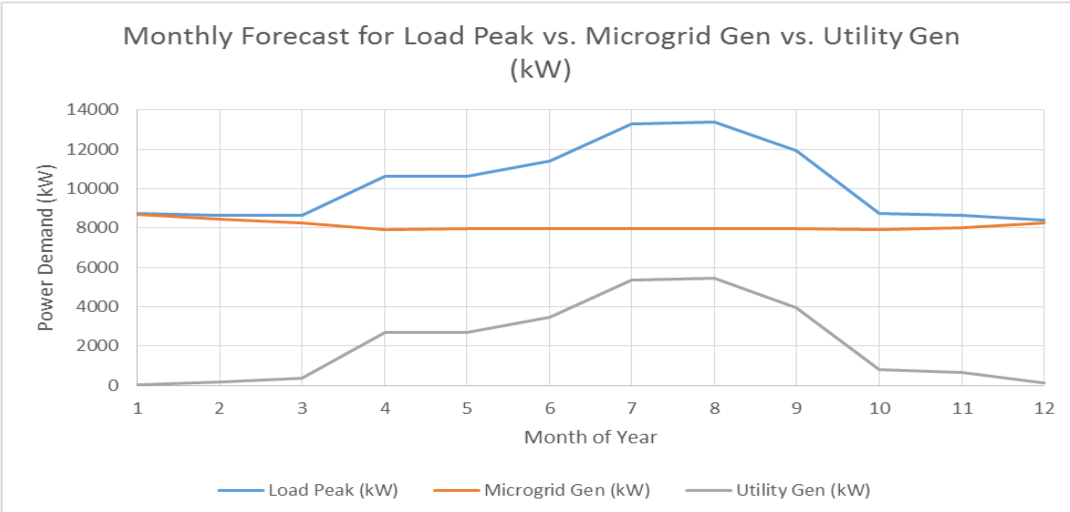
Grid Connected Mode:
Microgrid Generation (CHP+PV+Battery Storage) will provide electrical energy (kWh) for 92% of the historical yearly consumption and will provide thermal energy (MMBTU) for 98% of the historical yearly consumption.

The detailed data listed below is over the course of single year for Peak Demand and Total Annual kWh (2015). However, the Demand average and total energy average was averaged from 2009 to 2015.
Total Peak Demand kW: 13,392; Total Average kW: 8,123; Total Annual kWh: 71,159,119
Total Monthly (Average) kWh: 5,929,926; Total Weekly kWh: 1,368,444
Microgrid Generation Peak kW: 8,693; Microgrid Generation Annual kWh: 65,785,281
Microgrid Generation Monthly kWh: 5,482,106; Microgrid Generation Weekly kWh: 1,265,101
Utility Generation Peak kW: 5,439; Utility Generation Annual kWh: 5,373,838
Utility Generation Monthly kWh: 447,819; Utility Generation Weekly kWh: 103,343

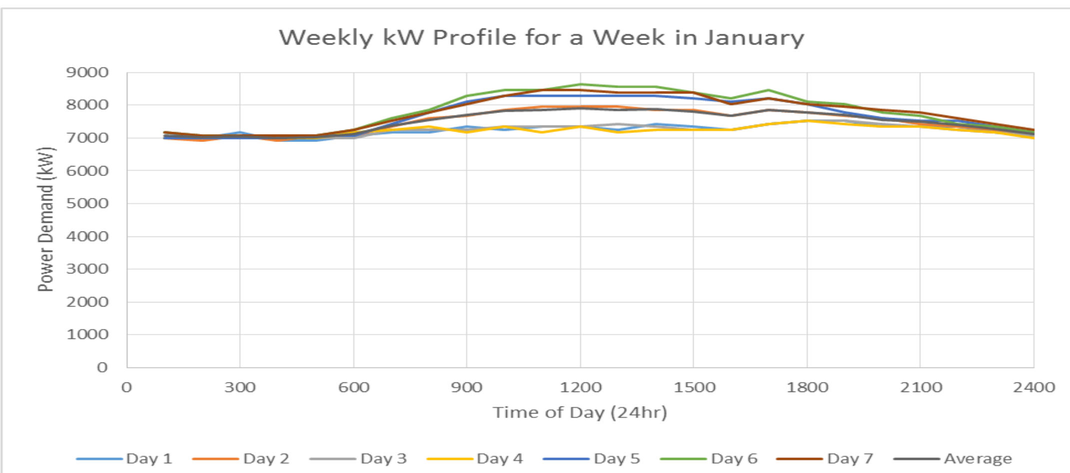
Annual MMBTU consumed: 475,370; Monthly MMBTU consumed: 39,614
Weekly MMBTU consumed: 9,141
Annual MMBTU recovered: 464,560; Monthly MMBTU recovered: 38,713
Weekly MMBTU recovered: 8,933

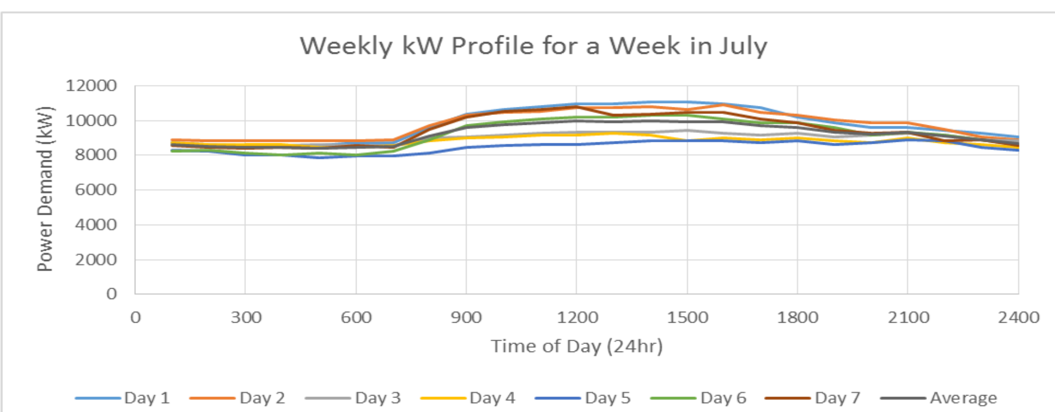
Island Mode:
Microgrid Generation (CHP+PV+Battery Storage) will provide electrical energy (kWh) for 92% of the historical yearly consumption and will provide thermal energy (MMBTU) for 98% of the historical yearly consumption. The gap between energy demand and generation will be equaled out by utilizing the onsite diesel generators or load shedding.
Total Peak Demand kW: 13,392; Total Average kW: 8,123; Total Annual kWh: 71,159,119
Total Monthly (Average) kWh: 5,929,926; Total Weekly kWh: 1,368,444
Microgrid Generation Peak kW: 8,693; Microgrid Generation Annual kWh: 65,785,281
Microgrid Generation Monthly kWh: 5,482,106
Microgrid Peak Support kW (onsite diesel generators or load shedding): 5,439

Annual MMBTU consumed: 464,560; Monthly MMBTU consumed: 38,713
Weekly MMBTU consumed: 8,933
Annual MMBTU recovered: 464,560; Monthly MMBTU recovered: 38,713
Weekly MMBTU recovered: 8,933



<u>Hourly Load Profile</u>





<u>Load Sizing</u>

Peak Demand for the site is 13MW. However, it's not recommend to size the CHP unit to meet the peak demand. This would be to avoid the constant ramping down of the turbine. The CHP at 8MW and 500kW solar combined (with energy storage) will provide about 92% electricity needs (for all facilities) and 98% of the steam load.

Proposed Generation Assets:
1. 8MW natural gas-fired CHP (with heat recovery steam generator). The proposed unit is a Solar Taurus 70. This unit will be able to meet approximately 90% of the annual energy needs of the entire microgrid. The unit can provide approximately 98% of the total steam requirement (baseloaded year round).

2. 500 kW solar PV - this will provide approximately 2% of the annual energy needs of the entire microgrid.

3. Supplemental Resources
a. Electricity: the existing diesel generators across the site will be utilized to meet peak loads during island mode operation when load is above CHP plus solar PV capacity
b. Steam: the remaining majority of steam required by the Jail and Public Labs should continue to come from the central steam plant
c. Manual load shedding scheme shall be implemented to lower the peak demand. The possibility of utilizing automatic controls will be evaluated at a later stage.

4. Redundancy
a. Electricity: There are four Con Edison feeders that terminate at the Central Electrical Distribution Facility (CEDF) for grid connection. In addition, there are two feeders that are routed from the CEDF to each building for feeder redundancy on campus. Currently, the proposed microgrid includes one (1) Solar Taurus 70 turbine (8MW) for CHP. Further evaluation will be considered in the next stage based on payback, economic incentives, and unit availability; in addition to other factors to determine if one unit is sufficient or two (2) Solar Mercury 50 turbines (4MW each) would be appropriate. The use of two units rather than one may be advantageous due to downtime during maintenance and other times when the CHP unit would be unavailable. This would be further evaluated during the next design stage.

b. Steam: additional boilers will be further evaluated at a later stage to determine if they are required to augment the steam production of the CHP.

<u>DER Locations</u>

See Appendix A simplified equipment layout along and one-line diagrams of the proposed microgrid. New infrastructure is indicated by dark, black lines. Existing infrastructure is indicated by light, gray lines. New DERs will include: a CHP plant, a battery storage facility, and two PV plants which will be roof mounted on the Public Labs building and DPS Training Center. The proposed new CHP plant and battery storage facility will be located in close proximity to the existing Central Steam Plant in order to re-use the existing steam distribution network and 15kV electrical distribution network that is already in place.

The proposed new CHP plant and battery storage facility is anticipated to occupy approximately 10,000 square feet (or one third of an acre). The rooftop PV units are anticipated to occupy approximately 18,000 square feet of rooftop space each.

DER Adequacy and Resilience to Forces of Nature

The proposed DERs include natural gas-fired CHP, solar PV, battery storage, and existing diesel-fired generators. The historical information from the proposed CHP unit manufacturer indicateds the unit has a 96% availability factor. Routine down time for the CHP unit is two days to perform maintenance. The CHP until will be backed up with standby boilers to provide the appropriate thermal energy in times of need. The utility, solar PV, battery storage, and onsite diesel generators will provide support during times the CHP is unavailable.

System resiliency is inherent and a top priority in the microgrid design. The existing campus has an underground 15kV electrical distribution as well as a 125psi high pressure steam distribution network already in place. As such, the primary infrastructure or backbone of the microgrid is already established. Distributed energy resources will be added to provide generation sources to the existing infrastructure. The entire campus is elevated and not located in a flood zone which alleviates the concern for flooding and the need for storm hardening. The CHP plant, solar PV plants, and battery storage will be designed to resist seismic and wind loads for this area of the country. Also, since by its nature PV generation is variable and can very quickly decrease in contribution to the system (i.e. increased cloud cover or snow covering PV panels), the MMC will incorporate additional margin of standby generation (either from the utility or onsite diesel generators) for when contribution is high to ensure there will always be adequate generation available to support the load. The rest of the electric and thermal distribution systems are located underground which provide protection and mitigation from most forces of nature.

DER Fuel Sources

The microgrid will include a CHP (natural gas-fired turbine with a firm supply of natural gas), photovoltaic generating system, with battery storage, that will allow for capabilities to provide power 24 hours per day and seven days per week. The proposed CHP unit has the capability of being purchased and utilized as a dual fired unit with fuel oil, however, at this time a dual fired unit is not being considered due the added cost of a dual fuel system, storage tank, and fuel forwarding system. In addition, the onsite diesel generators all have storage tanks that range in capacity for continuous use from 2-20 days. In general, the microgrid will be capable of providing continuous operations for a minimum of a week in islanded mode if a load shedding scheme is implemented.

DER Capabilities

The master microgrid controller will have the capability to utilize the DERs to follow the load, operate at part load and maintain voltage and frequency in islanded mode. The microgrid design of all equipment, installation, and functioning will be strictly based on Con Edison standard interconnection specifications EO-2022 and EO-4133 and EO-2115. In addition, the proposed microgrid will utilize a master microgrid controller and a digital voltage regulator to monitor and automatically adjust itself by following the load to regulate the voltage and frequency in grid-connected mode and meet the requirements of ANSI C84-1 in islanded mode. The digital voltage regulator has three control modes: automatic voltage regulation, power factor regulation, and reactive power regulation. The regulator has programmable stability settings, soft start control with an adjustable time setting in automatic voltage regulation mode, dual slope voltage versus frequency (V/Hz) characteristic, three-phase or single-phase voltage sensing, single-phase current sensing, and ten (10) relay protective functions. Load transfer system will be installed in turbine building which will enable stabilizing the generation system in the event of a total supply interruption from the utility. This load transfer will be initiated from signals from frequency sensors and upon reaching an alarming situation in the rise of rate of decline of frequency, signals will be initiated to trip the 15kV breakers in the County's CEDF substation.

Signals for the load transfer system will be transmitted through either an existing or extended fiber optic network.

Electrical and Thermal Infrastructure

The Valhalla buildings included in the microgrid are served by a well-established infrastructure (15kV electrical distribution and 125psu steam distribution) which will minimize the amount of new equipment required and construction costs for implementation. The existing steam piping network between buildings will be re-used and the underground electrical distribution system will be augmented with smart meters and new switching equipment where applicable. The CHP plant will be located in close proximity to the existing Central Steam Plant in order to minimize and simplify connecting the steam piping to the central steam distribution network. New 15kV switchgear will be installed near the site's Central Electrical Distribution Facility (CEDF) containing a high speed auto transfer system, CTs, PTs, breakers, relay protection. A feeder will connect the new CHP plant to this new switchgear. In addition, a feeder will be installed between the 15kV CEDF switchgear to the microgrid switchgear. The PV plants will be roof mounted units and will connect to the electrical system at that building. In addition, the existing diesel-fired generators that are spread out throughout the campus will be maintained in their present configuration and utilized to meet peak demand while operating in islanded mode. See Appendix A simplified equipment layout and one-line diagrams of the proposed microgrid.

Electrical and Thermal Infrastructure Resiliency

System resiliency is inherent and a top priority in the microgrid design. The existing campus has an underground 15kV electrical distribution as well as an underground 125psi high pressure steam distribution network already in place. As such, the primary infrastructure or backbone of the microgrid is already established. The existing distribution infrastructure is well hardened as all steam piping and electric is run undergrounds between buildings. In addition, the entire campus is elevated at an elevation of 300-400ft (or 300-400ft above sea elevation) and not located in a flood zone which alleviates the concern for flooding. The CHP plant and solar PV plants will be designed to resist seismic and wind loads for this area of the country. The rest of the electric and thermal distribution systems are located underground which provide protection and mitigation from most forces of nature.

Microgrid Interconnection

The microgrid will contain two points of interconnection to the grid. One at the CEDF and the other at Water District #3 Distribution Facility.

A redundant transfer trip system will be provided that will enable tripping of respective incoming 15kV circuit breaker at Westchester County's Central Electrical Distribution Facility (CEDF) on the Valhalla property upon tripping of the relevant breaker in Con Edison's Grassland Road substation. This system will also communicate via dedicated telephone lines.

A remote operating Synchronizing system will be provided that will enable synchronizing of local generation with the incoming utility circuits specially when total utility system gets isolated and re-appears as a result of a serious fault in the utility network. A SCADA system will be installed to provide status information of selected 15KV circuit breakers and metering data to Con Edison's substation via a dedicated telephone line.

The design of all equipment, installation, and functioning will be strictly based on Con Edison standard specifications EO-2022 and EO-4133 and EO-2115.

Microgrid Control Architecture

A master microgrid controller (MMC) and energy management system (EMS) will be utilized to manage and control distributed power generation plants and loads that use renewable and non-renewable energy resources at the Valhalla property. Communication to the generation plant as well as loads is achieved using various communication protocols, including bi-directional communications for control and one-way communication for system monitoring and reporting. All high level communication protocols used by the microgrid controller are based on either standard Ethernet TCP/IP or UDP and the expectation is that it will communicate with existing SCADA/BMS systems at the Valhalla campus and Water District #3. Westchester County will have access and control of all data and set points.
The network control will consist of a master microgrid controller and energy management system located at Westchester County's Public Works/Operations building on the Valhalla campus. A 'slave' controller will be located with all of the DERs as well as all building management systems and connect to the MMC and EMS. Through this network of master controller and slave controllers, the microgrid will be capable of monitoring and adjusting itself based on the real-time status of the system. The MMC will allow synchronization between the main grid and Microgrid. It can control power flow across the connection by controlling the power consumption/ generation of the electrical devices in the Microgrid. For locations of the control architecture, please see Appendix A simplified equipment layout diagram.

Load Shedding Controls

The existing site has a BMS style management system that only monitors large equipment such as chillers and boilers. This monitoring system provides real-time data only and does not allow for historical trending. This system would be upgraded and replaced by the MMC and EMS which will work together to optimize the microgrid performance by monitoring all equipment load information. The EMS will integrate various decisions on energy production, consumption, and storage and coordinate them with thermal energy conservation, emission limits and credits, wholesale market attributes such as transmission congestion and marginal energy prices. By taking these factors into account, the microgrid will be able to control load during times of stress to the utility's grid. The microgrid will be able to control such equipment as HVAC (such as boilers and chiller systems) and lighting which create a large demand of usage during time of system stress. These equipment will be automatically shed from the system in order to reduce the load profile of the microgrid. For example, reducing a 1MW of load in an overloaded system can do more to restore local voltage levels than supplying 2MW of generation from a distant generator. The ability to control load enables a powerful control of voltage.

Black Start Controls

The proposed CHP plant will be composed of a natural gas-fired turbine. We anticipate the gas supply to be firm which will limit the possibility of a loss of fuel supply. However, in case a black start is required, Westchester County has two portable 500kW diesel fueled generators. These portable generators would be relocated to the CHP plant in order to black start the unit. The CHP’s switchgear will be designed for connecting portable generators for black start capability. This emergency generator unit will be capable of starting the one turbine.

Economic Dispatch and Load Following Controls

The MMC is the central intelligence behind the controlling system of the microgrid providing management of all DERs while providing set points for dispatching each resource to provide power to meet the load demand in the most economical and efficient method possible. Using the load profile that was created based on historical energy usage and adjustments made on a real time monitoring basis, the MMC will optimize the use of available generation (CHP, PV, battery storage, onsite diesel generators, or the utility) to provide power in the most economical means possible. As a part of the configuration process of the MMC, each generation source is given a cost value to run that generating source. Renewable generators such as solar power and battery storage will be given a lower cost than diesel or natural gas-fired generators. Using this information, along with the operating and efficiency characteristics of the generators (i.e. such as the startup time period and minimal generation loading that is required to make it operate efficiently), the MMC will give commands to the dispatchable generators and/or storage devices to best match the generation with the load requirements.

Demand Response and Storage Optimization Controls

Based on the size of the load at the Valhalla property, anticipated peak demand, and proposed microgrid size there is no plan to participate in a formal demand response program but rather rely on load shedding or meet peak demand load with the onsite diesel-fired generation.

The proposed microgrid will utilize battery storage as a form of renewable generation. Energy storage is possible since low cost energy does not need to be used at the exact time that it is produced, therefore it can be used later when PV sources may not be available. Using cost information that was entered at the time of configuration of the MMC, the optimization algorithms in the MMC analyze the excess generation available within the microgrid and determine if it is economically beneficial to store energy at that time. The MMC will take into consideration the amount of time it takes the batteries to fully charge before initiating the storage process; the MMC will evaluate the efficiency of the storage process and how long it must run prior to seeing benefits). When there is not enough PV generation in the system to support load requirements and there is sufficient stored energy available to support the loads, the MMC will initiate the use of available stored energy and will help reducing the fossil fuel fired CHP or diesel generators to feed the loads. In this scenario, the stored energy will act as one of dispatchable generators in the system.

PV Controls and Forecasting

The master microgrid controller (MMC) is capable of forecasting the future load requirements to provide optimum generation to support the load. All loads are continuously tracked and used by the master microgrid controller to create a forecast for the load profile of the microgrid for the next 24 hours. If the actual measured load usage differs from what the MMC forecasts for such reasons as a drop in temperature resulting in less load requirements the MMC will continually adjust its forecast to make the best predictions for load requirements. Using the forecasts made for the amount of PV generation that will be available for that day in the microgrid, the MMC is able to provide additional cost savings in the microgrid network. By taking into the account of PV generation that will be available for future periods the MMC will reduce the amount of fossil fuel based generation running to meet the load requirements. Also, since by its nature PV generation is variable and can very quickly decrease in contribution to the system (i.e. increased cloud cover or snow covering PV panels), the MMC will incorporate additional margin of standby generation for when contribution is high to ensure there will always be adequate generation available to support the load.

Protection Settings Controls

The proposed microgrid will utilize a master microgrid controller which will monitor and analyze the state of the microgrid. Different protection settings will be required based on the state of the microgrid, either in grid connected mode or islanded mode. Fault current level depends on the type, size, and location of the distributed generation source and is lower than the fault current from the utility grid. After isolation from the utility grid in islanded mode, the local DERs are the only fault current sources. In general, the microgrid protection settings will be as generic as possible to be applicable for both grid and islanded operation, adaptable to any DER type and penetration level, and scalable so the protection philosophy will not need to be redefined with each new DER connection. The Valhalla microgrid will implement a centralized adaption scheme where master microgrid controller will monitor the various circuit breaker status signals and if the network's state changes it will initiate a signal to all appropriate equipment to change its settings group to fit the new network configuration.

Energy Selling Controls

Based on the size of the load at the Valhalla property, anticipated peak demand, and proposed microgrid size there is no plan to sell energy back to the grid.

Data Logging Controls

A data recorder will be included on an industrial computer which will interface with the microgrid master controller. It will provide a storage solution to record all monitored data points of the connected controllers/DERs. It can be equipped with standard 2.5” hard drives (500 GB, 1 TB, and 1.5 TB). The data recorder also hosts the SCADA interface to allow operators to monitor and control the distributed control system. The controller will be capable of recording all data points of the system. It can record any variable within the system. Various settings for recording are available:

• Data filters based on time (dt); Data filters based on change of value (dv); Periodic sampling of arbitrary ranges like 1 s, 10 s, 1 m, 10 m, 1 h, etc.
• High resolution sampling (as data gets measured)
• Number of samples recorded per monitoring point
Data is stored in a round-robin database that overwrites oldest values. Typical storage capacity on a 500 GB hard drive for high resolution data is around 6-12 months. This is highly dependent on the number of data points and resolution.

Automated reporting based on the aggregated data will be generated to develop trending reports to facilitate energy management decisions. These reports can be customized but typically are used for:
The report generation engine has access to the data warehousing database. It is used for:

• Fault analysis
• Optimization of operating parameters
• Long-term load monitoring
• Availability reports
• Out-of-limit reports

A standard graphic user interface (GUI) will be provided to control and monitor the system from a centralized location. The interface allows:

• Monitoring of data points
• Changing of parameters
• Issuing control commands (like remote start, stop, etc.)
• Visualizing historical data
• Displaying real-time and historical trend
• Displaying alarm status and history

Resiliency of Controls

System resiliency is inherent and a top priority in the microgrid design. The existing campus has an underground IT (fiber-based) infrastructure already in place for a large portion of buildings. As such, the primary IT infrastructure or backbone of the microgrid is already established. For those buildings that are not connected to the campus IT infrastructure, it’s proposed to implement wireless field networks (mesh network type) to connect to the Public Works Operations Building. The entire campus is elevated and not located in a flood zone which alleviates the concern for flooding and the need for storm hardening. The IT infrastructure is located underground which provide protection and mitigation from most forces of nature.

IT/Telecommunications Infrastructure

The existing campus has an underground IT (fiber-based) infrastructure already in place for a large portion of buildings. As such, the primary IT infrastructure or backbone of the microgrid is already established. For those buildings that are not connected to the campus IT infrastructure, it is proposed to implement wireless field networks to connect to the Public Works Operations Building. See attached equipment layout along with a simplified one-line diagram of the proposed microgrid IT infrastructure.

The existing campus has an underground IT (fiber-based) infrastructure already in place for a large portion of buildings. As such, the primary IT infrastructure or backbone of the microgrid is already established. For those buildings that are not connected to the campus IT infrastructure, it is proposed to implement wireless field networks to connect to the Public Works Operations Building. This solution also allows ease of integration of existing infrastructure and with modern advanced metering infrastructure (AMI) solutions. The control system communication media will consist of five (5) elements:

• Energy Management System (EMS - 1 for the site; located in the Public Works Operations Building) which would serve as the master control application and orchestrate all control actions as well as provide the utility interface.
• Master Microgrid Controller (1 for the site; located in the Public Works Operations Building): host EMS, orchestrate all control nodes and DER optimizer/dispatch controller.
• Microgrid Control Node (1 per facility): coordinate control across multiple buildings composing a specific facility.
• Microgrid Edge Control Node (1 per building): direct interface to any controllable device in a building.
• All hardware level control to be architected using programmable, multi-protocol, IED's to enable broadest support of industry standard protocols and interfaces (e.g. IEC61850, DNP3, Modbus TCP/IP, Modbus Serial, or Ethernet as interface to control ports on microgrid deployed devices such as IED's, PLC, switchgear, relay, sensors, meters, digital governors, etc.)

The microgrid will be able to operate if communications are lost with the utility. In this scenario, the microgrid will operate in an intentional islanded mode until communications are restored.

IT/Telecommunications Resiliency

System resiliency is inherent and a top priority in the microgrid design. The existing campus has an underground IT (fiber-based) infrastructure already in place for a large portion of buildings. As such, the primary IT infrastructure or backbone of the microgrid is already established. For those buildings that are not connected to the campus IT infrastructure, it is proposed to implement wireless field networks to connect to the Public Works Operations Building. The IT infrastructure will encompass alternate communication paths in the event one path is lost. All of the communication equipment/hardware will have self-diagnosing software to continuously monitor itself to ensure it's working appropriate; if an issue arises it will transmit a warning message to the EMS system.

Assessment of Microgrid's Commercial and Financial Feasibility

Impact of Microgrid for Customers

All customers participating in the microgrid have critical loads that would be affected if these loads go unserved. Each of the customers currently have backup generators to provide power in an emergency situation (e.g. in a storm event) at a reduced facility capacity. All customers on the campus that have an agreement with Westchester County will be participating in the microgrid and will be purchasing electrical energy and thermal energy based on the requirements of the facility. All of these customers will be affected positively by having local generation close to the load that will provide resilient and reliable power while minimizing their carbon footprint. All customers participating in the microgrid will purchase electricity and thermal energy during both normal operations (grid-connected mode) as well as during emergency operations (islanded mode).

The loss of power to the tenants of the Valhalla campus would have a crippling affect for many people. Even with all existing backup generators powered up on site, tenants would average approximately a 50% loss of service upon a complete grid outage. This would affect the nearly 10,000 people who are either a part of the workforce or are patients at the Valhalla campus which serves approximately 3 million people living and working throughout the region.

Direct/Paid Services Generated by Microgrid

At this time no direct or paid services generated by the microgrid will impact the operations of the Con Edison or the New York Independent System Operator (NYISO). This will be further evaluated in the design stage and further discussions will take place with Con Edison to understand if any ancillary services in this load pocket will benefit the utility's operation.

Relationship Between Microgrid Owner and Purchasers of Power

The microgrid owner and applicant is Weschester County. The existing configuration at the Valhalla campus has four (4) 15kV Con Ed feeders terminating at Westchester County's Central Electrical Distrubtion Facility (CEDF) where Westchester County is the purchaser of electricity (supply through NYPA; distribution through Con Edison) and from there electricity is distributed through a 15kV network that is operated and maintained by the County.

Contractual Agreements and Solicitations with Purchasers

All customers (with critical and non-critical loads) at the Valhalla campus who presently purchase electricity and thermal energy from Westchester County will automatically be registered to participate in the microgrid. Contractual agreements will remain in place. The handling of load shedding (in islanded mode only) will be evaluated at a later time including modifications to contractual agreements (if required).

All customers at the Valhalla campus who presently purchase electricity and thermal energy from Westchester County will automatically be registered to participate in the microgrid. Contractual agreements will remain in place. At this time, only those tenants on the Valhalla campus will be eligible to participate in the microgrid as the large driver behind the planned microgrid is the existing infrastructure that is already in place.

Other Commodities Provided by Microgrid

Thermal energy (steam) will be provided to the customers of the microgrid. The existing campus has an underground 15kV electrical distribution as well as a 125psi high pressure steam distribution network already in place. As such, the primary infrastructure or backbone of the microgrid is already established. Distributed energy resources will be added to provide generation sources to the existing infrastructure. The thermal energy will be distributed via the existing 125psi high pressure steam network. The steam will be stepped down to 15psi at each of the buildings where it will be utilized for heat and also converted to hot water.

Commercial Benefits and Costs

The microgrid will provide value to various parties affiliated with the project. The microgrid's capital expenditure payback is expected to be ten years, at which time the annual savings of $4.2 million is expected to be passed on to the end users in lower electric bills. In addition, the benefit of a resilient system will allow the community’s facilities to remain operational along with its vital services.

Based on the working session held with Con Edison, they do not anticipate incurring any costs associated with the installation of the microgrid at the Valhalla campus. Interconnection and communication costs have been included in the project budget to interconnect with the utility. However, Con Edison will see benefits from the installation of the microgrid. These benefits include a reduction in congestion for this particular load pocket as well as a potential to defer long-term planning to upgrade equipment. There will be less stress on this particular network based on the lower electrical loads.

Business Model (SWOT)

The proposed business model for this project includes Westchester County as the owner and operator of the microgrid. The County will secure financing through NYPA. NYPA will oversee the entire project (including permitting, design, engineering, construction, testing and commissioning) on behalf of the County. Westchester County is currently evaluating whether to operate the microgrid itself or outsource the operation and maintenance to a service provider. This will be further evaluated as the project moves forward. Westchester County currently provides electricity and thermal energy to end users at the

Valhalla campus. These participants will remain as the end users and reap the largest benefits of the microgrid.

Strengths:

- Will provide a reliable and resilient electrical and thermal energy supply with local generation.
- Will provide a greater efficiency with the combined heat and power in the range of 80-90%.
- Carbon footprint will be reduced annually by 30,500 tons of carbon dioxide (equivalent to over 5,000 cars removed from the road).
- Increase in local temporary and permanent jobs

Weaknesses:

- Single fuel source for the CHP unit (dual fuel source will be evaluated at a later design stage).

Opportunities:

- The electrical distribution and steam distribution network is already in place which will lessen the capital cost of the project.

Threats:

- Increase in gas prices
- Existing tariffs/standby costs charged by the utility
- Modifications to utility assets
- Incorporation/changes of utility monitoring and protection requirements
- Compliance with stricter air regulation requirements with larger onsite fossil fuel generation

<u>Unique Characteristics</u>

The existing site has an underground 15kV electrical distribution as well as a 125psi high pressure steam distribution network already in place. As such, the primary infrastructure or backbone of the microgrid is already established. Distributed energy resources will be added to provide generation sources to the existing infrastructure. This provides a unique opportunity to implement a microgrid where the project total cost will be reduced due to the re-use of existing infrastructure. In addition, the use of a master microgrid controller to monitor the load and adjust the multiple generator source's output to match is a newer technology and unique for Westchester County.

<u>Project Replicability and Scalability</u>

The proposed microgrid is replicable for campus style microgrids or if there are buildings/loads clustered very close together geographically. The electric and thermal distribution network can then be easily routed and tapped to the load centers for scaling up the size of the microgrid. The proposed microgrid will include additional capacity and space for a future CHP unit as well as an extension of the proposed

15kV switchgear. For renewable generation, solar rooftop PV panels can be added to any building roof with the required square footage and be easily connected to the building's electric system.

Reliability and Resiliency

The purpose of this project is to provide a resilient, reliable electric grid to the community of Valhalla. The area has been struck by many severe weather events including ice storms, blizzards, hurricanes, and flooding over the last 20 years. Each storm has had increasingly deleterious effects on the local community causing power outages, road closures, and disruptions to daily lives of the local businesses and citizens. The goal of the microgrid is to provide and maintain power and heat in the form of steam to all facilities. Islanding these facilities and maintaining power is critical during a power outage for the 1 million residents of Westchester County. The facilities include Westchester Medical Center which provides critical care including attending to approximately 28,000 emergency room visits per year and communication assets for the U.S. Department of Homeland Security which protects tens of millions of residents in the greater New York City area.

Overall Value to Customers and Stakeholders

The microgrid will provide value to various parties affiliated with the project. The microgrid's capital expenditure payback is expected to be ten years, at which time the annual savings of $4.2 million is expected to be passed onto the end users in lower electric bills. The community will see its property value increase in direct proportion to the reliability and resiliency added to its electric grid. The utility may defer long range plans to upgrade equipment within this particular load pocket. Suppliers will benefit from the experience of participating in this microgrid while building their resume and deploying new innovative technologies. NY State will benefit from gaining knowledge of implementing a successful deployment of a microgrid as well as moving towards meeting REV goals.

Benefits to Purchasers, State Policy and new Technologies

The microgrid's capital expenditure payback is expected to be ten years, at which time the annual savings of $4.2 million is expected to be passed onto the end users in lower electric bills.

This project is in line with NYS initiatives, including REV. This project will decrease GHG emissions, provide resiliency to the existing system and reduce electric costs to the building owners that will be connected to the microgrid.

Securing Stakeholder Support

The municipal government of Westchester County is sponsoring this project. They have held workshops at the government level to review the overall scope of the microgrid as well as the long term benefits of implementation. In addition, due to the funding/budget restrictions at the County level, NYPA has been involved in helping the County understand the near term and long term capital and O & M costs. As the local partners are all purchasers of thermal and electrical energy from Westchester County, they will see a seamless transition and overall benefit from the microgrid if the proposed project is implemented.

Teaming and Partnering

Westchester County will own and operate the microgrid. However, the County will further evaluate if their personnel will operate the microgrid or if a third party contractor will assume that role on behalf of the County. The County is planning to finance the project through NYPA. NYPA intends to issue an RFP for a design-build contractor to design, install, test, and commission the microgrid and its DERs. At this time, the contractors and suppliers are unknown. There are no public/private partnerships used in this project.

Financial Strength and Qualifications

Westchester County is rated AAA by Standard & Poor's and Fitch Ratings. The County has one of highest bond ratings in NYS. At this time, the only known team members are the applicant and owner, Westchester County and the financier, NYPA. A design-build contractor and suppliers are not known. However, qualifications and past performance on similar projects will be a part of the selection criteria in the future.

Contractors and Suppliers

No contractors and suppliers have been identified at this early stage. Westchester County will be utilizing NYPA for financing the project. NYPA intends to approach the design and construction of the microgrid through a design-build contract as well as advise the County on various aspects of the project moving forward. NYPA has previous experience installing a CHP unit as a microgrid and can offer the County its ‘lessons learned’. In addition, qualifications and past performance on similar projects will be a part of the selection criteria for the design-build contract. Suppliers of equipment will be evaluated on their adherence to equipment specifications, cost, and lead time.

Financiers and Investors

Westchester County will finance the project through NYPA. Westchester County is an electric customer of NYPA. NYPA is exploring other NYPA Grant and incentives to determine if the County will be eligible.

Legal and Regulatory Advisors

Westchester County in conjunction with NYPA have legal and regulatory advisors on their staff. If specific expertise is lacking, NYPA has contractual agreements with consultants that can provide advice or assistance when required.

Selected Microgrid Technologies - Benefits and Challenges

The team has identified a gas turbine (used in CHP), roof-top PV panels, and battery storage as DER microgrid technologies. Previous experience and knowledge from similar projects was used to select the technologies for the microgrid. The use of a gas turbine has many advantages, mainly the use of natural gas as a fuel, which is currently competitively priced. Gas turbines are a proven technology and NYPA has extensive experience working with these units. Potential challenges may include possible increase in gas prices. In addition, the site is uniquely qualified for the use of photovoltaic panels as this is an expansive site with large areas of unobstructed solar exposure. Technology is rapidly advancing in the area of battery storage. The cost per kWH has declined in recent years and the trend is expected to continue as more and more battery manufacturers market new technology using cheaper, faster manufacturing processes.

The microgrid control system will be an integral component of how the system functions and operates. At this time, specific components and modules has not been identified for the control system. However, it will be designed to maximize the reliability and resiliency benefit of the local generation sources (CHP, PV, and battery storage) followed by the economic benefits of the mix of generation sources.

A systems-based approach has been utilized to select the optimal scale and technology type of generation components, for managing cost efficiency by balancing the application of redundancy and hardening, and for defining a weighted set of metrics used to assess the criticality of loads.

Leveraging Assets

The site already has many assets in place which can be leveraged to complete the microgrid project with minimal impact to the microgrid partners. The existing campus has an underground 15kV electrical distribution as well as a 125psi high pressure steam distribution network already in place. As such, the primary infrastructure or backbone of the microgrid is already established. Distributed energy resources will be added to provide generation sources to the existing infrastructure. The rest of the electric and thermal distribution systems are located underground which provides protection from most forces of nature.

Generation and Load Balance Technology

The microgrid master controller (MMC) is the central intelligence behind the controlling system of the microgrid, providing management of all DERs. Set points dispatch each resource to provide power which meets load demands in the most economical and efficient method possible. Using the load profile that was created based on historical energy usage and adjustments made on a real time monitoring basis, the MMC will optimize the use of available generation (CHP, PV, battery storage, onsite diesel generators, or the utility) to provide power by the most economic means. As a part of the configuration process of the MMC, each generation source is given a cost value to run that generating source. Renewable generators such as solar power and battery storage will be given a lower cost than diesel or natural gas-fired generators. Using this information, together with the operating and efficiency characteristics of the generators (i.e. such as the startup time period and minimal generation loading that is required to make it operate efficiently), the MMC will give commands to the generators and/or storage devices to best match the generation with the load requirements.

As noted on pages 19 and 20, under the site electrical demand characteristics, the peak electrical demand for the site is approximately 13MW. The CHP has been sized at 8MW to meet the average demand of the site and to avoid constant ramping up and down of the gas turbine which would create undue stress on the mechanical equipment as well as having a negative impact on the efficiency ratings. The CHP at 8MW and 500kW solar combined (with energy storage) will provide about 92% electricity needs (for all facilities) and 98% of the steam load with the utility providing the supplemental electrical energy in grid connected mode and the onsite diesel generators providing the supplemental electrical energy in islanded mode in order to meet peak demand.

Permits and Development Approach

Due to the Valhalla campus being owned by Westchester County, the County would have to get the approval of the Board of Governors for use of the land as part of the microgrid. In addition, an interconnection agreement would be required between Westchester County and Con Edison. Based on the emissions of the planned CHP unit, the site's air permit would require modification and approval. The applicable building permits, zoning variances, and excavation permits would be pursued in similar manners as other large construction projects.

NYPA plans to issue an RFP to design-build the project. This approach will minimize the risk to the customer, Westchester County, will expedite the schedule, and minimize the overall project costs.

Benefits, Costs and Value to Community

The microgrid's capital expenditure payback is expected to be ten years, at which time the annual savings of $4.2 million is expected to be passed on to the end user in lower electric bills. As Westchester County is acting as the utility for this site (and bill their tenants on the property accordingly, they are paying very low energy rates for electricity through NYPA. In addition as a non-profit, the County passes its expenses to the end customers such that for this project a line item or surcharge will be added to the tenant’s bill to cover the expense of the microgrid.

In addition, the non-monetary benefits of the VCM community microgrid are plentiful, including:

1. *Reliability:* local generation reduces the risk of a catastrophic power loss which allow both community facilities and vital services to remain operational during weather related or man-made events including the Westchester Medical Center, Bus Depot, Radio tower, jail, water treatment center, and public safety facilities.
2. *Efficiency:* with advanced metering deployed at each facility, tenants will have a greater sense of transparency on their energy usage patterns.
3. *Security of supply:* with the appropriate physical and cyber security measures in place, the risk of local generation sources being compromised by terrorism is minimized.

4. *Sustainability:* Westchester County has committed to a Cleaner, Greener community. Reducing greenhouse gas emissions along with implementing renewable energy generation is in line with the County's long term goals.

Westchester County and Con Edison would be required to enter into an interconnection agreement. The microgrid will supply to a large percentage of the Valhalla campus electrical and thermal energy load. Con Edison will be available in a stand-by role to pick up the electrical load if the microgrid needs to be shutdown or local generation is reduced for any reason. A known potential regulatory hurdle is the stand-by charge levied by Con Edison. Currently, Westchester County pays $6/kW as a stand-by charge from Con Edison. This is a significant charge which would negatively impact the economic and financial feasibility of the microgrid and reduce the potential economic savings generated by the microgrid. Reduction of the stand-by rate would create value to the microgrid partners.

Experience with Technologies and Operations

NYPA completed a similar microgrid project, the Rikers Island Cogen Plant, in NYC. The project consisted of two 7.5MW gas turbine generators with heat recovery equipment and new 27kV electrical equipment. The construction was started in March 2012 and was completed in December 2014. The estimated project impacts included creating approximately two thousand temporary and permanent jobs, $8 million in annual energy savings, and a reduction of 22,000 tons of greenhouse gases along with a reduction of 37 tons of nitrogen oxides. The Plant was designed to operate in parallel to the grid and have the capability to delivery power to the community outside of Rikers Island. In addition, Con Edison, installed the island's first disconnects which allowed the cogeneration plant to operate independent of the grid during a major outage. Con Edison upgraded the existing substation with a transfer trip to allow power to flow in each direction. Emerson and Delta V wireless controls were utilized to achieve this strategy.

Some of the lessons learned include the need to: identify plant operators early in the design phase, have stronger coordination with the existing utility for the interconnection, and create an effective balance with the control scheme which will trip the unit. The control scheme will be a major component of the project and will be thoroughly evaluated during the design phase.

Charging Purchasers

The existing configuration at the Valhalla campus has four (4) 15kV Con Ed feeders terminating at Westchester County's Central Electrical Distribution Facility (CEDF). Westchester County is the purchaser of electricity (supply through NYPA; distribution through Con Edison). From there, electricity is distributed through a 15kV network that is operated and maintained by the County. The end users of electricity are the various tenants and agencies that maintain facilities on the campus. These end users purchase their electricity from Westchester County. Existing contractual agreements are already in place for the end users to purchase electricity from Westchester County. Each of the buildings are sub-metered and are billed accordingly. These sub-meters will be replaced with smart meters as a part of the microgrid. A 'line' or 'surcharge' will be added directly to the electric bill of Westchester County that will cover this project. This surcharge has not been calculated and will be further developed in the design stage of the project.

In addition, providing a pricing mechanism to appropriately charge purchasers for battery storage will need to be further evaluated and defined. For example, one avenue of revenue could be price arbitrage, or charging batteries at off-peak times when the prices are lower and discharging during peak times when energy prices are high. However, arbitrage pricing may not be sufficient in covering the capital and O&M costs of the battery storage system. Another potential pricing mechanism would be to bill all users a small capacity charge then charge users for its performance during discharge periods as well.

Commercialization and Replication

There are no business/commercialization and replication plans planned for this project. However, if implemented, the County in conjunction with NYPA would share lessons learned and benefits to other municipal governments throughout the state.

Market Barriers

The microgrid applicant and owner will not face any barriers to entry. All end users already purchase electricity through Westchester County and this arrangement will remain in place. Barriers of entry include economic (stand-by charges from Con Edison), modifications to the site air permit, and approval from Westchester's Board of Governors for use of the land for a microgrid. There are no specific rules governing microgrids in NY state (only regulated by ad hoc Public Service Commission rulings) and it is unclear what future regulations will be enacted.

At this time, only those tenants on the Valhalla campus will be eligible to participate in the microgrid as the large driver behind the planned microgrid is the existing infrastructure that is already in place. Barrier to entry for users outside the Valhalla campus would include an analysis of available capacity within the microgrid to add another user as well as the the cost to extend the infrastructure to that particular end user; the cost of the infrastructure could be prohibitive to entry.

In order to overcome these barriers, Westchester County/NYPA will need to work closely with Con Edison, the NYDEC, the County's Board, and state regulators to ensure that they understand how providing resilient and reliable generation with a microgrid results in significant benefits to the local community and regional electric grid.

Fixed vs. Variable Revenue Streams and Incentives

Westchester County will save approximately $4.2 million net per year (see below Table 3), starting in year one with an estimated 2% increase in savings for every year after. NYPA will finance the entire project for Westchester County. The rate will be variable. NYPA's historical rate has been less than 1% for the past 10 years. The savings includes the cost of fuel; utility stand-by charges; summer on peak, summer off peak, winter on peak, and winter off peak tariffs; O&M charges, boiler efficiency, and duct burner efficiency.

Table 3: Westchester County Valhalla Campus - 8 MW Taurus 70 Gas Turbine with 500KW Solar - Energy Modeling								
		Load	**Load**	**Cogen (CHP)**	**Utility**	**Utility**	**Load**	**Cogen (CHP)**
	Savings	**Off Peak kwh**	**Peak kwh**	**Gen KWH**	**Off Peak kwh**	**Peak kwh**	**Thermal (therms)**	**Thermal (therms)**
Jan	$ 335,903	2,240,798	3,433,681	5,581,617	38,750	54,113	701,875	610,147
Feb	$ 296,079	1,981,083	3,059,735	4,957,962	35,000	47,855	479,559	479,542
Mar	$ 317,269	2,158,214	3,330,397	5,397,345	38,625	52,640	494,443	494,443
Apr	$ 323,078	2,112,271	3,301,197	5,242,065	41,667	129,736	346,219	346,219
May	$ 320,675	2,323,351	3,688,073	5,678,007	53,123	280,293	264,940	264,940
Jun	$ 512,661	2,440,055	3,951,003	5,663,249	114,845	612,965	269,255	269,255
Jul	$ 572,645	2,733,526	4,376,842	5,903,218	281,792	925,359	312,870	312,870
Aug	$ 540,584	3,007,994	4,742,907	5,915,738	543,858	1,291,305	277,790	277,790
Sep	$ 527,470	2,327,919	3,742,351	5,545,219	80,148	444,903	260,739	260,739
Oct	$ 305,382	2,143,982	3,352,233	5,378,020	38,750	79,444	347,460	347,460
Nov	$ 298,348	2,044,372	3,178,460	5,127,163	37,500	58,169	412,384	412,384
Dec	$ 319,716	2,159,396	3,329,283	5,395,679	38,750	54,250	586,170	569,807
Grand Total	**$ 4,669,810**	**27,672,959**	**43,486,160**	**65,785,281**	**1,342,807**	**4,031,030**	**4,753,703**	**4,645,595**
Con Ed Stand-By Rebate	$ 536,400		71,159,119					
O&M Cost	$ (986,779)							
Solar	$ 56,940							
TOTAL SAVINGS	**$ 4,276,371**							

During the design phase, NYPA will explore any available NYPA incentives and grants. The team will investigate whether NYSERDA incentives (such as PON 2568), are applicable. The incentives will have an overall effect on the final cost of the project and will reduce the investment of the customer.

Capital and Operating Costs

As Owner, Westchester County will assume various costs associated with capital expenditures of building, installing, operating and maintaining the microgrid.

Capital component costs:

- CHP Unit - Cost: $6,100,000; Lifespan: 25 years; Description: Solar Turbine, Taurus 70
- Solar Units - Cost: $1,375,000; Lifespan: 25 years; Description: PV Solar Implementations @ $2.75/Watt

- Storage Units - Cost: $500,000; Lifespan: 20 years (batteries themselves would need to be replaced every 8-10 years depending on discharge rate); Description: Lithium Ion Batteries @ $500/kWh
- CHP Installation, Ductbank, Steam/Distribution Infrastrucure - Cost: $15,500,000; Lifespan: 50 years; Description: Transmission Infrastructure
- Grid Interconnection Incl. Above - Lifespan: 50 years; Description: Interconnection with Con Ed
- Siemens Microgrid Controls - Cost: $2,5000,000 Lifespan: 25 years; Description: Grid Operations
    - Note: Siemens has been a vendor that we have coordinated and consulted with regarding implementation of a control system and they provided an estimated cost. However, specific model numbers for control modules has not been determined at this point in the design process.

Fixed operating expenses:

- Estimated at $5.4 million per year
- Includes CHP Unit maintenance, PV, Storage Units, Steam distribution system, Electrical distribution system & Infrastructure, Interconnection, Maintenance Staff/Personnel, Service Contracts

Variable operating expenses:

- Estimated at $10/MWh for CHP maintenance and $2/MWh for microgrid operations

Business Model and Financing

Modern resilient communities support public safety, convenience, and economic growth. Westchester County is at the forefront of providing these attributes to its residents. As such, the Valhalla Community Microgrid will be a partnership between Westchester County and the New York Power Authority to provide a reliable and resilient energy portfolio to the Valhalla campus. Financing will be provided through NYPA over a 15 year period at a low, variable interest rate, which is expected to be under 1%. A line or surcharge will be added directly to the electric bill of Westchester County that will cover this project. This surcharge has not been calculated and will be further developed in the design stage of the project. At the end of the financing period, Westchester County will be the sole owner of the microgrid assets.

This partnership provides a simple business structure as Westchester County is a non-profit municipal government while NYPA will be providing an avenue for capital access. The Westchester County/NYPA relationship is a strong and healthy relationship as the County receives their electric supply through NYPA at the Valhalla campus and throughout the rest of the County. Transaction accounts and models are already in place.

The bulk of the underground 15kV electrical distribution system and 125psi steam distribution network is currently in place providing an attractive incentive to implement the project. Westchester County, currently bills each of the tenants for their electric demand usage and thermal energy usage transaction accounts and models are already in place.

The natural gas rates are currently low and are forecasted to remain low for the foreseeable future. Generating power from a natural gas CHP unit is currently estimated to be half the cost of the current electric rate Westchester County is receiving for the same amount of electricity.

Ownership/Applicant and Privacy Rights Description

The owner and the applicant are the same entity: Westchester County, who will secure financing for the project through NYPA. The primary stakeholders will be Westchester County and NYPA. Westchester County owns the 440 acre site of the Valhalla campus where the microgrid equipment and system will be installed.

Users of electricity and thermal energy at the Valhalla campus currently utilize Westchester County as their provider. These users have contractual agreements with Westchester County that includes protection of their privacy rights. These agreements will remain in place after the microgrid is installed and functioning.

Regulatory Hurdles

A known potential regulatory hurdle is the stand-by charge levied by Con Edison. Currently, Westchester County pays $6/kW as a stand-by charge from Con Edison. This is a significant charge which would negatively impact the economics and financial feasibility of the microgrid and reduce the potential economic savings generated by the microgrid. The estimated annual revenue from the microgrid will be $1.7 million whereas the Con Ed stand-by charge would cost the microgrid $957,000 or 56% of the revenue. Reduction of the stand-by rate would create value to the microgrid partners. The plan to address this would be to negotiate with Con Edison for a new rate case.

Another known regulatory hurdle would be modifications to the site's existing air permit. The proposed microgrid will be adding an 8MW gas-fired turbine to the site. This is a cleaner burning fuel then the nearly two dozen diesel-fired backup generators that are currently utilized onsite. However, the site will be required to comply with any and all modifications required at the site, possibly including a continuous emissions monitoring system (CEMS).

Develop Information for Benefit Cost Analysis

Rate Class, Economic Sector and Ratepayers

The rate class of each of the facilities included in the microgrid is Large Commercial/Industrial (>50 annual MWh). The facilities belong to the following economic sectors: Public (including Jail, Safety Training, Bus Depot, Public Laboratory, Radio Tower, Water Distribution), Hospital, and Academic. There is only one ratepayer per facility. The list of facilities is included on page 13 of this report.

Power Outage Scenarios

Microgrid Generation (CHP + PV + Battery Storage) will provide electrical energy (MWh) for 92% of the historical yearly consumption and will provide thermal energy (MMBTU) for 98% of the historical yearly consumption. The microgrid will include a CHP (natural gas-fired turbine with a firm supply of natural gas) and a photovoltaic generating system with battery storage that will be capable of providing power 24 hours per day and seven days per week in the event of a multi-day outage. The proposed microgrid will utilize existing diesel-fired generators on site to provide peak load support during islanded mode only. This peak load support is approximately 5.5MW. During normal operation (grid-connected mode), the microgrid will utilize the local utility to provide peak load support.

Energy/Fuel Source

The microgrid will include an array of distributed energy resources including a natural gas-fired combined heat and power unit (CHP), solar photovoltaic panels (PV) with battery storage. Existing diesel-fired generators will meet peak demand during islanded mode.

Nameplate Capacity

The following list identifies proposed generation resources that will be included in the microgrid:

1. New CHP Unit 1 – 8MW, 125pis steam (unfired) 36.37klb/hr, 125psi steam with duct burners 159.53klb/hr, natural gas-fired turbine, Fuel Consumption: 9.955 MMBTU/MWh
2. New DG Unit 1 – Battery Storage – 1.0MWh
3. New PV Unit 1 – 250kW (availability factor – 15%)
4. New PV Unit 2 – 250kW (availability factor – 15%)
5. Existing DG Unit 2 – diesel-fired generator, 175kW, Fuel Consumption: 210 gallons per day
6. Existing DG Unit 3 – diesel-fired generator, 150kW, Fuel Consumption: 185 gallons per day
7. Existing DG Unit 4 – diesel-fired generator, 40kW, Fuel Consumption: 57.6 gallons per day
8. Existing DG Unit 5 – diesel-fired generator, 100kW, Fuel Consumption: 128 gallons per day
9. Existing DG Unit 6 – diesel-fired generator, 400kW, Fuel Consumption: 458 gallons per day
10. Existing DG Unit 7 – diesel-fired generator, 425kW, Fuel Consumption: 486 gallons per day
11. Existing DG Unit 8 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
12. Existing DG Unit 9 – diesel-fired generator, 100kW, Fuel Consumption: 128 gallons per day
13. Existing DG Unit 10 – natural gas-fired generator, 100kW, Fuel Consumption: 1157 therms per day
14. Existing DG Unit 11 – diesel-fired generator, 750kW, Fuel Consumption: 871 gallons per day
15. Existing DG Unit 12 – diesel-fired generator, 30kW, Fuel Consumption: 46 gallons per day
16. Existing DG Unit 13 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
17. Existing DG Unit 14 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
18. Existing DG Unit 14 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
19. Existing DG Unit 15 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
20. Existing DG Unit 16 – diesel-fired generator, 250kW, Fuel Consumption: 286 gallons per day
21. Existing DG Unit 17 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
22. Existing DG Unit 18– diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day

Annual Production

During normal operation or in grid-connected mode, the microgrid generation (CHP + PV + Battery Storage) will provide electrical energy (kWh) for 92% of the historical yearly consumption and will provide thermal energy (MMBTU) for 98% of the historical yearly consumption.

Total Peak Demand kW: 13,392; Total Average kW: 8,123; Total Annual kWh: 71,159,119.
Total Monthly (Average) kWh: 5,929,926; Total Weekly kWh: 1,368,444.

Microgrid Generation Peak kW: 8,693; Microgrid Generation Annual kWh: 65,785,281.
Microgrid Generation Monthly kWh: 5,482,106; Microgrid Generation Weekly kWh: 1,265,101.
Utility Generation Peak kW: 5,439; Utility Generation Annual kWh: 5,373,838.
Utility Generation Monthly kWh: 447,819; Utility Generation Weekly kWh: 103,343.

Daily Production

During emergency operation or in islanded mode, the microgrid generation (CHP + PV + Battery Storage) will provide electrical energy (kWh) for 92% of the historical yearly consumption and will provide thermal energy (MMBTU) for 98% of the historical yearly consumption. The gap between energy demand and generation will be equaled out by utilizing the on-site diesel generators or load shedding.

Total Peak Demand kW: 13,392; Total Average kW: 8,123; Total Annual kWh: 71,159,119
Total Monthly (Average) kWh: 5,929,926; Total Weekly kWh: 1,368,444

Microgrid Generation Peak kW: 8,693; Microgrid Generation Annual kWh: 65,785,281
Microgrid Generation Monthly kWh: 5,482,106; Microgrid Generation Average daily production: 180.23 MWh/day.

Microgrid Peak Support kW (onsite diesel generators or load shedding): 5,439

Daily Production in Major Power Outage

The list below indicates fuel-based DERs with fuel consumption per MWh generated (MMBtu/MWh), including Distributed Energy Resource Name, Facility Name, Energy Source, Nameplate Capacity (MW), Fuel Consumption per MWh Quantity/Unit

- DER CHP 01 Central CHP Plant 1 - Natural Gas; nameplate 7.965MW; fuel consumption: 9.955 MMBtu/MWh
- DER Genset 04 (VC-1) WC DPS Training Center - Admin Diesel (existing); nameplate 0.175MW; fuel consumption: 210 Gal/Day
- DER Genset 05 (VC-16) WC DPS Training Center - Support Diesel (existing); nameplate 0.150MW; fuel consumption: 185 Gal/Day
- DER Genset 06 (VC-17) Woodfield Cottage Diesel (existing); nameplate 0.040MW; fuel consumption: 57.6 Gal/Day

- DER Genset 07 (VC-17) Woodfield Cottage Diesel (existing); nameplate 0.100MW; fuel consumption: 128 Gal/Day
- DER Genset 08 (VC-18) WC DPS Public Safety - HQ Diesel (existing); nameplate 0.400MW; fuel consumption: 458 Gal/Day
- DER Genset 09 (VC-4) WC Public Labs - Old Diesel (existing); nameplate 0.425MW; fuel consumption: 486 Gal/Day
- DER Genset 010 (VC-5) WC Public Labs - New Diesel (existing); nameplate 0.500MW; fuel consumption: 584 Gal/Day
- DER Genset 012 (SWGR-1) WC Swgr/Operating Bldg Diesel (existing); nameplate 0.100MW; fuel consumption: 128 Gal/Day
- DER Genset 013 (BF-1) WC Cerrato Satellite Bus Facility Natural Gas (existing); nameplate 0.100MW; fuel consumption: 1157 Therm/Day
- DER Genset 014 (VC-12) WC Jail Complex – New Jail Diesel (existing); nameplate 0.750MW; fuel consumption: 871 Gal/Day
- DER Genset 015 (VC-19) WC Jail Complex - Training Diesel (existing); nameplate 0.030MW; fuel consumption: 46 Gal/Day
- DER Genset 016 (VC-11) WC Jail Complex – Med. Wing Diesel (existing); nameplate 0.300MW; fuel consumption: 336 Gal/Day
- DER Genset 017 (VC-14) WC Jail Complex – Twins West Diesel (existing); nameplate 0.500MW; fuel consumption: 584 Gal/Day
- DER Genset 018 (VC-9) WC Jail Complex H-Block Diesel (existing); nameplate 0.50MW; fuel consumption: 584 Gal/Day
- DER Genset 019 (VC-9) WC Jail Complex - HQ Diesel (existing); nameplate 0.300MW; fuel consumption: 336 Gal/Day
- DER Genset 020 (VC-8) WC Jail Complex - Annex Diesel (existing); nameplate 0.250MW; fuel consumption: 286 Gal/Day
- DER Genset 021 (VC-13) WC Jail Complex - Funit Diesel (existing); nameplate 0.300MW; fuel consumption: 336 Gal/Day
- DER Genset 022 (DIT-RT-1) WC Radio Tower Unit 1 Diesel (existing); nameplate 0.500MW; fuel consumption: 584 Gal/Day

Peak Load Support

The proposed microgrid will utilize existing diesel-fired generators on-site to provide peak load support during islanded mode only. This peak load support is approximately 5.5MW. During normal operation (grid-connected mode), the microgrid will utilize the local utility to provide peak load support.

Demand Response Capacity by Facility

The following list indicates the capacity (MW/year) of demand response that would be available by each facility the microgrid would serve:

- DER CHP 01; Facility: Central CHP Plant 1; Capacity 7.965MW/year
- DER Storage 02; Facility: Central CHP Plant 1; Capacity 1,00kWh (0.200MW/year)
- DER PV Solar 03; Facility: WC DPS Training Center; Capacity 0.0375MW/year
- DER Genset 04 (VC-1); Facility: WC DPS Training Center - Admin; Capacity 0.175MW/year
- DER Genset 05 (VC-16); Facility: WC DPS Training Center - Support; Capacity 0.150MW/year
- DER Genset 06 (VC-17); Facility: Woodfield Cottage; Capacity 0.040MW/year
- DER Genset 07 (VC-17); Facility: Woodfield Cottage; Capacity 0.100MW/year
- DER Genset 08 (VC-18); Facility: WC DPS Public Safety - HQ; Capacity 0.400MW/year
- DER Genset 09 (VC-4); Facility: WC Public Labs - Old; Capacity 0.425MW/year
- DER Genset 010 (VC-5); Facility: WC Public Labs - New; Capacity 0.500MW/year
- DER PV Solar 011; Facility: WC DPS Training Center; Capacity 0.0375MW/year
- DER Genset 012 (SWGR-1); Facility: WC Swgr/Operating Bldg; Capacity 0.100MW/year
- DER Genset 013 (BF-1); Facility: WC Cerrato Satellite Bus Facility; Capacity 0.100MW/year
- DER Genset 014 (VC-12); Facility: WC Jail Complex – New Jail; Capacity 0.750MW/year
- DER Genset 015 (VC-19); Facility: WC Jail Complex - Training; Capacity 0.030MW/year
- DER Genset 016 (VC-11); Facility: WC Jail Complex – Med. Wing; Capacity 0.300MW/year
- DER Genset 017 (VC-14); Facility: WC Jail Complex – Twins West; Capacity 0.500MW/year
- DER Genset 018 (VC-9); Facility: WC Jail Complex H-Block; Capacity 0.500MW/year
- DER Genset 019 (VC-9); Facility: WC Jail Complex - HQ; Capacity 0.300MW/year
- DER Genset 020 (VC-8); Facility: WC Jail Complex - Annex; Capacity 0.250MW/year
- DER Genset 021 (VC-13); Facility: WC Jail Complex - Funit; Capacity 0.300MW/year
- DER Genset 022 (DIT-RT-1); Facility: WC Radio Tower Unit 1; Capacity 0.500MW/year

Transmission and Distribution Capacity Impacts

There is no impact on the transmission requirements with implementation of the proposed microgrid.

There is no impact on the distribution requirements with implementation of the proposed microgrid. Con Edison will be charging the Westchester County a stand-by rate to maintain the existing distribution capacity requirements in the area in case the microgrid goes down and the utility is required to provide power.

Ancillary Services to Utility

The proposed microgrid will have the capability of providing certain ancillary services to the local utility if called on (such as frequency and real power support, voltage and reactive power support and black start capabilities). However, at this stage of the design process, the microgrid is not expected to enter into an ancillary service market.

Projected Savings of New CHP

Microgrid generation (CHP + PV + Battery Storage) will provide electrical energy (MWh) for 92% of the historical yearly consumption and will provide thermal energy (MMBTU) for 98% of the historical yearly consumption. With the efficiency of the combined heat and power unit, the microgrid is expected to provide an annualized savings in fuel costs of $1.15 million per year.

Environmental Regulations and Emission Rates

Based on the proposed size of the microgrid, which is less than 25MW, purchase of emissions allowances will not be required. The Regional Greenhouse Gas Initiative system affects fossil fuel power plants with 25 MW or greater generating capacity.

The following list indicates emission rates from the microgrid for CO2, SO2, NOx, and Particulate Matter (emissions/MWh) based on normal operation:

- CO2: 1169 lbs/MWh
- SO2: 0.075 lbs/MWh
- Nox: 0.331 lbs/MWh
- PM: 0.066 lbs/MWh

Capital Equipment Costs and Life Span:
The estimated fully-installed cost and lifespan of all equipment associated with the microgrid is listed below. This includes equipment and infrastructure associated with power generation (including combined heat and power systems), energy storage, energy distribution, and interconnection with the local utility.

Components:

- CHP Units - Installed Cost: $6,100,000; Lifespan; 25 years; Description: Solar Turbine, Taurus 70
- Solar Units - Installed Cost: $1,375,000; Lifespan: 25 years; Description: PV Solar Implementations @ $2.75/Watt
- Battery Storage Units- Installed Cost: $500,000; Lifespan: 20 years (battery cells would need to be replaced every 8-10 years depending on discharge rate) Description: Lithium Ion Batteries @ $500/kWh
- Siemens Microgrid Controls - Installed Cost: $2,500,000; Lifespan: 25 years; Description: Grid Operations

Infrastructure:

- CHP Installation, Ductbank, Steam/Distribution Infrastrucure; Installed Cost: $25,000,000; Lifespan: 50 years; Description: Transmission Infrastructure. This cost includes labor and material to build the CHP plant and make the appropriate electrical and heating upgrades to the campus as well as modification to Con Ed’s point of interconnection.
- Grid Interconnection included the above; Lifespan: 50 years; Description: Interconnection with Con Ed [grid interconnection will be at the Valhalla campus Central Electrical Distribution Facility (CEDF) building]

Planning and Design Costs

The estimated magnitude of initial planning and design costs are approximately $1,000,000. These figures will be further defined and refined as the project team prepares for move this project forward into the design stage. The initial costs are broken down into the following categories:

1. Engineering and Design: $750,000
2. Environmental and Permitting: $75,000
3. Financing & Legal: $75,000
4. Marketing: $50,000
5. Selection of Vendors & Service Providers and negotiating contracts: $50,000

These costs include the following tasks: project design (site layout, electrical, mechanical, civil/structural); building and development permits (gas & electric interconnection agreements, building permit, fire department permit, air permitting, final inspections); efforts to secure financing; marketing the project to Westchester County and the tenants of the Valhalla campus; and negotiating contracts for equipment and service providers. These costs do not include costs associated with operation of the microgrid.

Fixed and Variable O & M Costs

Fixed O&M costs are costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces each year (e.g., software licenses, technical support). The estimated fixed O&M cost associated with operating and maintaining the microgrid is $108,000 per year. This cost value includes operating and maintaining the following items: CHP Unit maintenance, PV, Storage Units, Steam distribution system, Electrical distribution system & Infrastructure, Interconnection, Maintenance Staff/Personnel, and Service Contracts.

The estimated costs associated with operating and maintaining the microgrid that are likely to vary with the amount of energy the system produces each year are listed below. This cost value excludes fuel costs.
Variable O&M Cost Unit: $10 /MWh associated with CHP Unit Maintenance
Variable O&M cost Unit: $2 /MWh associated with Microgrid Operations

Fuel Consumption

The list below identifies each DER and the maximum amount of time each would be able to operate in islanded mode without replenishing its fuel supply. This includes the amount of fuel consumed during this period. Note: it is expected that the natural gas supply for the CHP would be a firm contract supply for the local provider, allowing the CHP unit to be run indefinitely.

- DER CHP 01 Central CHP Plant 1; Duration of event: Indefinitely; Fuel Consumption: 9.955 MMBtu/MWh; Capacity: Indefinite
- DER Battery Storage Storage 02 Central CHP Plant 1; Duration of event: Indefinitely; Fuel Consumption: 0
- DER PV Solar 03 WC DPS Training Center; Duration of event: Indefinitely; Fuel Consumption: 0
- DER Genset 04 (VC-1) WC DPS/Fire Training Center - Admin; Duration of event: 4 days; Fuel Capacity: 1,000 gallons; Fuel Consumption: 210 Gal/Day
- DER Genset 05 (VC-16) WC DPS/FireTraining Center - Support: Duration of event: 1 day; Fuel Capacity; 336 gallons; Fuel Consumption: 185 Gal/Day
- DER Genset 06 (VC-17) Woodfield Cottage; Duration of event: 8 days; Fuel Capacity: 500 gallons; Fuel Consumption: 57.6 Gal/Day
- DER Genset 07 (VC-17) Woodfield Cottage; Duration of event: 3 days; Fuel Capacity: 500 gallons; Fuel Consumption: 128 Gal/Day
- DER Genset 08 (VC-18) WC DPS Public Safety - HQ; Duration of event: 1 day; Fuel Capacity: 500 gallons; Fuel Consumption: 458 Gal/Day
- DER Genset 09 (VC-4) WC Public Labs - Old; Duration of event: 5 days; Fuel Capacity: 2,500 gallons; Fuel Consumption: 486 Gal/Day
- DER Genset 010 (VC-5) WC Public Labs - New; Duration of event: 5 days; Fuel Capacity: 3,000 gallons; Fuel Consumption: 584 Gal/Day
- DER PV Solar 011 WC DPS Training Center; Duration of event: Indefinitely; Fuel Consumption: 0
- DER Genset 012 (SWGR-1) WC Swgr/Operating Bldg; Duration of event: 7 days; Fuel Capacity: 1,000; Fuel Consumption: 128 Gal/Day
- DER Genset 013 (BF-1) WC Cerrato Satellite Bus Facility; Duration of event: Indefinitely; Fuel: natural gas; Fuel Consumption: 1157 Therm/Day
- DER Genset 014 (VC-12) WC Jail Complex – New Jail; Duration of event: 9 days; Fuel Capacity: 8,000 gallons; Fuel Consumption: 871 Gal/Day
- DER Genset 015 (VC-19) WC Jail Complex - Training; Duration of event: 21 days; Fuel Capacity: 1,000 gallons; Fuel Consumption: 46 Gal/Day
- DER Genset 016 (VC-11) WC Jail Complex – Med. Wing; Duration of event: 2 days; Fuel Capacity: 1,000 gallons; Fuel Consumption: 336 Gal/Day
- DER Genset 017 (VC-14) WC Jail Complex – Twins West; Duration of event: 13 days; Fuel Capacity: 8,000 gallons; Fuel Consumption: 584 Gal/Day
- DER Genset 018 (VC-9) WC Jail Complex H-Block; Duration of event: 4 days; Fuel Capacity: 2,500 gallons; Fuel Consumption: 584 Gal/Day
- DER Genset 019 (VC-9) WC Jail Complex - HQ; Duration of event: 2 days; Fuel Consumption: 1,000 gallons; Fuel Consumption: 336 Gal/Day
- DER Genset 020 (VC-8) WC Jail Complex - Annex; Duration of event: 3 days; Fuel Capacity: 1,000 gallons; Fuel Consumption: 286 Gal/Day
- DER Genset 021 (VC-13) WC Jail Complex - Funit; Duration of event: 2 days; Fuel Capacity: 600 gallons; Fuel Consumption: 336 Gal/Day

Fuel/Energy Source for Existing Backup Generators

The following list identifies the fuel/energy source of each existing backup generator:
1. Existing DG Unit 2 – diesel-fired generator, 175kW, Fuel Consumption: 210 gallons per day
2. Existing DG Unit 3 – diesel-fired generator, 150kW, Fuel Consumption: 185 gallons per day
3. Existing DG Unit 4 – diesel-fired generator, 40kW, Fuel Consumption: 57.6 gallons per day
4. Existing DG Unit 5 – diesel-fired generator, 100kW, Fuel Consumption: 128 gallons per day
5. Existing DG Unit 6 – diesel-fired generator, 400kW, Fuel Consumption: 458 gallons per day
6. Existing DG Unit 7 – diesel-fired generator, 425kW, Fuel Consumption: 486 gallons per day
7. Existing DG Unit 8 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
8. Existing DG Unit 9 – diesel-fired generator, 100kW, Fuel Consumption: 128 gallons per day
9. Existing DG Unit 10 – natural gas-fired generator, 100kW, Fuel Consumption: 1157 therms per day
10. Existing DG Unit 11 – diesel-fired generator, 750kW, Fuel Consumption: 871 gallons per day
11. Existing DG Unit 12 – diesel-fired generator, 30kW, Fuel Consumption: 46 gallons per day
12. Existing DG Unit 13 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
13. Existing DG Unit 14 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
14. Existing DG Unit 14 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
15. Existing DG Unit 15 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
16. Existing DG Unit 16 – diesel-fired generator, 250kW, Fuel Consumption: 286 gallons per day
17. Existing DG Unit 17 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
18. Existing DG Unit 18– diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day

Nameplate Capacity of Existing Backup Generators

The following list indicates the nameplate capacity of all existing backup generators:
1. Existing DG Unit 2 – diesel-fired generator, 175kW, Fuel Consumption: 210 gallons per day
2. Existing DG Unit 3 – diesel-fired generator, 150kW, Fuel Consumption: 185 gallons per day
3. Existing DG Unit 4 – diesel-fired generator, 40kW, Fuel Consumption: 57.6 gallons per day
4. Existing DG Unit 5 – diesel-fired generator, 100kW, Fuel Consumption: 128 gallons per day
5. Existing DG Unit 6 – diesel-fired generator, 400kW, Fuel Consumption: 458 gallons per day
6. Existing DG Unit 7 – diesel-fired generator, 425kW, Fuel Consumption: 486 gallons per day
7. Existing DG Unit 8 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
8. Existing DG Unit 9 – diesel-fired generator, 100kW, Fuel Consumption: 128 gallons per day
9. Existing DG Unit 10 – natural gas-fired generator, 100kW, Fuel Consumption: 1157 therms per day
10. Existing DG Unit 11 – diesel-fired generator, 750kW, Fuel Consumption: 871 gallons per day
11. Existing DG Unit 12 – diesel-fired generator, 30kW, Fuel Consumption: 46 gallons per day
12. Existing DG Unit 13 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
13. Existing DG Unit 14 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
14. Existing DG Unit 14 – diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day
15. Existing DG Unit 15 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
16. Existing DG Unit 16 – diesel-fired generator, 250kW, Fuel Consumption: 286 gallons per day
17. Existing DG Unit 17 – diesel-fired generator, 300kW, Fuel Consumption: 336 gallons per day
18. Existing DG Unit 18– diesel-fired generator, 500kW, Fuel Consumption: 584 gallons per day

The standard operating capacity of each of the existing diesel-fired backup generators is 75% of its nameplate rating. The standard operating capacity of the one existing natural gas-fired backup generator at the Bus Depot is 100% of its nameplate rating.

Daily Electricity Production and Fuel Required

The following is a list of the average daily electricity production (MWh/day) for each generator in the event of a major power outage. The list includes the associated amount of fuel required to generate that electricity:

- DER CHP 01 Natural Gas; Nameplate: 7.965MW; Electricity Production: 180.23MWh; Fuel Consumption: 9.955 MMBtu/MWh
- DER Storage 02 Battery Storage; Nameplate: 1,00kWh (200kW); Electricity Production: 0; Fuel Consumption: 0
- DER PV Solar 03 Solar (rooftop); Nameplate: 0.250MW (availability factor is 15%); Electricity Production: 0.900MWh; Fuel Consumption: 0
- DER Genset 04 (VC-1) Diesel (existing); Nameplate: 0.175MW; Electricity Production: 3.15MWh; Fuel Consumption: 210 Gal/Day
- DER Genset 05 (VC-16) Diesel (existing); Nameplate: 0.150MW; Electricity Production: 2.7MWh; Fuel Consumption:185 Gal/Day
- DER Genset 06 (VC-17) Diesel (existing); Nameplate: 0.040MW; Electricity Production: .72MWh; Fuel Consumption: 57.6 Gal/Day
- DER Genset 07 (VC-17) Diesel (existing); Nameplate: 0.100MW; Electricity Production: 1.8MWh; Fuel Consumption: 128 Gal/Day
- DER Genset 08 (VC-18) Diesel (existing); Nameplate: 0.400MW; Electricity Production: 7.2MWh; Fuel Consumption: 458 Gal/Day
- DER Genset 09 (VC-4) Diesel (existing); Nameplate: 0.425MW; Electricity Production: 7.65MWh; Fuel Consumption: 486 Gal/Day
- DER Genset 010 (VC-5) Diesel (existing); Nameplate: 0.500MW Electricity Production: 9MWh; Fuel Consumption: 584 Gal/Day
- DER PV Solar 011 Solar (rooftop); Nameplate: 0.250MW (availability factor is 15%); Electricity Production: 0.900MWh; Fuel Consumption: 0
- DER Genset 012 (SWGR-1) Diesel (existing); Nameplate: 0.100MW; Electricity Production: 1.8MWh; Fuel Consumption: 128 Gal/Day
- DER Genset 013 (BF-1) Natural Gas (existing); Nameplate: 0.100MW; Electricity Production: 1.8MWh; Fuel Consumption: 1157 Therm/Day
- DER Genset 014 (VC-12) Diesel (existing); Nameplate: 0.750MW; Electricity Production: 13.5MWh; Fuel Consumption: 871 Gal/Day
- DER Genset 015 (VC-19) Diesel (existing); Nameplate: 0.030MW; Electricity Production: 0.54MWh; Fuel Consumption: 46 Gal/Day
- DER Genset 016 (VC-11) Diesel (existing); Nameplate: 0.300MW; Electricity Production: 5.4MWh; Fuel Consumption: 336 Gal/Day
- DER Genset 017 (VC-14) Diesel (existing); Nameplate: 0.500MW; Electricity Production: 9MWh; Fuel Consumption: 584 Gal/Day

- DER Genset 018 (VC-9) Diesel (existing); Nameplate: 0.500MW; Electricity Production: 9MWh; Fuel Consumption: 584 Gal/Day
- DER Genset 019 (VC-9) Diesel (existing); Nameplate: 0.300MW; Electricity Production: 5.4MWh; Fuel Consumption: 336 Gal/Day
- DER Genset 020 (VC-8) Diesel (existing); Nameplate: 0.250MW; Electricity Production: 4.5MWh; Fuel Consumption: 286 Gal/Day
- DER Genset 021 (VC-13) Diesel (existing); Nameplate: 0.300MW; Electricity Production: 5.4MWh; Fuel Consumption: 336 Gal/Day
- DER Genset 022 (DIT-RT-1) Diesel (existing); Nameplate: 0.500MW; Electricity Production: 9MWh; Fuel Consumption: 584 Gal/Day

One-Time Costs for Backup Generators

The existing site has backup generators in place and connected if needed. The existing personnel have the knowledge and training to start the generators on a one-time basis. There are no one-time costs associated with connecting or starting each of the backup generators, except at the water facility where no backup generator is present. A backup generator would need to be procured, installed, connected, and started at the water facility with an estimated one-time cost of $1,500 for this rental.

Widespread Power Outage Costs

The following list provides a description of how a major power outage would impact each type of facility's ability to provide services. The list also includes estimated costs of any emergency measures that would be necessary for each facility to maintain operations, preserve property, and/or protect the health and safety of workers, residents, or the general public.

Water Services:
The Water District #3 Distribution Facility is not currently equipped with backup generators, but would rent portable generators in the event of a major power outage. Installing these generators would cost approximately $1,500; in addition, the daily rental cost would be approximately $110. The facility would be able to maintain its full level of service when operating on backup power, but would lose all functionality during a complete loss of power. The analysis calculates the impact of an outage on the provision of residential and commercial water service using standard FEMA methodologies. No additional costs are associated with emergency measures.

Academic Facilities:
This group includes seven facilities, all of which are currently equipped with backup generators. The facilities are able to maintain approximately 50 percent of operations while running on backup power, but would lose all functionality if the backup generators were to fail. The overall value of service for these facilities is based on IEc Calculator estimates. No additional costs are associated with emergency measures.

Public Sector Facilities:
This group consists of eight Westchester County facilities, including a correctional facility, jail complex, central heating plant, and fire training center. Each facility is currently equipped with backup generators capable of supporting between 40 and 90 percent of the facility's normal level of service. These facilities would lose all functionality during a complete loss of power. In addition, the jail complex and fire training center would incur costs associated with supplying emergency food and shelter for inmates and staff, which was estimated using data from the American Red Cross. The overall value of service for these facilities is based on IEc Calculator estimates. Additionally $46,300 of daily costs would be incurred for supplying emergency food and shelter for inmates and staff.

Hospital Facilities:
The Town of Valhalla's proposed microgrid would serve four hospital facilities, each of which is currently equipped with backup generators. These generators can support between 60 and 80 percent of each individual building's operations. Should the generators fail, the facilities would lose all functionality. In addition, the hospital would incur costs associated with supplying emergency food and shelter for staff. As with the public sector facilities, the cost of providing emergency food and shelter is estimated based on data from the American Red Cross. The overall value of service is based on IEc Calculator estimates. These facilities also provide emergency medical services (EMS). The analysis calculates the impact of an outage on EMS capabilities using standard FEMA methodologies. Additionally $25,900 of daily costs would be incurred for supplying emergency food and shelter for patients and staff.

Other Medical:
The microgrid also serves another medical facility that is not directly affiliated with the hospital. This facility, the Behavioral Health and Taylor Care Center, has a backup generator capable of supporting 15 percent of the facility's operations. The facility would lose all functionality during a complete loss of power. The value of service for this facility is based on the IEc Calculator's estimate. No additional costs are associated with emergency measures.

Other Facilities with No Backup Power:
The remaining four facilities served by the microgrid are not currently equipped with backup generators and are unlikely to rent backup generators in the event of a major power outage. Instead, these facilities would shut down and experience a total loss of service. No additional costs are associated with emergency measures.

In all cases, backup generators are assumed to have a 15 percent chance of failing, and the supply of fuel necessary to operate the backup generators is assumed to be maintained indefinitely.

Based on the estimated value of service as well as the backup power capabilities and operational features of the facilities, the analysis estimates that in the absence of a microgrid, the average cost of an outage is approximately $2.6 million per day as per IEc Benefit-Cost Analysis (see Appendix C.1).

Population Served

Due to the varied nature of the facilities at the Valhalla campus (including water services, academic facilities, public sector facilities, hospital facilities, and other medical facilities), the campus serves the entire Westchester County with an approximate population of 972,634, based on 2014 estimates.

Impact on Services

The following list provides a description of how a power outage would impact each facility's ability to provide services:
1. Water Services - Percent loss in service during an outage: 0% (with backup power); 100% (without backup power)
2. Academic Services - Percent loss in service during an outage: 51% (with backup power); 100% (without backup power)
3. Public Sector Facilities - Percent loss in service during an outage: 46% (with backup power); 100% (without backup power)
4. Hospital Facilities - Percent loss in service during an outage: 34% (with backup power); 100% (without backup power)
5. Other Medical Facilities - Percent loss in service during an outage: 85% (with backup power); 100% (without backup power)
6. Other Facilities with No Backup Power - Percent loss in service during an outage: N/A% (with backup power); 100% (without backup power)

Summary of Findings

IEc, as NYSERDA's agent in developing a Cost Benefit Analysis for the NY Prize Feasibility study, has performed a review and analysis on the technical, commercial, and financial analysis and has concluded that the Valhalla Community Microgrid would provide benefits to the local community.
IEc's analysis indicates the following results (see Appendices C.1, C,2, and C.3 for further information):
Scenario 1 - Benefit/Cost Ratio = 0.95, Internal Rate of Return = 4.2%
Scenario 2 - Benefit/Cost Ratio = 1.0, Internal Rate of Return = 6.5%

Opportunities and Challenges

The current power delivery system at the Valhalla campus is sufficiently modernized to facilitate a relatively simple conversion to a microgrid which supplies both electrical and thermal energy (steam) to customers. The existing campus has an underground 15kV electrical distribution network and a 125psi high pressure steam distribution network already in place. As such, the primary infrastructure or backbone of the microgrid is already established. Distributed energy resources would be added to provide generation sources to the existing infrastructure. The thermal energy will be distributed via the existing 125psi high pressure steam network. The steam will be stepped down to 15psi at each of the buildings, where it will be utilized for heat and also converted to hot water. In addition, existing backup generators will be incorporated into the design, making conversion to a microgrid even more attractive.

A known potential regulatory hurdle are the stand-by charges levied by Con Edison and NYPA. Currently, Westchester County pays $6/kW and $0.074/kW rate in stand-by charges from Con Edison and NYPA, respectively. Con Edison's charge is substantial and would negatively impact the financial feasibility of the microgrid. It is recommended to negotiate with Con Edison for a new rate case.

Another known regulatory hurdle would be modifications to the site's existing air permit. The proposed microgrid will be adding an 8MW gas-fired turbine to the site. This is a cleaner burning fuel than the nearly two dozen diesel-fired backup generators that are currently utilized onsite. However, the site will be required to comply with any and all new air quality requirements, possibly including providing a continuous emissions monitoring system (CEMS).

Benefits and Costs

To assist with completion of the project's NY Prize Stage 1 feasibility study, IEc on behalf of NYSERDA, conducted a screening-level analysis of the microgrid's potential costs and benefits. However, after reviewing IEc's initial Benefit Cost Analysis report and all of the input entries in its calculations, the Valhalla (project) Team disagrees with some of the input values that were utilized. These input values were reviewed with IEc for resolution. Their revised analysis suggests that if no major power outages occur over the microgrid's assumed 20-year operating life, 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 exceed approximately 0.3 days per year.

In the alternate BCA developed by the Valhalla Team (see Appendices C.4 and C.5), input values were changed for the following items: fuel costs, fuel cost escalation, and fixed and variable O&M costs. With these revisions, the Benefit Cost Analysis is more in line with the project team's expectations that benefits outweigh costs over the assumed 20-year operating life. In addition, the internal rate of return for the microgrid increases with the duration of a major outage.

The Valhalla Team BCA indicates the following results (see Appendices C.4 and C.5):
Scenario 1 - Benefit/Cost Ratio = 1.4, Internal Rate of Return = 20.4%
Scenario 2 - Benefit/Cost Ratio = 1.7, Internal Rate of Return = 28.4%

In addition, it should be noted that local gas rates and electric rates were utilized in the alternative BCA presented by the Valhalla Team. The local rates to the Valhalla area make this a favorable project.

Fuel Costs

The Fuel costs in the IEc BCA model are based on 2011 values, which are high relative to the market. The Valhalla Team believes a fuel cost of $3.35/MMBTU is more reflective of the current market prices, as indicated in EIA's "Short-Term Energy and Summer Fuels Outlook" published in April 2016. In addition, fuel cost escalation is assumed to be 3% per year. This is more in-line with EIA's "Natural Gas Prices Projections to 2040" published in April 2016, which reflects a 2.8% annual growth.

Energy Price

Westchester County is currently receiving its electric supply from NYPA and pays Con Edison's transmission and distribution charges. As such, "Energy Benefit Calcs" tab were adjusted to $100/MWh to accurately reflect the current rate Westchester County is being charged.

O & M Costs

The overall Project costs have increased to accurately reflect the cost in NYPA's financial model. Also, the Westchester County Department of Public Works currently operates and maintains its Central Steam Plant at the Valhalla Campus. The County would take over the operation and maintenance of the proposed microgrid. The project team does not believe that the County will incur additional fixed O&M costs from what it currently budgets annually. This cost has been reduced to $100,000 per year.

Therefore, in Q12, this cost has been decreased to $100K/yr, the value provided by Westchester County as existing O&M costs. The Valhalla Team does not believe that Westchester County will incur ADDITIONAL fixed O&M costs from what they currently are.

In Q14, values were reduced to $10/MWh and $2/MWh. After consultation with a few leading equipment manufacturers, the variable O&M costs have been reduced to $10/MWh for the CHP unit and $2/MWh for the microgrid operations.

Added Benefit- (Cost Avoidance)

Upon completion of the construction of the Microgrid, proof testing of all its components and acceptance by the client, the Microgrid will be placed into operation. The operating Valhalla Microgrid has the potential to avoid or reduce costs that would otherwise be incurred. These costs will include fuel savings in this case of a new CHP system and generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. It is estimated that the present value of these savings over a 20-year operating period, inclusive of all maintenance costs, is approximately$45.8 million. Additionally, the proposed CHP unit emissions of CO_2, SO_2, NO_x, and particulate matter will be reduced, resulting in emissions allowance cost savings at a present value of approximately $22,500.

The project team does not project distribution capacity benefits, except that additional cost savings will be generated by not needing to invest in expansion of the conventional grid's energy generation or distribution capacity. IEc's analysis estimates the impact on available generating capacity to be approximately 8.24 MW per year, based on estimates of the new CHP and solar units' output during system peak. The BCA estimates the present value of this benefit to be approximately $9.41 million over a 20-year operating period. The project team proposes that the microgrid be designed to provide added services to the New York Independent System Operator (NYISO) in the form black start capability, reactive power support, and frequency or real power support. We are hopeful that the NYISO would select the project to provide these services. This remains dependent on NYISO's requirements and the ability of the project to provide support.

Added Benefit- (Reliability Benefit)

An added benefit of the Valhalla Microgrid will be increased security for the power supply and reduced susceptibility to power outages. The design and operation of the Valhalla Microgrid will allow for an instantaneous transition from grid-connected mode to islanded mode. The analysis estimates that development of the Microgrid will yield reliability benefits of approximately $49,000 per year, with a present value of $555,000 over a 20-year operating period.

The estimate takes into account a number of factors, such as:

a) Small & large commercial and industrial customers the project will serve

b) Distribution of these customers by economic sector

c) Average annual electricity usage per customer

d) Prevalence of backup generation among these customers

It also takes into account costs such as operating existing backup generators both in the baseline and as integrated components of the Microgrid. Under the baseline conditions, the analysis assumes a 15 percent failure rate for backup generators. By placing the Valhalla Microgrid into operation, the resulting failure rate to produce power and support the campus is near zero.

Electrical Stability Benefits

In addition to sustained power outages, electrical utility events consist of transients that include voltage sags, voltage swells and momentary outages that are less than 5 minutes in duration. These short duration outages are not captured in reliability indices due to the short duration. The electrical stability and hence the power quality benefits of the microgrid depend on the team's ability to estimate the number of events that would be mitigated each year with implementation of the Microgrid. The Valhalla Team estimates that the Microgrid will help the facilities it serves to avoid an average of five power quality events per year. The model estimates the present value of this benefit to be approximately $9.5 million over a 20-year operating period. Some customers for whom power quality is critical (e.g., the hospital) may already have systems in place to protect against voltage sags, swells, and momentary outages. In this is the case, the electrical stability benefits would not apply.

Conclusion

The Valhalla Community Microgrid has the potential for multiple benefits including the ability to provide resilient and reliable 15kV distribution power, provide power to community critical loads, integrate renewable generation, reduce emissions, and provide a higher efficiency through technology such as combined heat and power.

With Westchester County leveraging their relationship with NYPA, this project can be a fruitful pilot project to showcase the County is taking a step forward to help provide a Cleaner, Greener Sustainable place to live and work. The County has an established 15kV underground distribution network, an underground 125psi steam distribution network, on site diesel generators, and a transaction/rate structure and model in place with the tenants at the Valhalla campus which makes the conversion into a microgrid very attractive.