63 - Village of Endicott

January 2017

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NYSERDA NY Prize
Endicott Community Microgrid

Contract ID: 655980

April 1, 2016

Submitted To:

NYSERDA
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Albany, NY 12203

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Executive Summary

The Village of Endicott, NY is located in the Southern tier Region of New York State, near Binghamton, NY. Endicott has experienced extreme weather, is a strategic economic development area for manufacturing, and has access to natural gas. Endicott has experienced two “100-year” floods in the last 10 years during which resulted in multiday power outages and significant damages. Huron Real Estates Associates owns the former IBM Campus, now called the Huron Campus, and leases space to industrial and commercial tenants. These C&I tenants contribute significantly to the economic health of the community. An example tenant is BAE Systems which relocated to Huron Campus as a result of the 2011 flood. The Southern Tier has been awarded Governor’s Cuomo’s Upstate Revitalization Initiative which includes an Endicott innovation district focusing on manufacturing. Endicott is located close to the Pennsylvania border and has access to uniquely low costing natural gas which can be used as the primary fuel source for reliable microgrid generation.

The Endicott Community Microgrid had been developed to meet all NY Prize requirements including a reliable means to black-start, island, and match load with generation. The proposed microgrid serves the Huron Campus substations during normal operating conditions and will be designed to operate at optimal economic dispatch. During an emergency the microgrid will have the capability to island and operate disconnected from the grid while continuing to serve the Huron Camus substations and also serving two substations that support the majority of the Village of Endicott. These substations are owned and operated by NYSEG and Endicott Municipal Light (EML) and provide service for an approximately 1,800 households, 28 commercial customers, and 8 critical facilities. Critical facilities that are served by the microgrid include: Huron Campus Waste Treatment Plant (building 96), Village of Endicott Fire Station, Village of Endicott Police Station, Waste Water Pumping Station, Storm Water Pumping, Village Library, Union-Endicott School, and UHS Walk-in Care.

The microgrid summer peak load is currently 34.0 MW and will be reduced to 28.3 MW by executing a proposed 5.3 MW reduction in demand via energy efficiency measures. The energy efficiency measures include a chiller replacement with an associated 4.7 MW reduction. The generation assets will be located on Huron Campus and include a highly efficient 28.7 MW combined-cycle combined heat and power (CC CHP) plant, three solar PV systems totaling 4.6 MW, and a 2.0 MW/8.0 MWH energy storage battery/inverter system. The system will leverage existing power distribution, substations, and campus thermal distribution and will include two new substations located on Huron Campus.

The microgrid system is both technically and commercially feasible. It has a simple payback of 11-12 years where the capital cost is $119M, the average annual operating cost is $9M, and the average annual revenue is $19M. For the purpose of financing and ownership the microgrid system is segmented into the core microgrid, solar PV, and chiller replacement.

This microgrid project has a significant benefit to society and the Endicott community. The society benefit Business Case Analysis (BCA) sensitivity analysis scenario, that best reflected the proposed microgrid, resulted in an internal rate of return of 7.3% and a cost benefit ratio of 1.0. In addition, the microgrid system is being developed to ensure a highly reliable and sustainable energy source to Huron Campus. This energy source will contribute to a larger initiative to attract and maintain commercial, industrial, and manufacturing to Endicott and Huron Campus.

1. Microgrid Capabilities

The Endicott Community Microgrid meets all of the minimum and preferred capabilities defined by NYSERDA NY Prize Program.

1.1 Minimum Required Capabilities

The capabilities described in this section were designated as minimum required capabilities by NYSERDA NY Prize. The Endicott Community Microgrid approach includes all minimum required capabilities as described below.

1.1.1 Critical Facilities

Serves at least one but preferably more, physically separated critical facilities located on one or more properties.

The microgrid includes the following critical facilities: Huron Campus waste treatment plant (building 96), Village of Endicott Fire Station, Village of Endicott Police Station, waste water pumping station, storm water pumping, Village Office, Library, Union-Endicott School, and UHS Walk-in Care. These critical facilities were identified by the Chief of Police, Chief of Fire, and Water Works supervisor as key to the community in the case of an emergency and are included in the microgrid during emergency island mode.

The Huron Campus includes a waste water treatment plant at Building 96.

The NYSEG Endicott Rail Substation feds the Union Endicott High School which was identified as the most likely location of a community safe haven in Endicott. It also feeds the UHS Walk-in Care facility.

The Endicott Municipal Light (EML) South Street Substation supports the Village of Endicott Fire Station, Village of Endicott Police Station, Village Office, Library, wastewater, storm water, and waterworks systems.

For Waste Water the South Street Substation supports two big pumping stations which pump waste water to the central wastewater plant. The central plant is powered by a separate EML substation. The pumping stations do not currently have backup power and if they are not powered, waste water can get backed up to residences and businesses. During a 2011 flood this occurred. One of these pumping stations is the South Street Pumping Station. The South Street Pumping Station has two separate pumps, one for storm water and one for wastewater.

The South Street Pumping Station pumps storm water during a flood as diagramed below. Storm water from Main Street normally flows to the Union-Endicott High School baseball field area, flows across the tennis courts, and into the Susquehanna River. During a flooding event, the baseball field can become flooded, and then the water flows towards the American Red Cross near Booth Ave and South St. It then flows to a South Street Pumping Station, building next to the South Street Substation and is pumped into the Susquehanna River. This system is contingent upon the Susquehanna River not rising above the break wall next to River Terrace.

The Nanticoke Avenue and the Oak Hill Avenue underpass pumps provide storm water pumping to help avoid or reduce flooding near the Huron Campus and in the Village of Endicott. Both of these pumps are supplied power by the South Street Substation.

The Municipal Central Water Works Plant is powered by the South Street Substation. It provides water treatment and feeds a well that supports part of Endicott. It can provide water for around 1 day independent of the main well. The main well is powered by a substation not included in the microgrid.

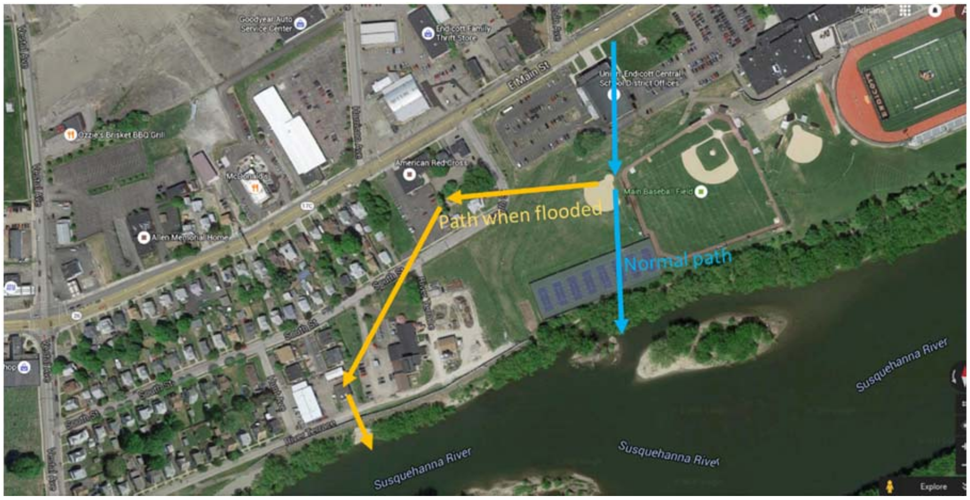

Figure 1: Storm water path during normal conditions (blue) and flooded conditions (orange).

1.1.2 Primary Generation is Not Diesel Generation

The primary generation source capacity cannot be totally diesel fueled generators.

The primary generation source will be based on combined cycle combined heat and power (CHP) with the primary fuel source natural gas. Three MW scale solar PV systems are proposed.

1.1.3 Combination of Generation

A combination of generation resources must provide on-site power in both grid-connected and islanded mode.

Energy generation resources are described in section 1.1.2. The combined cycle CHP system will be located on-site at Huron Campus and operate in both grid-connected and islanded mode. Solar PV will be located on-site at Huron Campus and will be operated in grid-connected mode and islanded mode with the support of a 2 MW/8 MWH battery storage system.

1.1.4 Intentional Island

Must be able to form an intentional island.

Upon request from NYSEG to intentionally island, any additional generating assets needed to support the current operating load of the microgrid will be brought on-line. A command will then be issued to trip the grid-tie breakers at Robble Ave substation, separating the microgrid from the utility grid. Simultaneously, all generator voltage regulators will switch from power factor to voltage control mode;

the gas turbine governors will switch to droop control; the steam turbines will switch to isochronous governor control.

1.1.5 Automatic Disconnect and Restoration

Must be able to automatically separate from grid on loss of utility source and restore to grid after normal power is restored.

Upon sensing a loss of the utility source at the grid-tie breakers at Robble Ave Substation, the grid tie breakers will immediately trip. If the currently operating generation resources for the microgrid are not sufficient to support the microgrid load at the moment of transfer, a pre-planned partial load reduction will be initiated by a high speed load management system to allow the remainder of the microgrid to continue operating while additional generation is brought on line. Once the additional generating capacity is on-line the previously shed loads will be restored. As described in 1.1.4, simultaneously with separation from the utility grid, all generator voltage regulators will switch from power factor to voltage control mode; the gas turbine governors will switch to droop control; the steam turbines will switch to isochronous governor control. Once the normal utility voltage and frequency is restored, the system will wait for five minutes, then it will initiate automatic re-synchronization with the utility grid. The microgrid frequency and voltage will be automatically adjusted to match the utility, and a close command will be issued to the utility tie breakers at Robble Ave Substation. At that point, generator voltage control will switch to power factor mode, and all governor controls will be set to droop. Generator dispatch will revert to the economic dispatch control system. Unneeded generation assets will be shut down.

1.1.6 24-7 Uptime

The system must comply with manufacturer's requirements for scheduled maintenance intervals for all generation; plan on intermittent renewable resources that will be utilized toward overall generation capacity only if paired with proper generation and/or energy storage that will allow 24 hours per day and 7 days per week utilization of the power produced by these resources.

Combined cycle plant to be designed for 99.9% availability and will provide power 24/7/365. Downtime for individual units will be scheduled to have no impact on operational capability. The peaking capability of the combined cycle plant along with energy storage will allow utilization of intermittent renewable resources.

1.1.7 Grid Tied Operation

Generation must be able to follow the load while maintaining the voltage and frequency when running parallel connected to grid. It also needs to follow system load and maintain system voltage within ANSI c84-1 standards when islanded.

When in Grid Paralleled operation, the microgrid voltage and frequency are controlled by the utility grid. Microgrid generation will provide MW and MVARS to the system based on the generator set points determined by Economic Dispatch. When operating in Island Mode, generator voltage regulators will maintain the system voltage, with the MVAR contribution of each generator proportional to the generator load. System frequency will be maintained by isochronous operation of the peaking generators.

1.1.8 Microgrid Control

Include a means for two-way communication and control between the community microgrid owner/operator and the local distribution utility through automated, seamless integration. Include processes to secure control/communication systems from cyber-intrusions/disruptions and protect the privacy of sensitive data.

The entire microgrid communications and control system will be NERC CIP compliant using a dedicated communications network, and password authentication. A secure communications gateway with firewall will be constructed to allow NYSEG to monitor operation of the microgrid and allow them to have operational control of certain functions.

1.1.9 Customers

Provide power to critical facilities and a diverse group of customers connected directly to the microgrid—diversity should apply to customer type (e.g. residential, small commercial, industrial, institutional, etc.) and overall demand and load profile.

The system includes Huron Campus, NYSEG Endicott Railway Substation, and Endicott Municipal Light (EML) South Street Substation. Huron Campus is a large mixed use commercial & industrial campus. Loads on Endicott Railway and South St. substations include approximately 8 critical facilities, 1,800 residential housing units, and 28 commercial loads.

1.1.10 Uninterruptible Fuel

Must include an uninterruptible fuel supply or minimum of one week of fuel supply on-site.

Natural gas will be the primary fuel source, reducing system dependence on the electrical transmission system. In addition, the gas turbines and two of the three HRSG duct burners will be equipped for dual fuel operation using No.2 fuel oil as a backup fuel. The existing 503,927 gallon fuel storage tank is anticipated to provide up to 9 days of full load operation, before additional fuel deliveries would be required.

1.1.11 Resilience to Natural Disaster

Demonstrate that critical facilities and generation are resilient to the forces of nature that are typical to and pose the highest risk to the location/facilities in the community grid. Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time.

The natural disaster type of highest concern for the site is flooding. The CHP, solar PV, energy storage and new substations will be outside of the flood plain. The CHP and energy storage equipment will be housed in structures compliant with the NY building code and will withstand all weather and seismic events anticipated for the Endicott NY area.

1.1.12 Black Start

Provide black-start capability.

The 2 MW/8 MWH energy storage system will supply power to the CHP facility to allow starting of the gas turbines in the event of a complete outage.

1.2 Preferred Required Capabilities

The capabilities described in this section were designated as preferred microgrid capabilities by NYSERDA NY Prize. The microgrid has been assessed to include both of the two primary preferred capabilities as described below.

1.2.1 Advanced Innovative Technologies

Integrate and demonstrate operation of advanced, innovative technologies in electric system design and operations, including, but not limited to, technologies that enable customer interaction with the grid such as, Microgrid Logic Controllers, Smart Grid Technologies, Smart Meters, Distribution Automation, Energy Storage.

The microgrid load management system will incorporate real time metering and preplanned prioritizing of loads to permit the system to react to contingencies during islanded operation while maintaining system voltage and frequency and spinning reserve. Energy storage will be utilized for efficient dispatch of renewable energy and black start capabilities. An economic dispatch system will provide lowest cost power from conventional and renewable sources based on continually shifting market prices. The capabilities of the distributed generation resources allow the project to participate in ancillary market opportunities. The microgrid controller will smoothly integrate efficient generation dispatch and economics while maintaining reliable power under both grid paralleled and islanded operation.

Optimized Controls

Include an active network control system that optimizes demand, supply and other network operation functions within the microgrid.

A fully integrated control system will be incorporated into a high speed, cyber secure communications system to monitor and control all aspects of microgrid operation, power generation and load management. All critical functions will be performed on redundant computer servers for maximum reliability.

Demand Management

Include energy efficiency and other demand response options to minimize new microgrid generation requirements.

The microgrid leverages energy efficiency and demand response to reduce peak loads at Huron Campus that enable reduction in generation sizing. The energy efficiency represents a 15% reduction in peak demand.

Interconnection

Address installation, operations and maintenance and communications for the electric system to which interconnection is planned (e.g., underground networks, overhead loops, radial overhead systems);

The microgrid substation will incorporates flexibility and redundancy to allow planned and unplanned maintenance without affecting power delivery to end users. The microgrid will provide additional energy supply redundancy to the utility and municipal distribution system during emergencies. The majority of microgrid load feeders and interconnection of substations are via underground feeders.

REV

Coordinate with the Reforming the Energy Vision (REV) work to provide a platform for the delivery of innovative services to the end use customers;

The project team will continue to follow the progress of the REV work in order to provide innovative services that are aligned with REV.

Multi-Perspective Cost-Benefit

Take account of a comprehensive cost/benefit analysis that includes, but is not limited to, the community, utility and developer's perspective.

The requirements of Task 3 and Task 4 of the statement of work have been met. Additionally, a financial model of the microgrid was created and shared with potential project owners and developers.

Capital Investment

Leverage private capital to the maximum extent possible as measured by total private investment in the project and the ratio of public to private dollars invested in the project.

Ownership and cost recovery mechanisms were explored as part of the Task 4 commercial feasibility assessment.

Clean Power Supply

Involve clean power supply sources that minimize environmental impacts, including local renewable resources, as measured by total percentage of community load covered by carbon-free energy generation.

Large scale PV was assessed with the goal to optimize the amount of carbon-free energy generation. Replacing 40 year old conventional steam boilers with highly efficient CHP systems will provide low cost thermal energy to the facility. CHP also achieves reductions in utility power generation emission by eliminating transmission losses and reducing demand on utility peaking facilities. The ability of the energy storage system to store low-cost renewable and baseload generated power for utilization during periods of peak demand further reduces overall emissions.

Community Benefit

Demonstrate tangible community benefits, including but not limited to, (e.g. jobs created, number of customers served, number of buildings affected, scale of energy efficiency retrofits, etc.)

The project includes a community engagement plan to ensure that the project is developed to provide community benefits and involvement. The project has been developed to optimize the benefits to the community including an emphasis on economic development.

1.2.2 Grid and Customer

Incorporate innovation that strengthens the surrounding power grid and increases the amount of actionable information available to customers—providing a platform for customers to be able to interact with the grid in ways that maximize its value.

Methods for customer engagement married with a business model that rewards positive engagement will be considered. The specific approaches will be customer type dependent and include demand response.

2. Preliminary Technical Design

This section provides a summary and details of the preliminary technical design for the microgrid.

2.1 Microgrid Infrastructure and Operations

This section provides a high level/simplified infrastructure overview and then a narrative of how the system will operate in normal and emergency modes.

2.1.1 Infrastructure Overview

The proposed Endicott Community Microgrid consists of loads at Huron Camus and in the Village of Endicott. Huron Campus is currently fed power by two substations – Robble Ave Substation and Clark St. Substation. The microgrid will tie to the Endicott Municipal Light (EML) South St. Substation and the NYSEG Endicott Rail Substation via a connection to the existing NYSEG 34.5 kV loop system. The Endicott Municipal Light service territory is fed by three substations, and only one of those is included in the microgrid. The EML South St Substation was selected because it feeds a number of critical facilities. The EML South St. Substation feds the Village of Endicott Fire Station, Police Station, Waste Water Pumping Station, Storm Water Pumping, Village Office, and Library. The NYSEG Endicott Rail feeds the Union-Endicott School. In addition to these critical facilities, the two community substations feed power to an estimated 1,800 households and 28 commercial customers, which will benefit from the microgrid.

The generation assets are located at or adjacent to the Huron Campus and include a combined-cycle combined heat and power (CC CHP) plant, three solar PV systems, and an energy storage battery/inverter system. The solar PV nominal power output in MW is rated in DC, all other systems are rated in MW AC. The 28.7 MW CC CHP plant will be adjacent to the Huron Campus - Building 39 - Power House for access to thermal distribution and is designed to meet the thermal load of the campus. The solar PV systems will include a ground mounted 1.7 MW solar PV system at the former Endicott Forging property, which is a brown field adjacent to Huron Campus, a 2.3 MW carport solar PV system next to Huron Campus - Building 40, and a roof top mounted 1.6 MW solar PV system on Huron Campus - Building 53/48. The 2.0 MW/8.0 MWH energy storage battery will be in the new Microgrid Substation and its inverter system will be located at the CHP plant, the Microgrid Substation. Load reduction via energy efficiency will include 4.7 MW in chiller replacement at the Huron Campus – Building 39 – Power House, 0.3 MW in LED Lighting Improvements across Huron Campus, and 0.2 MW in low-cost measures across the campus. Existing backup generators are rated for 6 MW at Huron Campus and 0.1 MW for the Endicott Police and Fire station. The total site nameplate generation is: 28.7 MW CC CHP, 2.0 MW/8.0 MWH of storage, 4.6 MW of solar PV generation, and 6.8 MW backup generators. The total dispatchable capacity is 30.7 MW not including backup generation. The total energy efficiency summer peak load reduction is 5.3 MW. The total current summer peak load is 34.0 MW with energy efficiency it can be reduced to 28.7 MW. Numbers may not add up due to rounding.

A new substation, referenced Microgrid Substation, will be constructed adjacent to the CHP facility and will serve as the primary connection point for all of the distributed generation as well as the interconnection to the NYSEG 34.5 kV system and connections to Robble and Clark substations. A new substation to be known as “Clark No. 2” will be constructed adjacent to the existing NYSEG Clark Substation and will serve as the distribution point for all 12.47 kV microgrid feeders on the east side of the microgrid. The existing NYSEG Clark Substation will remain to serve 4 kV distribution circuits that are not included in the microgrid. The microgrid control room and control system servers, operator workstation, load management system, and data historian servers will all be located in the new facility housing the CHP plant.

The equipment and its relative location is identified in Figure 2 and Table 1 below. The reference numbers on itemized in Table 1 are identified on Figure 2. A simplified one-line diagram is provided in Figure 3. A full page version of the simplified single line diagram and supporting single line diagrams for each of the primary blocks can be found in Appendix A.

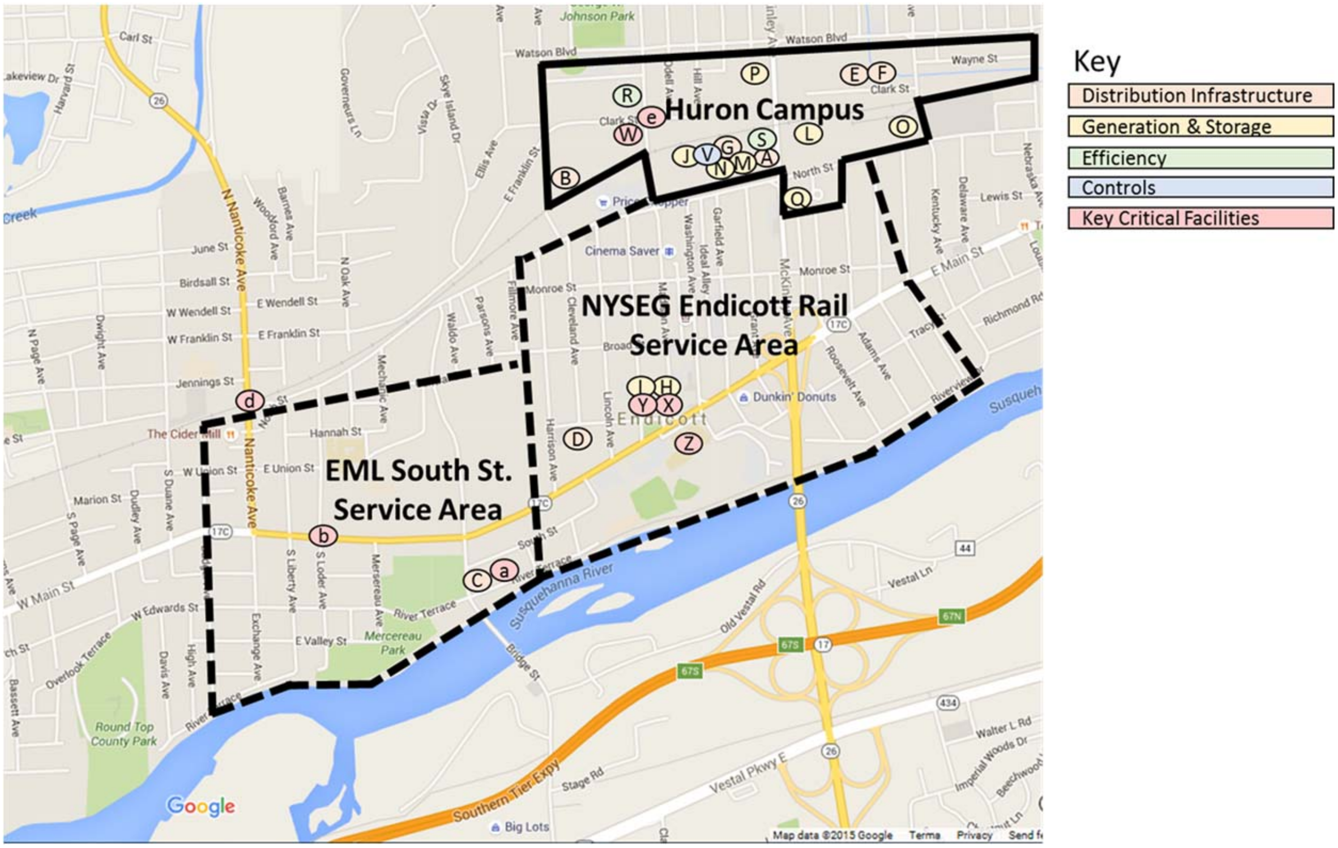

Figure 2: Simplified equipment location layout diagram for Endicott Community Microgrid.

Table 1: Simplified Equipment List for Endicott Community Microgrid

Simplified Equipment List						
Type	Ref.	Name	Rating	Status	Service Area	Location
Distribution Infrastructure	A	Power House		Existing	Huron	Bldg 39, North St, Oak Hill Ave & McKinley Ave, Endicott, NY
	B	Robble Ave Substation		Existing	Huron	E. Franklin St. & Robble Ave, Endicott, NY
	C	South St. Substation		Existing	EML	550 W. Book Ave, on South St., Endicott, NY
	D	Endicott Rail Substation		Existing	NYSEG	E. Main St, Harrison Ave & Lincoln Ave, Endicott, NY
	E	Clark St. Substation		Existing	Huron	E. Clark St. & Hayes Ave, Endicott, NY
	F	Clark Substation No. 2		New	Huron	E. Clark St. & Hayes Ave, Endicott, NY
	G	Microgrid Substation		New	Huron	W. Bldg 39 Power House, W. CHP, Endicott, NY
Generation & Storage	H	Diesel Backup Generator – Police/Fire	0.1 MW	Existing	EML	101 Park St., Endicott, NY
	I	Diesel Backup Generator - Communications	0.02 MW	Existing	EML	101 Park S, Endicott, NY
	J	Diesel Backup Generators – Central System	5.8 MW	Existing	Huron	Bldg 87, Oak Hill Ave, Endicott, NY

	K	Diesel Backup Generators – Stand Alone	0.9 MW	Existing	Huron	Bldg 40 & 60, Distributed on Huron Campus, Endicott, NY
	L	Natural Gas Backup Generator	0.02 MW	Existing	Huron	Bldg 20, McKinley Ave, North St. & Watson Blvd, Endicott NY
	M	Combined Cycle CHP	28.7 MW	New	Huron	West Bldg 39 Power House, North St. & McKinley Ave, Endicott NY
	N	Energy Storage Battery & Inverter	2 MW/ 8MWH	New	Huron	Microgrid Substation, W. Bldg 39 Power House, W. CHP, North St. & McKinley Ave, Endicott NY
	O	Brownfield Solar PV	1.7 MW	New	Huron Campus	Endicott Forging Site, NW Hayes Ave. & North St., Endicott, NY
	P	Building 53/48 Roof Solar PV	1.6 MW	New	Huron Campus	Bldg 53/48, Watson Blvd/Squires Ave, Endicott, NY
	Q	Adam's Ave Carport Solar PV	2.3 MW	New	Huron Campus	Bldg 40, Adam's Ave. & McKinkley Ave, Endicott Ny
Efficiency	R	LED Lighting		Existing	Huron Campus	Bldg 257, Oak Hill Rd., Watson Blvd & North St., Endicott, NY
	S	New Chiller	4.5 MW	New	Huron Campus	Building 39 Power House, near North St. & McKinley Ave., Endicott, NY
	T	LED Lighting	0.3 MW	New	Huron Campus	Distributed buildings on campus, Endicott, NY
	U	Low Cost – No Cost Efficiency	0.2 MW	New	Huron Campus	Distributed buildings on campus, Endicott, NY
Controls	V	Microgrid Control Room		New	Huron Campus	At CHP, West of Power House, near North St. & McKinley Ave, Endicott, NY

Key Critical Facilities	W	Waste Water Treatment	Existing	Huron Campus	Building 96, Clark St. between Robble Ave. & Oak Hill Ave., Endicott, NY
	X	Endicott Police Station	Existing	EML	1101 Park St., Endicott NY
	Y	Endicott Fire Station	Existing	EML	Attached to Endicott Police Station, Endicott, NY
	Z	Union-Endicott High School	Existing	NYSEG	1200 E. Main St. Endicott, NY
	a	Municipal River Street Terrace Waste Water Pumps	Existing	EML	River Street Terrace, next to South Street Substation, Endicott, NY Aka South Street Pump Station
	b	Municipal Sewage Treatment	Existing	EML	S. Loder Ave, Endicott, NY
	c	Municipal Water Works	Existing	EML	Endicott, NY
	d	Nanticoke Avenue Storm Water	Existing	EML	Nanticoke Ave, Endicott, NY Underpass pump

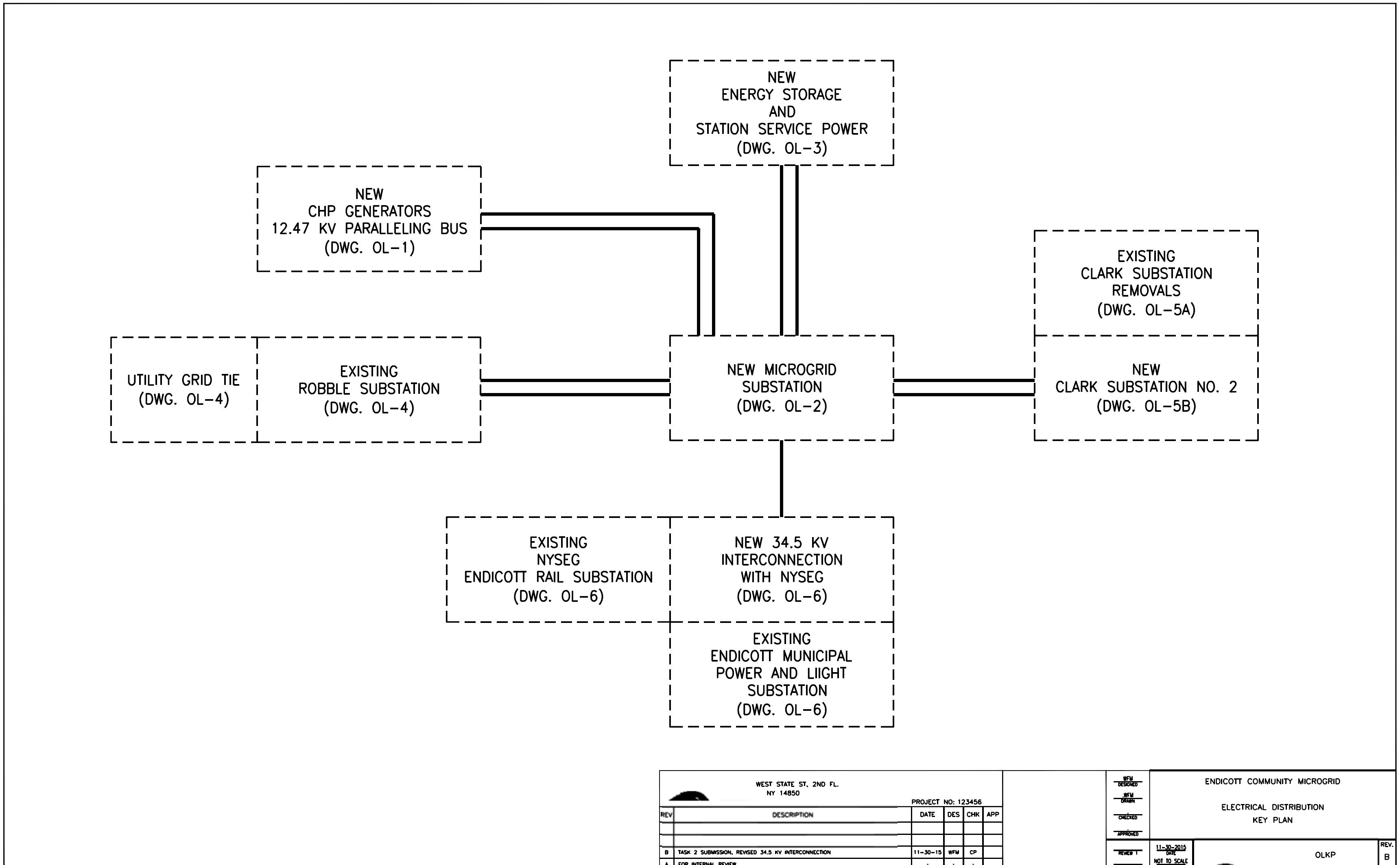

Figure 3: Simplified single-line diagram of Endicott Community Microgrid.

2.1.2 Operation Narrative

During normal operation the substations will be tied to the grid via the 115 kV interconnection at Robble Substation, and the distributed generation and energy storage will be dispatched by the microgrid control system for optimal economic benefit to the microgrid. During an emergency, additional generation will be brought online to meet the load requirement, then the Robble substation will disconnect from the grid. The load management system will maintain the balance between online generation capacity and load, and will temporarily shed a portion of the load if necessary until additional generation is brought online. Generation and storage will be dispatched to ensure that the load is met, the microgrid system remains stable, and the community loads are supported. More detailed descriptions of the operation of each primary component is provided with more detail below and single line diagrams are provided in Appendix A.

Normal Operation Mode

This section provides a description of normal operation of the three substations: Robble, New Microgrid, and Clark Substation and the generation and storage assets: combined cycle CHP, battery, and solar PV.

Grid tie at Robble Substation

During normal, grid paralleled operation, the utility tie breakers at Robble Substation will be closed, allowing bi-directional transfer of power to/from the NYSEG transmission system (Appendix A, Electrical One Line Drawing OL-4). The 12.47 kV voltage and frequency will be continuously monitored at both tie-breakers and in the event of over or under voltage or frequency, or detection of a fault external to the microgrid distribution system, the tie breaker will open separating the utility source from the microgrid.

Note that there are two utility tie breakers at Robble Substation, under normal operation both breakers will remain closed, and the 12.47 kV bus-tie breaker will remain open. Controls at both grid tie breakers have out of synchronization protection and auto synchronizing capability that allow re-synchronizing with the utility grid across either or both breakers.

New Microgrid Substation

The New Microgrid Substation is a "breaker and half" design with two substation busses (Appendix A, Electrical One Line Drawing OL-2). This arrangement allows isolation of any breaker for maintenance and allows for de-energizing either bus for maintenance. Various switching arrangements can transfer the loads and generation sources to either bus for maintenance, or in the event of an emergency.

During both grid paralleled and islanded operation the normal operation of the breakers at the new Microgrid Substation would be unchanged. Breakers 12A1 and 12B3 provide connection of the CHP generation to substation bus 1 & 2 respectively.

Breakers 12A3 and 12B1 provide connection to Robble substation.

Breaker 12C1 provides the connection the energy storage system and primary station service power. Breaker 12E3 provides alternate station service power.

Breaker 12D1 provides power via the NYSEG 34.5 kV transmission system to feed loads at Endicott Rail, and South St. (Appendix A, Electrical One Line Drawing OL-6).

Breakers 12C3 and 12E1 provide connection to Clark No.2 substation.

Under normal operation, breakers 12A1, 12B1, 12C1, 12D1, 12E1, 12A3, 12B3, 12C3, 12E3 are closed; breakers 12A2, 12B2, 12C2, 12D2 and 12D3 are open.

Clark Substation No. 2

The operation of Clark Substation No. 2 is unchanged in both normal and emergency operation (Appendix A, Electrical One Line Drawing OL-5B). All breakers, except the bus tie breaker will be closed. Power to the substation is from feeders 12C3 and 12E1 originating at the Microgrid Substation.

Combined Heat and Power

Under normal grid paralleled operation, the output of the CHP facility will be optimized by the Economic Dispatch system, which will set the power output of the three gas turbines to meet the steam requirements of the Huron Campus. Steam will be generated from the exhaust heat of the three gas turbines at 600 psig, superheated to 750° F. This high pressure steam will be directed to a back pressure steam turbine-generator which will produce additional electrical energy from the steam, thereby improving the overall cycle efficiency. The steam leaving the back pressure turbine at 200 psig, will then serve the campus steam loads for heating, process use, and air conditioning. The CHP thermal flow diagram can be found in Appendix B.

During periods when the campus steam demand exceeds the amount of steam produced from recovery of exhaust heat from the gas turbines, additional steam may be produced by firing natural gas burners in the inlet side of the heat recovery steam generator (Appendix B, Thermal Process Flow Diagram FD-1. The turbine exhaust gas contains approximately 14% oxygen which allows combustion of additional fuel. It is an efficient process since no additional air is needed for combustion and the exhaust gas is already in excess of 900° F. It is also an environmentally friendly means of generating steam. Because no additional air is needed for combustion, there is no additional production of NO_x. This process of steam production is far more efficient than conventional steam boilers.

The Economic Dispatch system will utilize current market rates for natural gas supply to the facility, cost indices for low cost power from NYPA, incentives for exporting power to the grid during peak demand periods, and incentives for ancillary services such as Volt/VAR control and frequency regulation.

During normal operation the microgrid will not export power to the grid, but when there is a financial incentive to do so, the CHP facility is capable of producing additional power via the 3 MW condensing steam turbine generator. The condensing steam turbine generator can use excess steam production to produce more electrical energy which can then be exported.

The electrical output of all 5 generators will be synchronized and paralleled to a 12.47 kV generator bus which in turn feeds Bus 1 and Bus 2 at the Microgrid Substation (Appendix A, Electrical One Line Drawing OL-1).

Energy Storage

During normal operation, the energy storage system will store energy produced by the 5.6 MW utility scale PV arrays to smooth the input of energy delivery to the microgrid system and to allow partial time-shifting of that energy to be used to offset system peaks, when they do not coincide with daily solar energy peaks. Energy can also be stored during off peak hours to compensate for cloudy or stormy times, when there is less sunlight available to the PV system.

Use of stored energy will be controlled by the Economic Dispatch system to ensure the lowest cost energy is used, while meeting the thermal and electrical needs of the microgrid. Recharging of the energy storage will occur during the hours between midnight to 6 AM to levelize the load on the CHP plant and take advantage of time of day energy pricing for purchased energy.

Under normal grid paralleled operation, the energy storage system inverters will operate in a grid following mode where the system voltage and frequency is set by the microgrid bus voltage. The output of the inverters will vary in real power (MW) as dispatched, at a fixed power factor. Power absorption (charging) rate will also vary as dispatched.

In a black start operation, the energy storage system will maintain bus frequency and voltage and provide starting power for the gas turbines and balance of plant equipment for the CHP. Once one or more gas turbine generators are on line, the energy storage inverter will switch to grid following mode and will provide frequency and VAR support to the bus as needed.

In Island mode, the energy storage system will provide peaking power and will assist in frequency and voltage regulation.

Utility Scale PV

Under both normal and emergency conditions the utility scale PV will operate in grid following mode with output frequency and voltage controlled by the microgrid bus. The power output will vary based on the solar energy the array is receiving. The output will be continuously metered via a radio link to allow real-time data collection of the energy produced. This data link will be bi-directional and will allow remote control of the PV inverters to adjust power factor or curtail operation when needed.

Emergency Operation Mode

This section provides a more detailed description of emergency operation under two types of emergency mode planned intentional islanding and unplanned loss of the utility source. In includes a description of generation/storage operation in an emergency and reconnection and black-start operations.

Planned - Intentional Islanding

Prior to separating from the utility grid, additional generation will be brought on-line, if necessary to handle the full load of the microgrid. The MW output of all generation will be ramped up to reduce the level of the power imported from the utility to zero, at which time the grid tie breakers at Robble Substation will open. At the same time, the motor operated switches on the 34.5 kV line will open, isolating the microgrid from the remainder of the transmission and distribution system. Simultaneously, the gas turbine generators will be placed in droop control to maintain the base load power set point set by the load forecasting function of the microgrid controls, while the steam turbines and energy storage will be in isochronous control to maintain system frequency. All voltage regulators will switch from power factor control to voltage control.

Unplanned - Loss of Utility Source

If there is a failure of the 115 kV utility transmission system feeding Robble Substation, one or both grid tie breakers will automatically open (Appendix A, Electrical One Line Drawing OL-4). If the loss of one utility source is local, and the other source remains viable, breaker 12B2 at the New Microgrid Substation will automatically close to supply power to both sides of the 12.47 kV bus at Robble (Appendix A, Electrical One Line Drawing OL-3). Under this condition the microgrid will still remain in synchronism with the utility voltage and frequency, and power can still transfer to/from the utility grid.

If the NYSEG source for the 34.5 kV system remains normal, the motor operated line switches will remain in their normally closed position, and the microgrid will remain in synchronism with the utility source.

If the 34.5 kV source from NYSEG fails but the 115 kV feed at Robble Substation remains normal, the motorized line switches on the 34.5 kV line will open isolating that portion of the distribution feeding NYSEG Endicott Rail and the Endicott Municipal Light (EML) South St. Substation. The microgrid will continue to operate in synchronism with the utility via the connection to the 115 kV at Robble Substation.

If both the 115 kV and 34.5 kV utility sources fail and both grid-tie breakers plus the motorized line switches open, all operating generation in the CHP facility will switch from grid parallel control mode to island control mode. Simultaneously, the load management system will temporarily shed load equal to the amount of utility that was being imported at the moment of separation from the grid. This load will be re-energized as soon as additional generators are brought on line. If there is sufficient spinning reserve at the moment of separation, no load shed will occur.

Once separated from the utility, the microgrid 12.47 kV bus voltage will be maintained by the active generating units. System frequency will be controlled by the steam turbines and energy storage inverters operating in load sharing isochronous mode. The gas turbines will run in droop mode with power output set-points set by the load forecasting control function that uses historical load data, real time load measurements, and weather data to predict base load requirements.

Energy storage

During island mode operation, the energy storage inverters will continue to operate in grid parallel mode and will follow the system voltage and frequency set by the CHP generators. The energy storage system will perform two functions during island mode operation. The first being smoothing of energy produced by the utility scale PV system to limit the swings in output due to varying solar intensity. The resulting swings will be restricted to <5% averaged over 60 minutes, by alternately absorbing power and charging the batteries, and releasing power from the batteries. The second function of the energy storage system in island mode is frequency regulation. The inverters will operate in conjunction with the steam turbines to follow the microgrid electrical load and maintain frequency.

Utility Scale PV

The utility scale PV system will operate in grid parallel mode with the voltage and frequency of the inverter output following the microgrid voltage and frequency of the CHP generators.

The overall operation will be the same as described for normal operation, with the exception being that the microgrid control system will have the ability to partially or completely curtail the output as may be needed to balance the generation/load ratio or to avoid overcharging energy storage batteries.

Output metering, inverter status, and control functions will be communicated via radio links (Appendix C, Control Architecture Drawing CA-2).

Reconnection to the Utility

The microgrid bus voltage and frequency will be adjusted to match the utility source. When synchronized the grid tie breakers will close. Simultaneously, all generators will switch to droop mode with set-points controlled as previously described under "normal operations". All voltage regulators will switch from voltage control to power factor mode.

Any generation that is not needed to support normal operation will be shut down.

The energy storage system will return to normal operation.

Emergency Operation - Black Start

In the event of a total loss of power: no utility source and no microgrid generation, the microgrid is capable of restarting without any outside power source. The energy storage system will have sufficient stored energy to allow a restart of the CHP facility.

In the event of an outage, all emergency generators at facilities within the microgrid will be immediately started and will run until the system is fully restarted and stable.

All control system power will be maintained via the 125 VDC station service battery system and will be unaffected by any AC power outage. All controls, and operation of power switching equipment will be capable of normal operation.

The output of the energy storage inverters will automatically be directed to the 480 volt station service bus and isolated from station service transformer T1 (Appendix A, Electrical One Line Drawing OL-3). This will provide up to 2MVA of power for CHP starting, boiler feedwater pumps, water treatment systems etc.

One gas turbine generator will be started using power from the energy storage system. Normal start-up time is 15 minutes. The first gas turbine will be placed on line in isochronous control to the dead generator bus (Appendix A, Electrical One Line Drawing OL-1). Breaker 12B3 at the new microgrid substation will close to energize Bus 2 (Appendix A, Electrical One Line Drawing OL-2). Breaker 12E3 will close to energize the alternate station service transformer, T2.

Once the second and third gas turbines are started and synchronized, Breaker 12A1 will close to energize Bus 1. After a delay, breakers 12B1, 12C1, 12D1 12E1, 12A3, 12C3 and 12E3 will close sequentially.

After the CHP plant is stable and there is sufficient spinning generation available, Breaker 34-1 will close energizing the 34.5 kV service to Endicott Rail and EML South St. Substation (Appendix A, Electrical One Line Drawing OL-6).

The 480 volt station service bus will then be transferred to transformer T1, via high speed bus transfer.

Restoration of individual loads within buildings will be determined by the load management system to balance the generation/load ratio.

2.2 Load Characterization

The microgrid includes three primary load groups: the Huron Campus, NYSEG Endicott Rail Substation service area, and Endicott Municipal Light (EML) South St. Substation service area. This section provides load summary and load profile information for these load groups.

2.2.1 Load Summary

A summary of the power demand and energy demand are provided in Tables 3 and 4. The maximum peak power demand is listed for July and February to represent the max coincident demand when Huron Campus is at a peak, 34.0 MW, and when Endicott Municipal Light (EML) is at a peak, 31.8 MW. Non-peak and granular power data for Huron Campus is detailed in section 2.2.2. Limited granular data is available for the EML and NYSEG substations. These values represent the baseline energy consumption trends and do not take into account the impact of the proposed microgrid to the consumption.

Energy consumption per month and day are averages based on the total annual energy. The energy usage of NYSEG Endicott Rail and South St. Substations were not provided, therefore the energy/peak demand relationship is assumed to be the same as the ratio provided for the total of the EML substations.

Table 2: Baseline Power Demand Summary

Baseline Power Demand Summary			
Area	Description	Peak Demand – July (MW)	Peak Demand – Feb (MW)
Huron	Clark St. Substation	7.18	7.07
	Robble Ave Substation	18.91	14.81
	Huron Total	**26.09**	**21.17**
NYSEG	Robble Ave Substation	4.19	5.59
	NYSEG Total	**4.19**	**5.59**
EML	South St. Substation	3.78	5.06
	EML Total	**3.78**	**5.06**
Parallel Mode	Huron	**26.09**	**21.17**
Island Mode	Huron + NYSEG + EML	**34.06**	**31.82**

Table 3: Baseline Energy Summary

Baseline Energy Summary			
Area	Description	Annual Electricity (MWh)	Annual Natural Gas (dTherm)
Huron	Clark St. Substation	49,877	
	Robble Ave Substation	111,360	
	Huron Total	**161,240**	**744,520**
NYSEG	Robble Ave Substation	29,835	
	NYSEG Total	29,835	
EML	South St. Substation	24,333	
	EML Total	**24,333**	
Parallel Mode	Huron	**161,240**	**744,520**
Island Mode	Huron + NYSEG + EML	**215,408**	**744,520**

2.2.2 Load Profile

The Huron Campus power and energy load is analyzed followed by the Village of Endicott load. Additional load data analysis and graphics can be found in Appendix D, Load Profile.

Huron Campus – Power and Energy

For Huron Campus 5 minute interval power load data was available from the Clark and Robble Substations for 2014 and 2015. 2015 data was available up through June 2015. The 2014 load is summarized in this section. Additional 2014 and 2015 load analysis is provided in Appendix D: Load Profile.

The campus coincident demand was calculated by adding the two substations power demand together at each instance in time. The load was visualized in 3D graphs showing the annual and monthly relationship between day, time of day, and demand. The load was then summarized in load duration profiles and max/min summary data per day.

Coincident demand is graphed for 2014. The load is typical of commercial space with natural gas based heating. The annual peak load occurs in the summer with daily peaks occurring in the mid-afternoon.

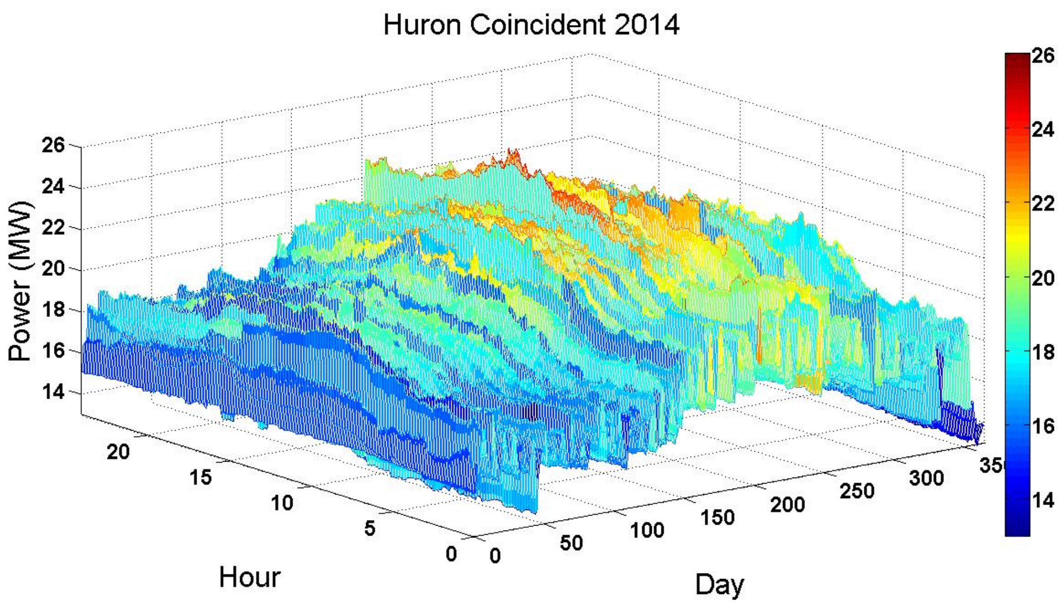

Figure 4: Huron Campus coincident demand, 2014

The maximum and minimum daily demand are graphed sequentially (from Jan. 1 – Dec. 31) to show a summary of the daily load over time.

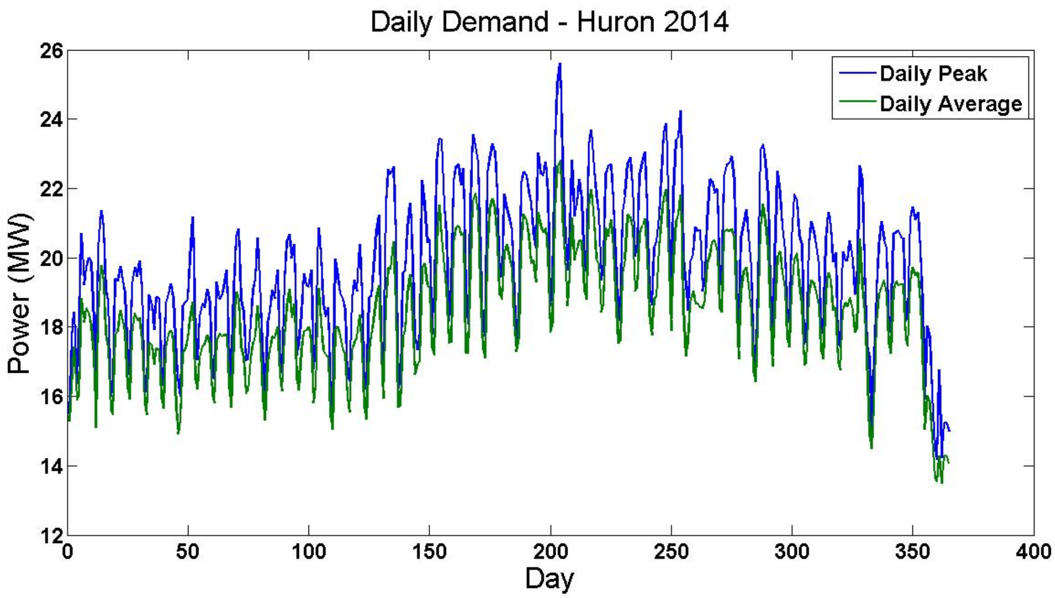

Figure 5: Huron coincident maximum and average load by day, 2014

Monthly demand data is graphed for 2014 during low (January) and high (July) usage months. Appendix D includes graphs showing each individual month. Visualized over a month period, daily peaks and weekend troughs are clear.

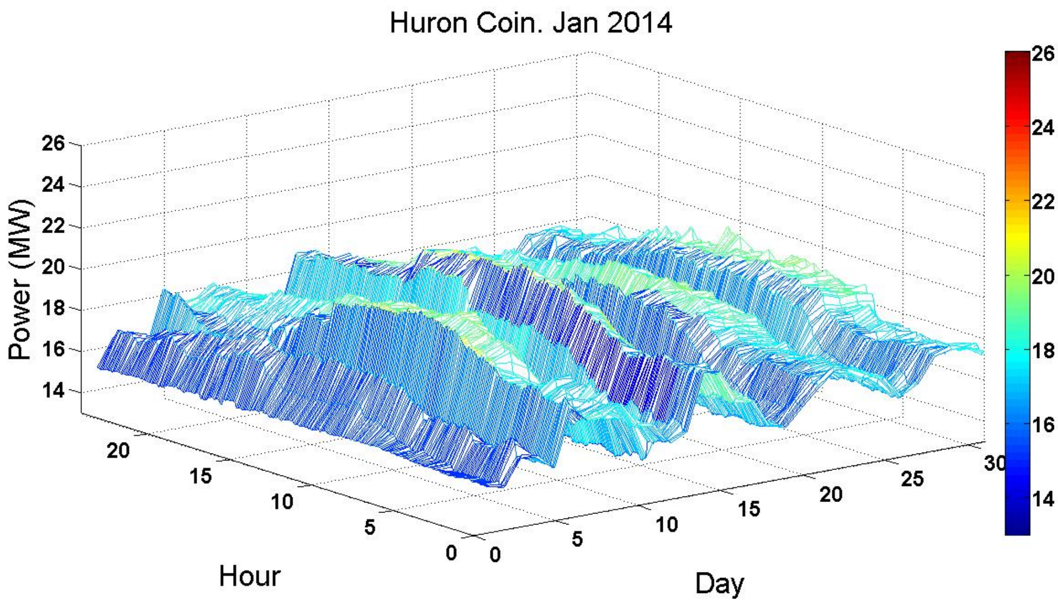

Figure 6: Huron Campus coincident demand, January 2014.

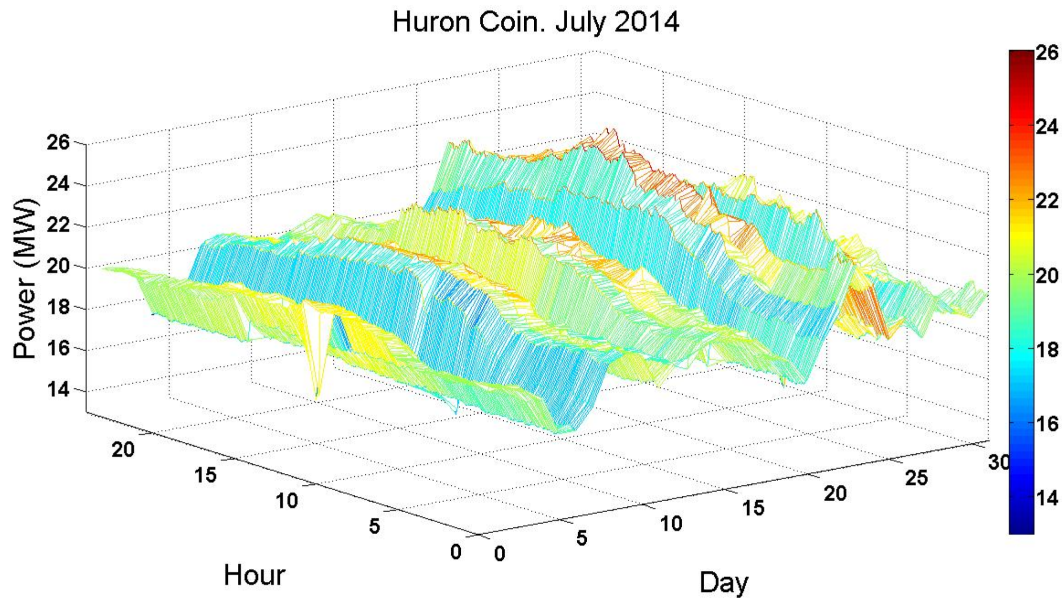

Figure 7: Huron Campus coincident demand, July 2014.

The data was down sampled by taking the minimum, average, and maximum coincident demand for each time duration (each 5 minute interval) for the months of January and July.

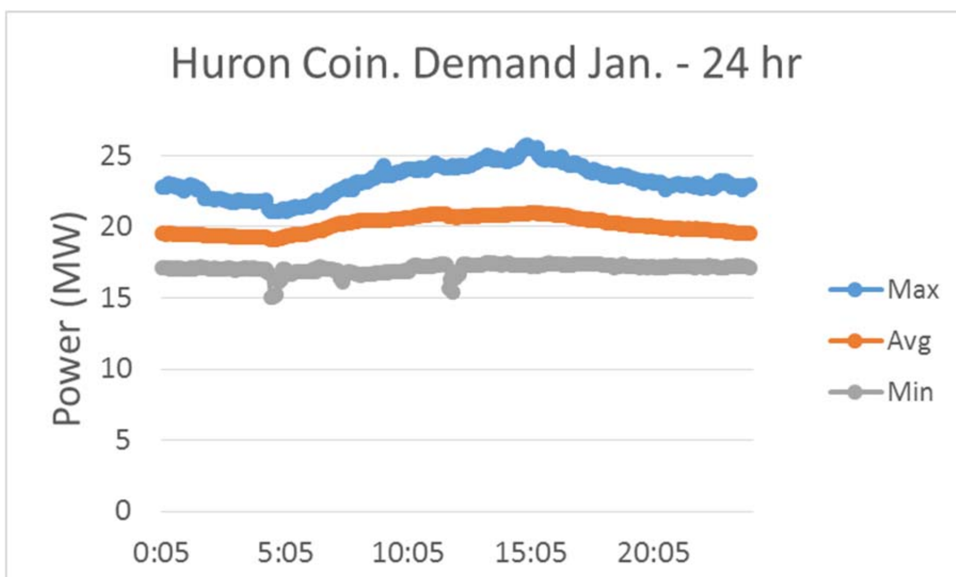

Figure 8: Huron coincident demand summarized for each 5 minute interval, January

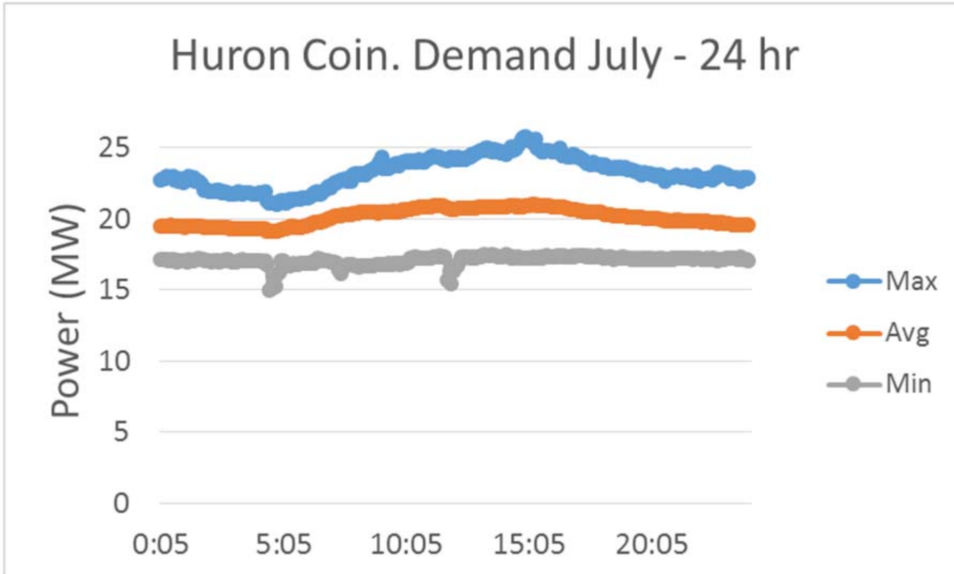

Figure 9: Huron coincident demand summarized for each 5 minute interval, July

There are two methods for graphing the load duration profile that were both used. The first, uses every 5 minute data point, which more accurately reflects how often the load is at a given level over the course of the year. The second is defined by PEER as graphing the frequency of the peak demand of each day of the year, this shows how often a daily peak demand level is reached. For the 5-minute interval data, near peak (97.5 percentile) is 22.2 MW and near base (2.5 percentile) is 14.7 MW. The base (lowest percentile) is 12.8 MW and the peak (highest percentile) is 25.6 MW.

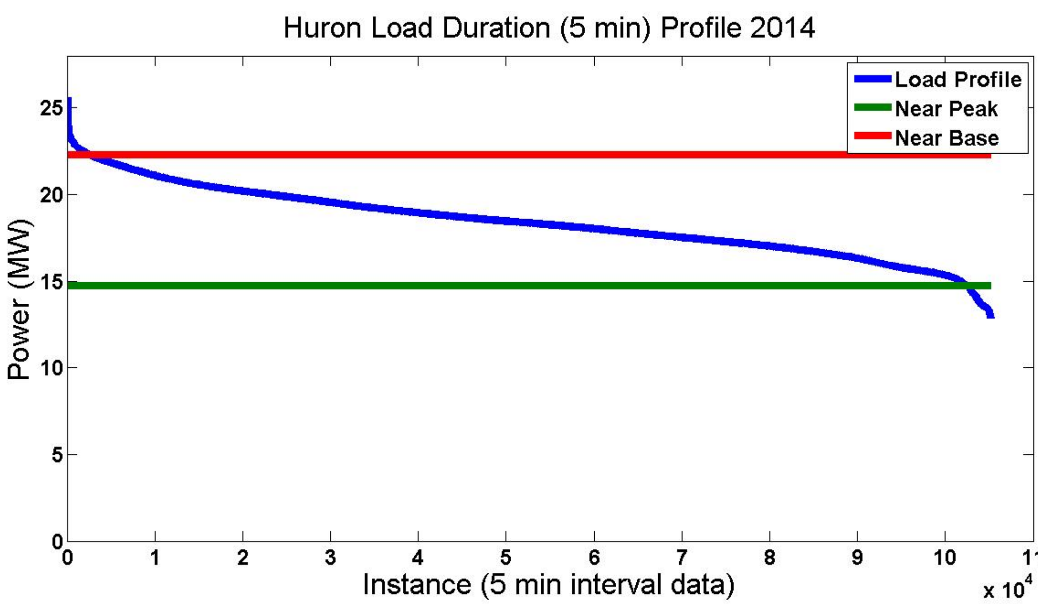

Figure 10: Huron load duration profile, 2014.

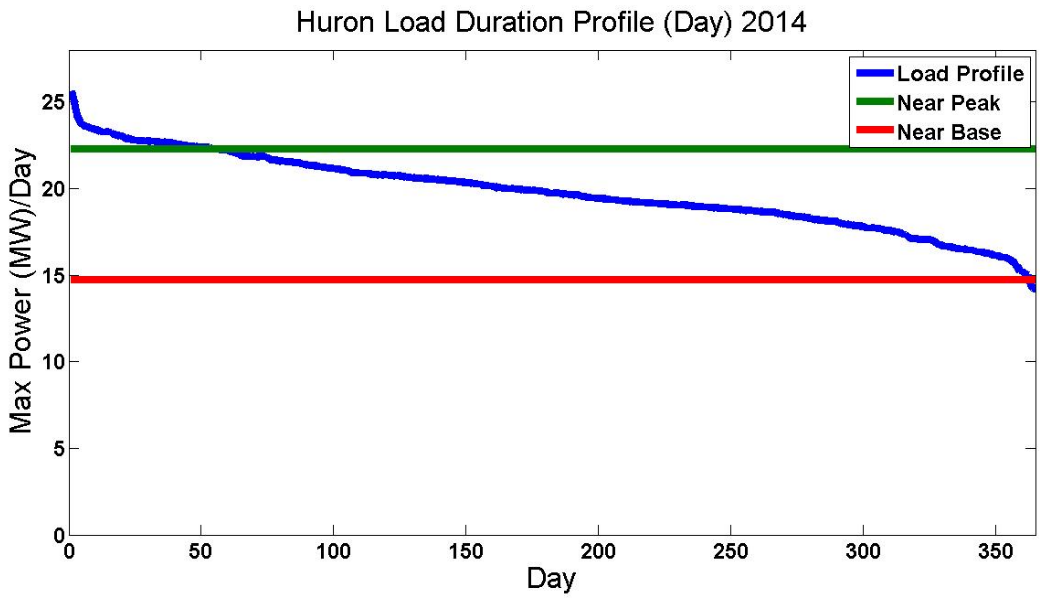

Figure 11: Huron load duration profile using the PEER approach, peak/day

Of particular interest is managing above near peak (top 2.5 percentile) loads. Loads above near peak are isolated and graphed showing the amount the power demand is above near peak (above 22.72 MW). The peaks tend of occur between Day 151 (June 1) to 290 (Oct. 17) and are above 2 MW between 9 am to 5 pm. The greatest peaking occurred at the end of July and reached an above near peak value of 3.3 MW.

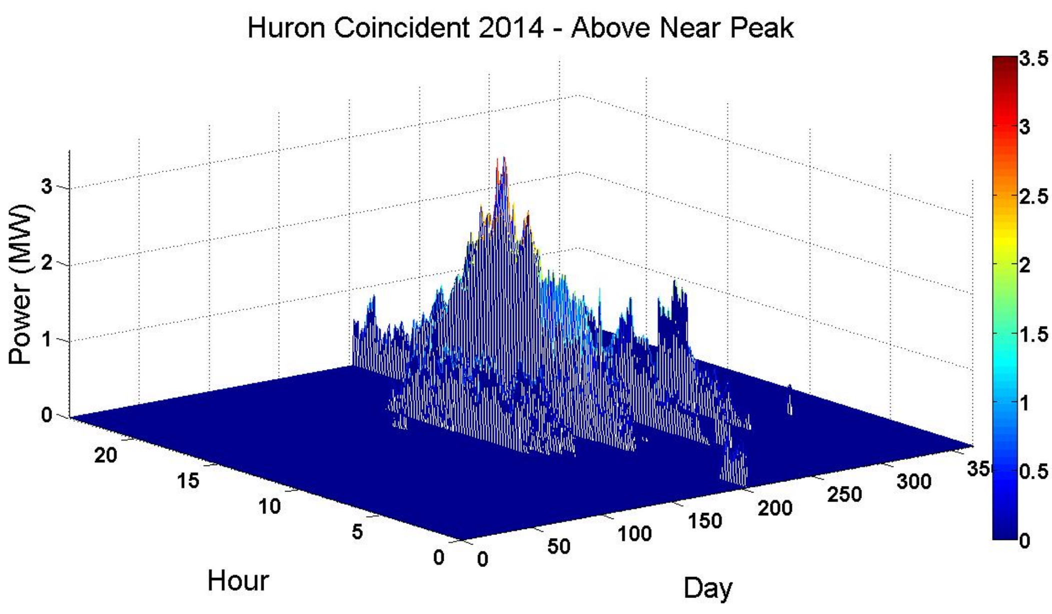

Figure 12: Huron coincident demand above near peak

There are two primary energy sources at the Huron Campus: electrical and natural gas. The natural gas is used for heating, cooling, and process use.

The Huron Campus electrical demand data 1 was integrated for energy consumption by month. The total campus electric energy consumed in 2014 was 161,240 MWh or 550,140 MMBTU, of that consumption 49,877 MWh was supplied by Clark Substation and 111,360 was supplied by Robble Substation.

Natural gas consumption was provided on a monthly basis and is provided in Fig. 12. Consumption ranged from a low in October of 44,161 decatherms to a high in January of 78,750 decatherms.

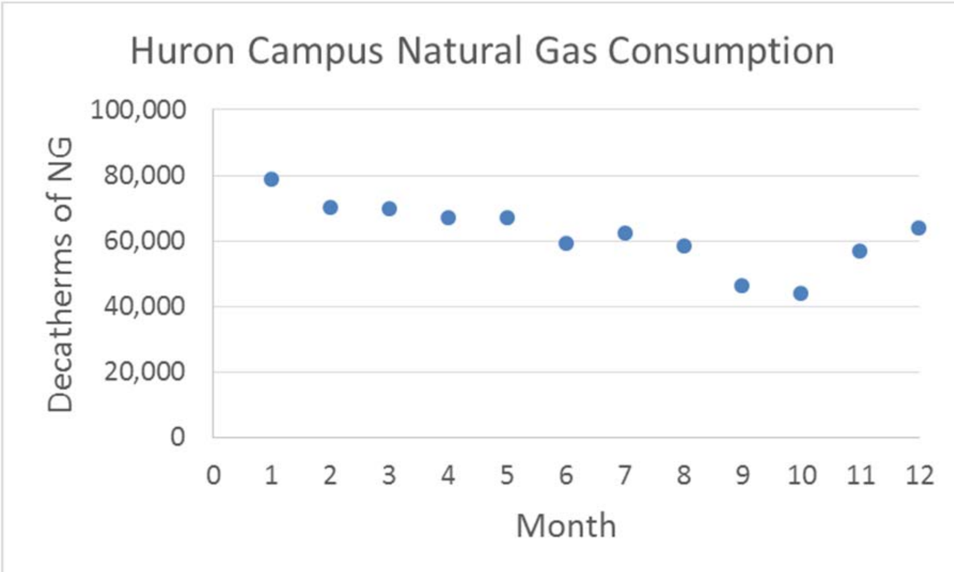

Figure 13: Huron Campus natural gas consumption, dtherms

Endicott Municipal Light - Power and Energy

For Endicott Municipal Light (EML) the peak demand and energy consumption were provided by EML for February 2015, which represented an annual peak.

Table 4: EML Energy and Peak Demand

EML Energy and Peak Demand		
Substation	Peak Demand (MW)	Energy Consumption (MWh)
Franklin St. Substation	4.552	2,271
Rannywell Substation	2.454	1,362
South St. Substation	5.065	2,757
Total	12.070	6,390

The projected total EML demand and energy consumption for Jun 2015 to May 2016 was provided. The Jan 2016 – May 2016 data was shifted to provide projected annual demand and consumption graphics with months in order of Jan – Dec so that month 1 = January.

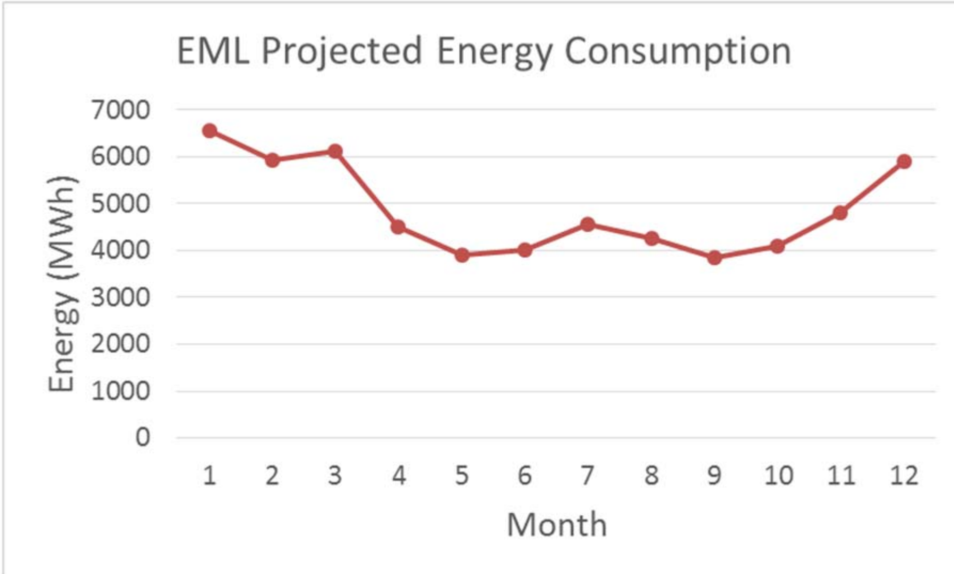

Figure 14: EML total projected monthly energy consumption.

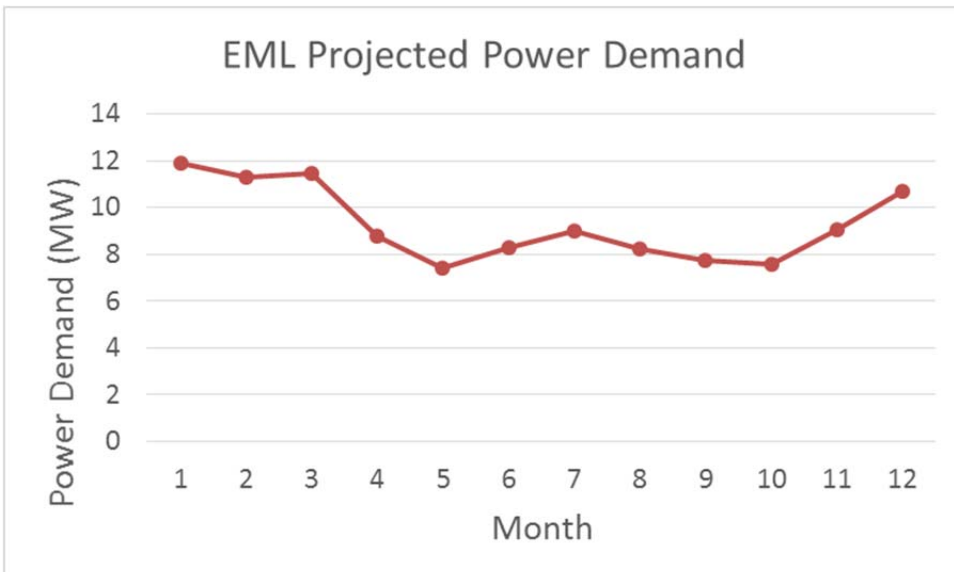

Figure 15: EML total projected power demand.

NYSEG Endicott Rail - Power and Energy

For NYSEG Endicott Rail the peak demand was provided by NYSEG for the three rail load sections in MVA and was converted to MW.

Table 5: NYSEG Peak Demand

NYSEG Peak Demand	
Substation	**Demand (MVA)**
Endicott Railway 4.8 kV	2.53
	2.39
	1.29
Total	5.61

2.2.3 Load Sizing Reduction via Energy Efficiency

In order to reduce system demand and emissions the Huron Campus was assessed for energy efficiency.

The largest energy consumer of the Endicott Community Microgrid project is Huron Campus which has an energy efficiency, sustainability, and environmental impact mission statement. Huron Campus is committed to energy efficiency and has a history of using utility and NYSERDA programs to support efficiency projects. For continued load reduction, three energy efficiency activities were considered for the microgrid: Low-Cost No-Cost EMCs, LED Lighting, and Chiller Replacement**.** Huron Campus could implement all the recommended Low-Cost No-Cost measures in the short-term future by using in-house staff and resources. The lighting LED Lighting Improvement in each building could be achieved by engaging with tenants and using utility or NYSERDA incentives. For longer term microgrid planning a significant summer peak demand reduction could be achieve by replacing electric chillers. This represents a major capital cost improvement that requires secured financing and is recommended to be planned and executed as a component of or parallel to the microgrid project.

The estimated energy reduction for summer peak demand is detailed by measure in Table 6 and totals 5.3 MW and 4,000 dtherms.

Table 6: Energy Efficiency Summary

Energy Efficiency Summary			
Activity	**Electric Energy Savings (MW/yr)**	**Natural Gas Energy Savings (dtherms/yr)**	**Summer Demand Reduction (MW)**
Low-cost No-cost EMCs	1,237	4,035	0.233
Lighting	1,610		0.300
Chiller Replacement	15,140		4.758
Total	**17,977**	**4,035**	**5.29**

The Huron Campus uses a Supervisory Control and Data Acquisition system, and most of the critical information for the buildings are monitored from a central location. The Huron campus has traditionally been using Site-EUI (kBtu/sqft) to track the energy efficiency.

Low-Cost/No-Cost Energy Conservation Measures

The largest 16 buildings, which accounts for almost 80% of the Huron Campus site, have been benchmarked by using EnergyStar Portfolio Manager during FlexTech Benchmarking ASHRAE Level 1 studies that took place in the last three years. The ASHRAE Level 1 studies mainly consisted of detailed analysis of low-cost/no-cost measures and identified capital improvements as opportunities only, without calculations. The remaining facilities (either in or out of Huron Campus) that are not benchmarked are recommended to be benchmarked during the design phase of NY Prize. From the previous study the following low-cost/no-cost energy measures were identified and have been or can be executed in the near future:

- Temperature setback, occupancy sensors on lighting in Building 18,
- Occupancy controls on lighting, exhaust fans and vending machines in Building 32,
- Repair compressed air leaks in Building 32,
- Weather-stripping, low-flow water fixtures, temperature setbacks in Building 33-40,
- Occupancy controls on vending machines, and lighting improvement in Building 33-40,
- Occupancy controls on lighting and vending machines, lighting improvements in Building 41,
- Demand-controlled ventilation, occupancy controls on lighting, and lighting improvements in Building 42,
- Occupancy sensors on lighting, exhaust fans and vending machine, and timer control on exhaust fans in Building 46A,
- Lighting improvement in Building 46A,
- Domestic hot water return aquastat control in Building 46A,
- Lighting improvements, reducing the compressed air leaks in Building 47,
- Occupancy controls on vending machines in Building 47, Building 48, Building 53 and in Building 258,
- Thermostat controls, lighting improvements, insulating the condensate tank in Building 48,
- Controls on air-handling unit, sealing the leaking ductwork in Building 53,
- Timer control on fans, lighting improvement in Building 53,
- Remove unnecessary chilled water circulation, lighting improvements, and delamping on exterior lamps in Building 95,
- Thermostat setback, air sealing and occupancy controls for lighting in Building 95,
- Thermostat setback, lighting improvement, Occupancy controls for vending machine in Building 96,
- Controlling the bathroom fans, and ventilation at night time in Building 250 and in Building 256,
- Thermostat setback and lighting improvement in Building 250, in Building 256, and in Building 258,
- Occupancy controls on lighting, and vending machines in Building 250, in Building 256 and in Building 257,
- Lighting improvement, thermostat setback, and controlling the outside air in Building 257,
- Hot water pipe insulation in Building 258.

The potential energy savings and demand reduction for the 16 buildings that have been studied.

Table 7: Low Cost, No Cost Energy Conservation Measures

Table 7: Low-cost, no-cost energy conservation measures (ECMs) based on the Benchmarking energy assessments (From NYSERDA reports completed by Taitem between 2012-2014)								
	Annual Savings						Peak Demand Reduction	
	Electricity	Steam	Chilled Water		Total Electricity	Total Natural Gas		
Buildings	Electricity (kWh)	Steam (klbs)	(ton-hrs)	Equivalent Electricity (kWh)	(kWh)	(Therms)	Possible Operating Hours (hrs)	Summer Peak Demand Reduction (kW)
18	3,882	53	0	0	3,882	527	50	1.5
32	65,501	0	0	0	65,501	0	60	21.0
33-40	9,807	168	0	0	9,807	1,684	66	2.9
41	66,294	0	0	0	66,294	0	168	7.6
42	659	349	0	0	659	3,497	55	0.2
46a	303,937	263	0	0	303,937	2,637	96	60.9
47	48,969	0	0	0	48,969	0	168	5.6
48	15,942	476	0	0	15,942	4,779	81	3.8
53	166,972	1,052	8,346	9,656	176,628	10,555	75	45.3
95	21,517	946	368,076	425,860	447,376	9,492	168	51.2
96	1,699	9	0	0	1,699	91	168	0.2
250	24,931	125	0	0	24,931	1,259	60	8.0
256	30,920	220	0	0	30,920	2,211	60	9.9
257	33,380	322	0	0	33,380	3,229	45	14.3
258	6,944	38	0	0	6,944	385	168	0.8
Total	**801,355**	**4,021**	**376,422**	**435,516**	**1,236,871**	**40,346**		**233.1**

LED Lighting Improvement

The proposed lighting improvement focuses on replacing all the existing lighting fixtures with LED fixtures while keeping light levels the same. A summary of the energy and demand reduction per building is shown in the table below.

Table 8: Lighting Improvement

Table 8: Lighting Improvement (One-to-one replacement of existing fixtures with LED lighting fixtures)								
Buildings	Area (sqft)	Occupancy (hrs/wk)	Existing LPD (W/sqft)	Proposed LPD (W/sqft)	Existing Electricity (kWh/yr)	Proposed Electricity (kWh/yr)	Savings (kWh/yr)	Summer Peak Demand Reduction (kW)
18 - Office	58,814	50	1.0	0.9	152,916	137,625	15,292	**5.9**
18 - Manufacturing	117,629	144	1.3	1.1	1,145,048	977,695	167,353	**22.3**
32 - Office & data center	59,200	60	1.0	0.9	184,704	166,234	18,470	**5.9**
33-40 - Office	106,225	66	1.0	0.9	364,564	328,108	36,456	**10.6**
33-40 - Vacant	28,481	0	0.0	0.0	0	0	0	**0.0**
41 -Manufacturing	131,458	168	1.3	1.1	1,492,942	1,274,743	218,199	**25.0**
42 - Office	53,133	55	1.0	0.9	151,960	136,764	15,196	**5.3**
46a - Office	4,500	96	1.0	0.9	22,464	20,218	2,246	**0.5**
46a - Data Center	36,000	96	1.3	1.1	233,626	199,480	34,145	**6.8**
46a - Manufacturing	193,150	96	1.3	1.1	1,253,466	1,070,267	183,199	**36.7**
46a - Storage & Common Spaces	229,457	96	0.7	0.6	744,542	738,815	5,727	**1.1**
47 - Manufacturing	115,058	168	1.3	1.1	1,306,691	1,115,713	190,978	**21.9**
48 - Office	22,400	81	1.0	0.9	94,349	84,914	9,435	**2.2**
48 - Manufacturing	164,270	81	1.3	1.1	899,477	768,015	131,462	**31.2**
53 - Office	37,530	75	1.0	0.9	146,367	131,730	14,637	**3.8**
53 - Manufacturing	187,630	75	1.3	1.1	951,284	812,250	139,034	**35.6**
95 - Manufacturing	55,000	55	1.3	1.1	204,490	174,603	29,887	**10.5**
96 - Office	2,000	168	1.0	0.9	17,472	15,725	1,747	**0.2**
96 - Manufacturing	49,915	168	1.3	1.1	566,875	484,024	82,851	**9.5**
250 - Office	89,600	60	1.0	0.9	279,552	251,597	27,955	**9.0**
256 - Office	137,580	60	1.0	0.9	429,250	386,325	42,925	**13.8**
257 - Office	146,000	45	1.0	0.9	341,640	307,476	34,164	**14.6**
257 - Data Center	20,090	45	1.3	1.1	61,114	52,182	8,932	**3.8**
257 - Vacant Office	10,317	0	1.0	0.9	0	0	0	**1.0**
258	120,732	168	1.3	1.1	1,371,129	1,170,733	200,396	**22.9**
Total	**2,176,169**				**12,415,921**	**10,805,234**	**1,610,687**	**300.2**

Chiller Replacement

The Chiller Replacement activity considers replacing the existing electric chillers that are 35-45 years old and near the end of their lifespan. The proposed new chillers is planned to be frictionless magnetic bearing compressor controlled with VFD at 1,500 tons cooling capacity each and recommended to install seven of those chillers (with a total cooling capacity of 10,500 tons) in lieu of four existing chiller (Chiller # 1, 4, 5, and 6 that have total cooling capacity of 11,000 tons). The electric chiller #2 will stay as is as a backup, and steam chiller #3 will continue with the current operating schedule.

The total investment cost of the chiller replacement is estimated around $5 million with a simple payback of 6 years. Simple spreadsheet calculation methodology is utilized in this analysis to roughly estimate the savings and peak demand reduction, but not included the interactive effects between the measures. Spreadsheet summaries can be referenced in Appendix E: Efficiency.

The energy efficiency efforts can be staggered with NY Prize phase as follows:

- NY Prize Phase 1-2: All low-cost/no-cost measures identified
- NY Prize Phase 2: Indoor lighting improvement
- NY Prize Phase 3: Replacing electric chillers in the Power House Utility Plant

2.3 Distributed Energy Resource Characterization

The Distributed Energy Resources (DER) for the Endicott Community Microgrid include a combined heat and power (CHP) facility which will provide both electricity and steam, utility scale PV installation, and an energy storage facility. A summary of the DER systems and their locations can be seen in Table 1 and Figure 2.

The CHP steam will displace the boiler plant currently using natural gas. The CHP and energy storage facilities will be constructed adjacent to the Building 39 Power House on the Huron Campus. The Power house is the location of the existing thermal energy plant and presently provides steam for process and building heating as well as chilled water for cooling to the Huron Campus tenants. The CHP facility will be housed in a new 51,000 sq. ft. metal sided building which will also house the control room, telecommunications, and data servers and station service power (Appendix F, CHP Layout Diagram LP-1).

There are three proposed solar PV systems. The solar PV systems will include a ground mounted 1.7 MW solar PV system at the former Endicott Forging, which is a brown field adjacent to Huron Campus, a roof top mounted 1.6 MW solar PV system at Huron Campus - Building 53/48, and a 2.3 MW car port solar PV system next to Huron Campus - Building 40.

2.3.1 Combined Cycle – Combined Heat and Power (CHP)

The combined-cycle CHP facility will include the following generating resources:

- Three dual fuel gas turbines each having a nominal capacity of 7.9 MW
- One backpressure steam turbine with a capacity of 2 MW
- One condensing steam turbine with a capacity of 3 MW

The total rated generation capacity is 28.7 MW.

All of these turbines will generate power at a voltage of 12.47 kV paralleled on a common bus within the CHP facility (Appendix A, Electrical One Line Diagram OL-1). All generators are synchronous type.

Each of the three gas turbine generators will be coupled with a Heat Recovery Steam Generator (HRSG) to produce high pressure steam from heat recovered from the gas turbine exhaust. The CHP Thermal Process flow diagram shows the thermal processes (Appendix B, Thermal Process Flow Diagram FD-1).

The gas turbines' exhaust outlet temperature is approximately 957° F. This heat is directed to the HRSG which will produce 26,227 lb/hr of steam at 600 psig, superheated to 750° F, with no additional heat input.

Because the turbine exhaust gas contains approximately 14% oxygen, additional fuel can be burned in a duct burner in the turbine exhaust gas stream ahead of the HRSG, to further increase the steam output to a maximum of 110,000 lb/hr per unit. Production of additional steam by duct firing is much more efficient than operation of a conventional boiler as it does not require any additional air supply for combustion and therefore reduces heat losses while at the same time does not introduce additional nitrogen from the combustion air that would otherwise be converted to NOx. This results in emissions improvement over conventional boilers.

The 600 psig, 750°F steam is supplied to a back pressure steam turbine generator (STG-1) which extracts energy from the steam to produce up to 2 MW of electrical energy as the pressure and temperature is reduced to 200 psig, ≈ 390° F. This 200 psig steam is then delivered to the Huron Campus steam system for use as process and heating thermal energy. The electrical output of STG-1 will vary depending on the thermal requirements of the 200 psig steam system.

During winter operation when steam demand exceeds the 78,680 lb/hr that can be produced by heat recovery alone from all three gas turbines, additional fuel gas can be burned in one or more duct burners to augment the steam production, which in turn will also increase the electrical output of STG-1.

During summer weather when the steam demand is low, excess high pressure steam can be utilized to produce additional electrical energy by use of the condensing steam turbine generator (STG-2).

The excess 600 psig/ 750° F steam will be sent to the steam turbine and all of the available thermal energy will be converted to electricity. The outlet of the steam turbine will exhaust to the air cooled condenser at less than atmospheric pressure (a vacuum), thereby extracting as much power as possible from the steam. During emergency islanded operation, STG-2 can be used to for peaking by intentionally increasing the steam production beyond what is needed to satisfy the facilities thermal loads.

Inlet air cooling

Gas turbine engines are power limited by the maximum allowable temperature to the power turbine section to avoid damage. The higher temperatures of outdoor air in summer have the effect of lowering the maximum power that the engine can produce. At 90°F outdoor air, the gas turbine generators in the CHP facility would require derating from 7.9 MW to 6.4 MW.

Because the electrical demand peak for the microgrid occurs during summer, it is beneficial to the operation of the CHP facility and to the microgrid to use the available excess chiller capacity in the Huron Campus chilled water plant to cool the outdoor air from 90°F dry bulb/ 78°F wet bulb to the ISO standard rating condition which is 59°F/ 51.6° This will allow the gas turbine generators to achieve their full power rating of 7.9 MW regardless of outdoor temperature. A total of 486 tons of cooling is required, which will yield a net power increase of 4.3 MW in summer conditions.

Fuel Supply

The normal fuel source for the gas turbine generators and the duct burners is natural gas. Both the gas turbines and duct burners will be equipped for operation on number 2 fuel oil as an emergency fuel source in the event of a disruption in natural gas supply. The gas turbine generators can switch between fuels while in operation. The duct burners must be shut down on one fuel before firing can occur on the alternate, however this does not affect the operation of the gas turbine.

Operation of one gas turbine at full load on oil will consume 587.6 gallons/hr. For all three gas turbines the consumption rate is 1,763 gallons/hr, which is 42,314 gallons/day.

Huron Campus currently has a large oil storage tank with a working capacity of 453,534 gallons which will supply all three gas turbines operating at full load for 9 days, without refueling.

Energy Source Displacement

The CHP system will use natural gas to displace the majority of the electricity currently provided by the utility grid as well as all of the natural gas currently consumed to generate heating, cooling, and process heat. A summary of Huron Campus's baseline current state energy usage compared to the combined cycle CHP system energy usage is provided in Table 9. These numbers are based on 2014 energy load data and estimated energy cost data for the site. The annual energy cost savings using the provided cost rates is $5.9M.

Table 9: CHP Annual Energy Usage and Cost

Table 9: Annual Energy Usage and Cost					
Scenario	**Grid Electricity**		**Natural Gas**		**Total**
	kWh	**$**	**dTherm**	**$**	**$**
Baseline	182,766,830	$10,234,942.48	744,698	$ 1,985,364.87	$12,220,307.35
W/ CHP System	9,230,750	$ 516,922.00	2,159,494	$ 5,757,211.00	$ 6,274,133.00
Change from Baseline	-173,536,080	$ (9,718,020.48)	1,414,796	$ 3,771,846.14	$ (5,946,174.34)

Average Cost Assumptions	
2.666	$/dTherm
0.056	$/kWh

2.3.2 Utility Scale Solar PV

Locations to host solar photovoltaic (PV) systems were identified with ten promising sites considered. These sites each had the potential to generate from 100+ kW to over 2 MW.

The potential array locations included roof mounted and ground mounted systems. Roof mounted arrays may be ballasted or roof penetrating depending on array requirements and building structural constraints. Ground mounted systems will be a mix of carports and fixed-tilt racking systems. The sites were: Endicott Forging brownfield fixed-tilt, Clark St. carport, Adams Ave. carport, Building 53/48 roof mounted, Building 57 roof mounted, Building 57A roof mounted, Building 250 roof mounted, Building 256 roof mounted, Building 40/42 roof mounted, and Building 2500 roof mounted. For each of these systems, the high level energy performance was specified, and the aggregated power rating of the ten systems was over 10 MW and 11,509 MWh/year. A summary of each of the ten sites is in Appendix G, Solar PV.

Of these systems three systems were selected to be included in the microgrid: former Endicott Forging Brownfield Solar PV fixed-tilt – 1.7 MW, Clark St. Carport Solar PV– 2.3 MW, and Building 53/48 Roof Mounted Solar PV– 1.6 MW. A description of the Method and Assumptions is provided in Appendix G: Solar PV.

NY Prize Phase 2

Design phase activity involves more in depth analysis of each proposed system. Specifically, we will examine electrical interconnection issues, tune array layouts, analyze subgrade conditions for ground mounts, and evaluate structural requirements for roof mounted arrays. Additionally, further development of system financing and ownership opportunities will be required.

Design phase layouts will more closely evaluate site constraints to finalize system size. During this stage, we will also get detailed drawings from the racking vendor(s) and perform structural engineering calculations for ground mounted and roof mounted arrays. Site plans will also be created for client evaluation and coordination. Fortunately, full building plan sets are available which reduces structural engineering workload.

Financial variables will also be addressed. For example, material prices are very volatile and we may see significant changes in total system cost between feasibility and design phase. Also, the rebates and tax incentives are fluid and will certainly look different in 2016 and beyond. The NYSERDA rebate is on a declining schedule and the Federal ITC is set to drop from 30% to 10% in 2020. We will evaluate financial risks and provide recommendations based on development timeframe and client needs.

Finally, system ownership models will be explored based on client preferences, capital limitations, and tax considerations. There are various purchase options and system ownership vehicles including loans, leases, and power purchase agreements. During the design phase, we can explore trade-offs between these options and provide guidance to decision makers.

Brownfield Solar PV System, Site #1

Huron Campus contains a brownfield that was the former site of Endicott Forging Company. The site is currently undergoing remediation to deal with soil contaminants derived from the former foundry's activities. Huron Real Estates Associates, the owner of Huron Campus, owns the property mortgage, but site control is under Village of Endicott and New York State. The site is currently fenced in but provides great potential for a solar photovoltaic array. The available space is approximately 5.8 acres and composed of brush and small trees with monitoring well heads scattered across the area. Overall solar access is very good (>95% TSRF) and material staging is straightforward. The Brownfield is also close to medium voltage transmission lines which will facilitate interconnection. Initial modeling indicates the site can support a 1.735 MW array.

Site preparation will involve clear and grub, partial foundation demolition and removal, as well as further investigation of soil contaminants, and identification of any hazards associated with site disturbance. The proposed array will use the entire available area. The Brownfield may be seen from adjacent buildings, but will not impact Campus aesthetics and will be a revenue generating application for otherwise unused real estate. The site is unused and overgrown.

Figure 16: Brownfield PV array

Figure 17: Brownfield as seen from Building 47 rooftop.

Design and Performance

The Brownfield Solar PV provides enough area for a 1.735 MW array based on 5688 Hanwha Q-Cells 305 Watt modules (or equivalent). Array racking is based on a Schletter PV Max 2V ballasted ground rack (2 modules high in portrait). The array will be at a 30 degree tilt to maximize solar production and project economics. Three 500 kW inverters will convert module produced direct current to alternating current more appropriate for grid interconnection via a step-up transformer. The array's average annual energy production is estimated at 2,113 MWh/year.

Table 10: Design summary for Brownfield Solar PV (Site #1)

	Site #1
Location / Building #	Brownfield
Number of modules	5688
Module type	Hanwha Q-Cells Q.Pro L-G3 305
Array size (kW)	1735
est. prod (MWh/y)	2113
Inverter type	KACO XP500U-TL
Racking type	Schletter PV Max
Proposed tilt	30
Array spacing (if applicable)	2x

Feasibility Considerations/Capital Cost

The total system cost for the Brownfield Solar PV system (site 1) is estimated at $3.2M before any incentives are applied. Applying the current NYSERDA rebate reduces the system cost to $2.4M before any tax credits or depreciation expenses.

Feasibility considerations are related to the Brownfield site contamination, transfer of liability to Huron Campus, and electrical interconnection.

Adams Ave. Carport Solar PV System, Site #3

Huron Campus has several parking lots surrounding campus buildings that have potential for solar development. Two of the largest parking areas are located adjacent to Clark Street (Site #2) and Adams Avenue (Site #3). These sites have excellent solar access, require only modest site work, and are well situated to take advantage of secondary benefits associated with carport solar PV arrays. The Clark

Street site is planned to house the new Clark No. 2 substation and therefor Adams Ave. was selected for inclusion in the microgrid.

Figure 18: Adams Ave. Carport

The Adams Ave. carport location – the largest contiguous site identified during the Campus survey - is approximately 6.3 acres and has sufficient area for a 2.328 MW array. The site TSRF is estimated at 95% based on array tilt, orientation, and shade. Equipment staging is straightforward based on the usable parking area. The Adams Ave. array will be located near medium voltage distribution lines facilitating interconnection.

Site preparation at both carport locations is manageable. The Adams Ave. carport does not require significant restriping but existing streetlights will be removed. Parking lot illumination may be provided through carport integrated lighting. The proposed array will use most of the available area as shown in Figure 18. The Adams Ave. carport does not utilize all of the available area due to shading concerns on the south end of the parking lot.

Secondary benefits associated with the carport arrays include shelter from rain, snow, and sun. Also, as electric vehicles (EV) gain more acceptance these facilities may serve as convenient locations for EV charging facilities. Such parking structures can increase site attractiveness to existing and new tenants because of these features.

Figure 19: Adams Ave Carport site seen from Bldg 40

Design/Performance

The Adams Ave. Carport Solar PV system provides enough area for a 2.328 MW array based on 7632 Hanwha Q-Cells 305 Watt modules (or equivalent). The array will be at a 10 degree tilt to keep the maximum carport height below 20' while keeping modules high enough above grade to accommodate high clearance vehicles, and minimize vandalism opportunities; although, final height and tilt may be adjusted based on client preference and site requirements. Four 500 kW inverters will convert module produced direct current to alternating current more appropriate for grid interconnection via a step-up transformer. The Adams Ave. array will produce an estimated 2,591 MWh/year on average.

Table 11: Design summary for Adams Ave Carport (Site #3)

	Site #3
Location / Building #	Carport - Adams Ave
Number of modules	7632
Module type	Hanwha Q-Cells Q.Pro L-G3 305
Array size (kW)	2328
est. prod (MWh/y)	2591
Inverter type	KACO XP500U-TL
Racking type	Schletter Park@Sol (or equivalent)
Proposed tilt	10
Array spacing (if applicable)	3x

Feasibility Considerations/Capital Cost

The total system cost for the Adams Ave. Carport (site #3) is estimated at $4.9M before any incentives are applied. Applying the current NYSERDA rebate reduces the system cost to $3.95M before any tax credits or depreciation expenses.

Feasibility considerations are related to maintaining good site access for high clearance vehicles such as delivery trucks, and ensuring electrical interconnection meets National Electric Code standards and utility requirements.

Building 53/48 Roof Mount Solar PV System, Site 9

Among the eighteen buildings examined during the feasibility phase, Building 53/48 on Huron Campus stood out as the best option for a solar PV installation. The rooftop is large with excellent solar access. There are obstructions presented by HVAC equipment, skylights, pipes, conduits, and vents; however, the space is easily utilized with a roof penetrating rack system that avoids many of the obstacles. This installation will require roof penetrations and the owner indicated that the roof is in line for replacement, which provides an excellent opportunity to coordinate array installation during the roof replacement cycle.

Figure 20: Building 53/48 Array

The targeted roof space covers approximately 180,000 square feet and will allow for a 1.635 MW array. Material staging will require lift equipment to access the rooftop but the site has good access for heavy equipment and containers. Interconnection will be managed through medium voltage transmission lines adjacent to the building.

Building 53/48 is one of the tallest structures on Huron Campus; the solar PV array will be facing the existing steam generating facility. Accordingly, the array will not significantly impact residential aesthetics. The array may be visible from other campus buildings but will not be easily seen from the ground.

Figure 21: Building 53/48 Rooftop

Design/Performance

The Building 53/48 rooftop, with good solar access, has enough area for a 1.635 MW array based on 5360 Hanwha Q-Cells 305 Watt modules (or equivalent). Array racking is a Schletter IsoTop penetrating roof system. The array will be at a 20 degree tilt to maximize solar production without excessively increasing wind loads. Three 500 kW inverters will convert module produced direct current to alternating current more appropriate for grid interconnection via a step-up transformer. The array's average annual energy production is estimated at 1,920 MWh/year.

Table 12: Design Summary for Building 53/48 (Site #9)

	Site #9
Location / Building #	Bldg 53/48
Number of modules	5360
Module type	Hanwha Q-Cells Q.Pro L-G3 305
Array size (kW)	1635
est. prod (MWh/y)	1920
Inverter type	KACO XP500U-TL
Racking type	Schletter IsoTop or equivalent
Proposed tilt	20
Array spacing (if applicable)	2x

Feasibility Considerations/Capital Cost

The total system cost for the Building 53/48 Roof Mounted Solar PV (site #9) array is estimated at $3.2M before any incentives are applied. Applying the current NYSERDA rebate reduces the system cost to $2.6M before any tax credits or depreciation expenses.

Feasibility considerations are dependent on structural analysis for acceptable roof loads, material staging, and electrical interconnection.

2.3.3 Energy Storage

An energy storage system with an inverter capacity of 2 MW and a storage capacity of 8 MWH will be installed adjacent to the CHP facility and the New Microgrid Substation (Appendix A, Electrical One Line Diagram OL-3).

The energy storage system will provide the following functions:

- Black start – Stored Energy will be used to power the black start-up of the CHP facilities including the gas turbines and steam system auxiliaries.
- Time shifting of energy resources – Low cost energy produced by PV or purchased at a low rate can be stored for use to displace higher cost purchased power during peak demand periods.
- Peaking – During Island Mode operation, the energy storage system can follow the microgrid load and meet peaking power requirements.
- Frequency regulation – During Island Mode operation the energy storage system can assist frequency regulation. During grid parallel operation it can also provide ancillary service to NYSEG for frequency regulation if there is a financial incentive.
- Volt/VAR support - During Island Mode operation, the energy storage system is capable of providing voltage support and regulation to maintain the microgrid system voltage stability. It can also provide additional VAR support when necessary to supply motor starting demands etc. During grid parallel operation it can also provide ancillary service to NYSEG for Volt/VAR support if there is a financial incentive.
- Spinning Reserve – During Island Mode operation, the Energy Storage system will provide spinning reserve capability with its ability to rapidly follow load swings as they occur.

2.3.4 Demand Response

Demand response (DR) provides an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. Huron Campus is the primary customer of the microgrid and has an existing commitment to DR on the order of 1 MW. Opportunities to increase DR participation will be further assessed in the microgrid design phase of NY Prize.

Table 13: Summary of NYSEG Demand Response Programs

Summary of NYSEG Demand Response Programs				
Program Name	**Type**	**Load Reduction**	**Notification**	**Rate**
CA$HBACK	Voluntary	>= 100 kW	>= 1 hr	$0.45/kwhr
CA$HBACK Plus	Contract	>= 300 kW	>= 4 hrs	
Commercial System Relief Program	Voluntary & Reservation	>= 50 kW >= 4 hrs	<21 hrs	Voluntary- $0.15/kwhr Reserve- $2.75-3.00 / kW/ month $0.15/kwhr
Distribution Load Relief Program	Voluntary & Reservation	>= 50 kW >= 4 hrs	<= 2 hrs	Voluntary- $0.15/kwhr Reserve- $2.75-/ kW $0.15/kwhr Over 4 hrs $0.30/kwhr

2.4 Electrical and Thermal Infrastructure Characterization

This section described electrical and thermal infrastructure characterization. These sections reference Appendix A, Electrical One Line Diagrams and Appendix B, Thermal Flow Diagrams.

2.4.1 Electrical infrastructure

The Endicott Community Microgrid will be interconnected with NYSEG's 115 kV Transmission system at the existing Robble Substation. The 115 kV side of the substation is owned by NYSEG, and will not require any modifications. The 12.47 kV side is owned by Huron Campus and will remain in use. Two presently unused feeder positions will be used to connect the 12.47 bus at Robble to the new microgrid substation.

All new protective relays will be installed at Robble to accommodate the bi-directional power flows and to incorporate control of the main 12.5 kV breakers that will function as grid-tie breakers for the microgrid.

An additional interconnection will be made to NYSEG's Existing 34.5 kV sub-transmission line that runs between the North Endicott and Endicott Rail substations. This is a loop system that also feeds from North Endicott substation to Clark Street substation and then to Endicott Rail substation via the Kentucky Tap. A new motorized line switch with line relay will be required between North Endicott Substation and a new tap from the new breaker 34-1 at the microgrid substation (Appendix A, Electrical

One Line Diagram OL-6). A second motorized line switch with line relay will be required at Endicott Rail Substation to isolate the microgrid portion of the 34.5 kV system during an emergency.

The three gas turbine generators and two steam turbine generators in the new CHP plant will be paralleled at 12.47 kV on the paralleling bus in the plant. Two feeder connections from that paralleling bus will connect to Bus 1 and Bus 2 respectively at the new Microgrid Substation.

The new Microgrid Substation will be a 5 bay, 12.47 kV Breaker and Half type constructed adjacent to the new CHP plant (Appendix A, Electrical One Line Diagram OL-2). This substation will also incorporate the 2MW/8MWH energy storage battery as well as the 12.47/34.5 kV step up transformer and Breaker to feed the EML.

The existing Huron Campus feeders from NYSEG's Clark Substation will be removed and rerouted to a new outdoor metal clad substation: "Clark No.2" which will be fed with two feeders from the new Microgrid Substation (Appendix A, Electrical One Line Diagram OL-5A & OL-B).

2.4.2 Weather Resiliency

The CHP and energy storage system will be contained in new structures that will comply with the New York State building code and will withstand wind rain, snow, seismic and other events as may be expected in Broome County NY., without interruption of power and steam production. Most of the power feeders to the microgrid will be underground and will not be affected by weather.

The 34.5 kV connection to the NYSEG and Endicott Municipal Light (EML) is presently constructed above ground. The new tap from the microgrid substation will also be above ground and will employ weather hardened steel pole construction.

The location of the CHP, energy storage, and New Microgrid Substation is outside of the 100 year flood plain and not expected to be subject to flooding.

The output of the utility scale PV array may be temporarily reduced by heavy snowfall, however sufficient reserve capacity exists in the CHP and energy storage to offset the temporary loss of PV generation.

Portions of the Endicott Municipal Light distribution system and substations are in areas subject to flooding, and could be affected by a severe flood. Power from the microgrid will permit continued operation of wastewater and sewage pumps that will help reduce the extent of flooding during an emergency.

In the event that power must be curtailed to all or part of the Endicott Municipal Light system due to flooding, it will have no effect on the remainder of the microgrid, and there will be no loss of generating capacity.

2.4.3 Black Start

In the event of a total loss of power: no utility source and no microgrid generation, the microgrid is capable of restarting without any outside power source. The energy storage system will have sufficient stored energy to allow a restart of the CHP facility.

In the event of an outage, all emergency generators at facilities within the microgrid will be immediately started and will run until the system is fully restarted and stable.

All control system power will be maintained via the 125 VDC station service battery system and will be unaffected by any AC power outage. Control system Economic Dispatch and Load Management computer servers and operator workstations will be equipped with dual power supplies, capable of operation on either uninterruptable power supply (UPS) backed 120 volt AC or 125 volt DC. All controls and operation of power switching equipment will be capable of normal operation.

See Section 2.1.2.2 for a detailed description of power switching for black start operation.

Restoration of individual loads within buildings will be determined by the load management system to balance the generation/load ratio.

Once steam becomes available, STG-1 will be placed in operation and synchronized on the generator bus. Power flow from STG-1 will be dependent on steam flow determined by the pressure at the 200 psig steam header.

The gas turbine governors will switch to droop mode and operate in response to the load forecasting function of the microgrid controls. STG-1 will be placed in isochronous operation and will maintain frequency in parallel with the energy storage system.

STG-2 will be started and placed on line in load sharing isochronous mode and will handle peaking power demands to maintain system frequency.

Breakers 12E1 and 12E3 will close and Clark No.2 substation loads will be restored.

All emergency generators will be shut down.

The 480 volt station service bus will re-transfer to T1, via the high speed bus transfer function.

The utility scale PV system will be placed into normal operation, and all system loads will be sequentially.

The black start sequence will be performed by the microgrid controller with step-by-step acceptance by the microgrid operator. Manual operator intervention will be required to place each HRSG on line, as will the start-up of the steam turbine generators. All generator synchronization is automatic once the operator signals approval.

At this point, the microgrid continues to operate in island mode until the utility source becomes available.

2.4.4 Load following operation – Grid paralleled

During normal grid paralleled operation the CHP resources will be dispatched by the Economic Dispatch function of the microgrid controls. Power and fuel price indexes, operational efficiency, weather, and historical forecasting will all be factored in order to determine the optimum mix of generation.

In general during normal grid paralleled operation, the CHP will operate to meet the thermal requirements of the Huron Campus, extracting the maximum amount of power from the available steam flow, while meeting the steam delivery needs for process and heating use.

The energy from the utility scale PV system will be time shifted by the energy storage system to reduce daily peak power demand, thereby achieving maximum value for the renewable energy.

Load following operation – Island operation

During island operation, the gas turbine generators will be dispatched as “base load” resources, with MW set points established by the load forecasting function of the microgrid controls. The load forecasting function takes into account historical load profile weather and real time microgrid load.

The base load generation operating point will be maintained approximately 1.5-2 MW below forecast peak to allow room for the peaking generation to follow the load. Base load generators will operate in “droop” mode.

The steam turbine generators STG-1 and STG-2 will operate in isochronous mode while islanded. STG-2 will be the primary load following generator and will maintain system frequency at 60 HZ. STG-1 will have limited load following capability within its steam flow and backpressure limitations.

The energy storage system will also provide frequency regulation during island operation.

Part load operation – Grid Paralleled

As previously discussed, the operation of the CHP facility during grid paralleled will be dispatched based on economics. If it is more economical during some periods to take advantage of low-cost power purchased from NYPA, the electrical output of the CHP will be scaled back allowing the import of cheaper energy.

Because gas turbines are more fuel efficient at full load than at part load, under some conditions seasonally when power demand and thermal demand are both low, one of the gas turbines can be shut down. These are also periods when scheduled maintenance will be performed.

Using the time-shifting capabilities of the energy storage system, renewable energy can be stored when not needed immediately for use later to offset the cost of more expense energy.

Part Load Operation – Island Operation

During island operation, the priority is reliability more so than energy efficiency. All DER resources will be maintained on-line. Setpoints for base load generation (gas turbines) will be adjusted to maintain the 1.5 - 2MW “headroom” for the peaking generators.

Power produced by the utility scale PV system will be stored by the energy storage system and utilized for demand peak leveling and frequency regulation.

Low Voltage and Frequency Protection and Ride through

Relay settings at the grid – tie breakers at Robble substation will be set to quickly separate the microgrid from the utility transmission system in the event of a loss or fault on the utility side. Settings for undervoltage (ANSI function 27), overvoltage (ANSI function 59), and over frequency (ANSI function 81_O) will comply with IEEE-1547, Standard for Interconnection of Distributed Generation with Electric Power Systems. Underfrequency protection (ANSI function 81_U) will be set per recommendations of the Northeast Power coordinating council (NPCC) standard NPCC-A03, which allows distributed generation to remain on-line longer during a low frequency event to avoid cascading outages.

Generator and feeder protection within the microgrid will have two settings: one with settings normal to utility paralleled operation, and the other settings which will be used when the microgrid is islanded. The latter settings will allow a greater tolerance and longer time settings for both voltage and frequency to allow the system to re-stabilize from momentary upsets. The island mode settings will also reflect the reduced available fault current to maintain coordination between generator and feeder breakers.

The settings changes will be made instantaneously whenever the grid-tie breakers open.

Voltage and Frequency Control

During normal grid paralleled operation the microgrid voltage and frequency will be controlled by the utility system.

When the microgrid is separated from the utility system and operating as an island, the system voltage will be controlled by the generator voltage regulators maintaining a fixed voltage referenced at the generator bus.

When islanded, frequency will be maintained by isochronous control of the peaking generators (steam turbines) and the energy storage system's frequency support function.

2.5 Microgrid and Building Controls Characterization

See Appendix C, Control Architecture Diagrams CA-1 and CA-2 for a graphical representation of the control architecture. All microgrid controls will communicate over a dual redundant fiber optic network using SONET fiber communications protocols. The fiber network will be looped, and can operate with the complete loss of either loop and will automatically redirect network traffic in the event one or more cable sections are damaged.

SONET protocol allows both TDM and Ethernet communications over dedicated ePipes that establish low latency high speed communications for time critical operations and conventional packet switched Ethernet for non-time critical operations.

Protective relays and RTU's will communicate using NERC-IP compliant IEEE-61850 messaging allowing GOOSE and other message formats in a secure environment.

All devices on the control network will have redundant power supplies, at least one of which is DC supplied from the dedicated station service batteries. AC control power via the station UPS system will be used for control power as a redundant source and to power instruments that to not have DC power capability.

Servers

Dual Industrial hardened servers will be installed for each major function. Dual servers will be used for the Microgrid Controller, Data Historian, Event Recorder and HMI servers.

The Data Historian servers will run industry standard PI software for archiving and data retrieval.

The HMI servers will provide operational data to 4 operator workstations, each capable of performing all control and monitoring functions. The HMI software will be industry standard Wonderware.

All devices will receive an IRIG-B time synchronization signal from a GPS clock, distributed over the fiber network and corrected for latency at the multiplexers.

The following is a list of dedicated servers and workstations for the microgrid control and monitoring functions:

<u>Load Management</u> – dual redundant servers, 125 VDC powered industrial computer, 1TB SSD, SEL-3355

1. Inputs: Time, all load metering, DI from remote I/O for load status, Generation metering, utility tie metering
2. Outputs: load shed to remote I/O.

<u>Historian/Forecasting</u> dual redundant servers, 125 VDC powered industrial computer, 1TB SSD, SEL-3355

1. Inputs: Time, generation status and load - 5 minute basis, all load metering 5 min data, outdoor temperature, energy storage charge/discharge 5 min data, steam production 5 min data.
2. Outputs: previous day load curve, previous day outdoor temperature curve, current day forecast vs. actual load- real time, day-ahead load forecast.

Economic dispatch - 125 VDC powered industrial computer, 1TB SSD SEL-3355

1. Inputs: time, weather, fuel price index, purchased electric price index, generation efficiency, steam demand, PV availability
2. Output: Generation selection and setpoints, calculation of operating cost.

Microgrid Controller- dual redundant servers, 125 VDC powered industrial computer, 1TB SSD, SEL-3355

1. Inputs: Time, Bus voltage and frequency, generator breaker status, generator kW, Vars, PF, governor control (isoc. or droop) VR mode (PF or volt) Generator status `(assigned load or frequency control)
2. Outputs: Generator kW or frequency, PF or volts. Storage charge/discharge rate.

Steam System Control- dual redundant servers, 125 VDC powered industrial computer, 1TB SSD, SEL-3355

1. Inputs: time, All HRSG temperatures, levels and pressures. Duct burner status and firing rate. Feedwater, condensate and water treatment status and levels
2. Output: Duct burner control and rate, Steam turbine setpoint (to generation control), Bypass PRV control, Vent valve control, Feedwater pump control, condensate pump control, Deaerator level and pressure control

Data Logging – 1 125 VDC powered industrial computer, 1TB SSD SEL-3355

1. Input: time, 1 minute data logging all GT-1 and HRSG-1 operating parameters
2. Output: archive to hot swappable hard disks.
3. Output: Generation selection and setpoints, calculation of operating cost.

Data Logging – 2 125 VDC powered industrial computer, 1TB SSD SEL-3355

1. Input: time, 1 minute data logging all GT-2 and HRSG-2 operating parameters
2. Output: archive to hot swappable hard disks.

Data Logging – 3 125 VDC powered industrial computer, 1TB SSD SEL-3355

1. Input: time, 1 minute data logging all GT-3 and HRSG-3 operating parameters
2. Output: archive to hot swappable hard disks.

Data Logging – 4 125 VDC powered industrial computer, 1TB SSD SEL-3355

1. Input: time, 1 minute data logging all STG-1, STG-2 and balance of plant operating parameters
2. Output: archive to hot swappable hard disks.

Event recorder – 5 Dual redundant servers, 125 VDC powered industrial computer, 1TB SSD, SEL-3355

1. Input: Time, all plant and electrical distribution alarms, status of all generation, power circuit breakers and reclosers.
2. Output: time stamped daily and event logs

Operator workstations – 1, 2, 3, 4 - 12 VDC powered industrial computer, 500 GB SSD, SEL-3360, provide dual monitors, keyboard and mouse. Provide two SEL-9331 power supplies, 120 VAC/12VDC to power the 4 workstations.

Telecom workstation - 12 VDC powered industrial computer, 500 GB SSD, SEL-3360, provide monitor, keyboard, mouse and power supply SEL 9331, 120VAC/12VDC.

Security - 125 VDC powered industrial computer, 1TB SSD SEL-3355

1. Inputs: Security cameras, card readers, door switches
2. Outputs: daily entry log, video log, intrusion alarms.

PLC's

The following Programmable logic controllers will provide operating control for the major systems of the CHP plant. All are integrated into the overall plant control and SCADA system and provide both operational control as well as data gathering and alarm reporting functions over a common communications backbone.

GT-1 - Allen Bradley 1756 control logix with PanelView industrial touch screen, integrated in Solar Turbines package, power 120 VAC from UPS.
GT-2 - Allen Bradley 1756 control logix with PanelView industrial touch screen, integrated in Solar Turbines package, power 120 VAC from UPS.
GT-3 - Allen Bradley 1756 control logix with PanelView industrial touch screen, integrated in Solar Turbines package, power 120 VAC from UPS.
STG-1 - Allen Bradley 1756 control logix with PanelView industrial touch screen, integrated in STG package, power 120 VAC from UPS.
STG-2 - Allen Bradley 1756 control logix with PanelView industrial touch screen, integrated in STG package, power 120 VAC from UPS.
Balance of plant – dual, redundant Allen Bradley 1756 control logix each with redundant 120 VAC power supplies from UPS.

Network and Communications

The following equipment forms the data network and communications backbone for the microgrid, integrating the protection, control and data collection functions into a secure and reliable system with integral redundancy and dedicated high speed communications paths for critical control functions:

Multiplexer – SEL-ICON, dual protected line modules, dual Ethernet modules (8 LAN points ea.), (1) 125 VDC power supply, (1) 120 VAC power supply, (from ups)
Time Synchronization – SEL-2047, IRIG-B output, 125 VDC, remote antenna.
RTU – for non-relay switchgear and load management I/O: SEL-2240 Axion RTAC, 10 or 4 module as needed, 125 VDC/120VAC power input.

2.6 Information Technology (IT)/Telecommunications

The primary telecommunications media for the microgrid control system will be the redundant, self-healing looped fiber optic network, running SONET protocol. Dedicated pathways will allow both TDM (high speed communications between time critical devices) and conventional packet switched Ethernet.

The communications backbone will only communicate with the outside world through a dedicated gateway that employs user authentication via Radius Server.

Communications with the utility (NYSEG) will be via this gateway. NYSEG will have full monitoring privileges as well as limited control functions that will be determined by a future operating agreement.

Outside vendor connections via the Web will not be allowed, but limited access will be given through the secure gateway for remote troubleshooting and diagnosis.

Where the control network extends to outlying substations such as South Street, the primary communications medium will be via Ethernet over Radio link.

3. Microgrid's Commercial and Financial Feasibility

The overall microgrid business case was developed and the microgrid was assessed to be commercially and financially feasible.

3.1 Customers

This section describes the commercial terms/relationship between participants in the microgrid project, products expected to be produced by the microgrid, and arrangements for sharing of benefits.

A summary of the primary stakeholder relationships for the microgrid is provided in Figure 21. The primary relationship is the Microgrid and Huron Campus relationship. However, additional key relationships are between the Microgrid and: NYSEG, Endicott Municipal Light (EML), and NYISO.

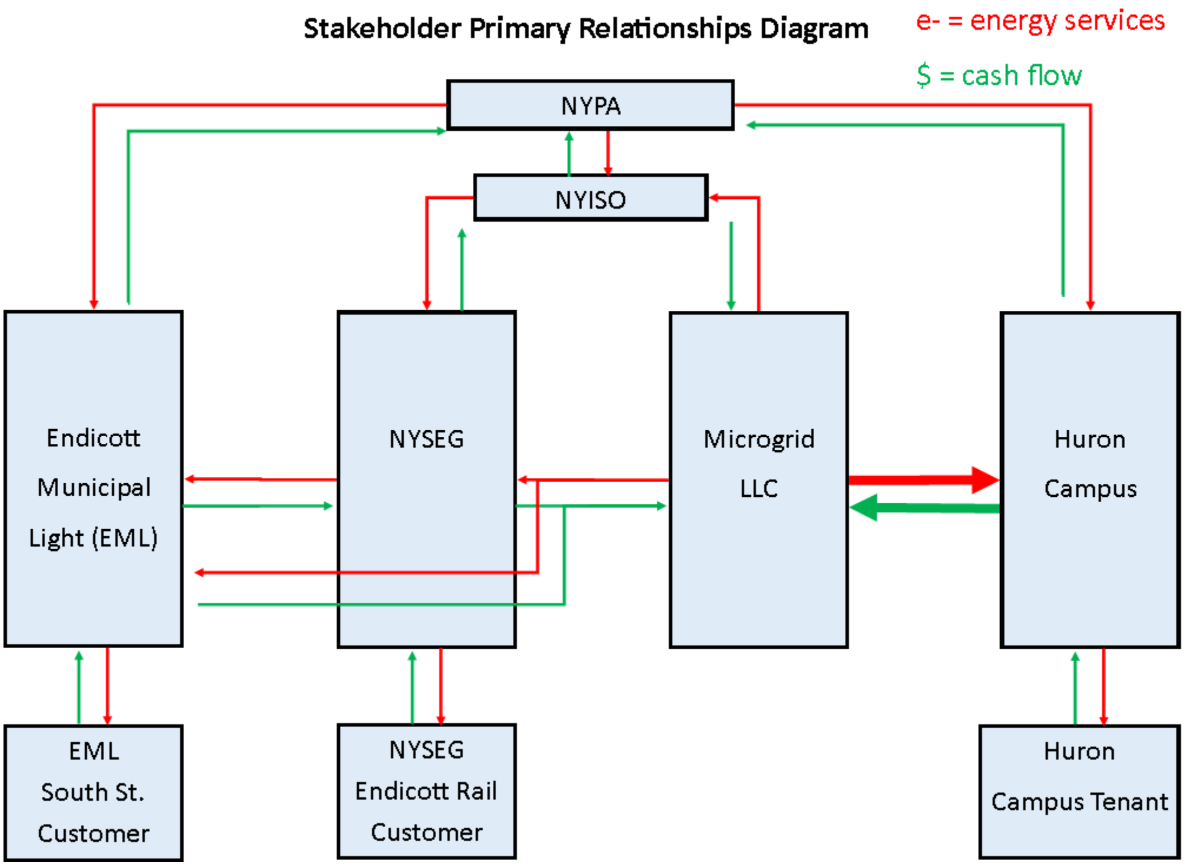

Figure 21: Primary relationships of microgrid stakeholders.

3.1.1 Individuals Affected

Identify the number of individuals affected by/associated with critical loads should these loads go unserved (e.g. in a storm event with no microgrid).

During normal and emergency operations this project will affect the Huron Campus owners (Huron Real Estate Associates), tenants, and tenant employees. Huron Campus hosts businesses that employee a approximately 4,000 people. By ensuring reliability during a storm event, the microgrid will help attract, retain, and encourage the growth of tenants at Huron Campus.

During an emergency operations, power will be provided to the Village of Endicott community and critical facilities. The Village of Endicott community has 13,392 individuals, 6,058 households, 2,994 families in residence, according to the 2010 census. The median income for a household is $32,599 and the median income for a family was $46,761. Over 16% of families and 21% of the population are below the poverty line.

3.1.2 Direct Services

Identify any direct/paid services generated by microgrid operation, such as ancillary services, or indirect benefits, such as improved operation, to the utility or NYISO? If yes, what are they?

The campus has historically participated in demand response with NYSEG on the order of 1-2 MW load reduction. The microgrid CHP-battery system will have the ability to reduce load by 28 MW.

The microgrid may provide direct/paid services in the form of ancillary services the NYISO market in the form of capacity, wholesale electricity, emergency energy support, voltage support, and Renewable Energy Credits (RECs).

In the event that the NYSEG transmission and distribution systems feeding the microgrid experience instability or outage, the microgrid system will provide reliable energy to the microgrid customers including the Huron Campus and the customers of Endicott Rail Substation and the South Street Substation.

3.1.3 Customers

Identify each of the microgrid's customers expected to purchase services from the microgrid.

The primary customer of the microgrid is Huron Real Estate Associates (refered to as Huron). Huron is expected to purchase electricity and thermal energy services from the microgrid. Huron Campus tenants already pay Huron for utilities and energy services. Tenants will continue to pay Huron, the change will be the source of the energy that Huron is procuring.

During emergency conditions NYSEG Endicott Rail and Endicott Municipal Light (EML) South Street will purchase electricity from the microgrid. NYSEG and EML will continue to provide direct energy services to their customers.

3.1.4 Other Stakeholders

Identify other microgrid stakeholders; what customers will be indirectly affected (positively or negatively) by the microgrid.

The overall impact to stakeholders is anticipated to be positive.

Huron Campus commercial and industrial tenants will benefit from cost competitive, sustainable, reliable energy that will support their business uptime and their corporate sustainability goals. It is anticipated that the microgrid will contribute to an increase in tenant occupancy positively impacting both Huron and the Village of Endicott community.

The community facilities and residences that are included in the microgrid will have access to reliable power during emergency conditions. This will increase community safety and community pride.

3.1.5 Owner – Purchase Relationship

Describe the relationship between the microgrid owner and the purchaser of the power.

The microgrid will likely be a separate legal entity, the structure of which would be dependant upon the investors and developers preferences. For the purpose of this study the entity is referenced as the Microgrid LLC. The Microgrid LLC will rent space from and sells energy services to Huron. Huron has expressed interest in being a customer of the Microgrid LLC. Some investors in Huron may be interested in investing in the Microgrid LLC.

The microgrid will have the capacity to almost fully meet the Huron Campus's energy needs in terms of both heat and power. This will allow the microgrid owner to determine the level of operation of the CHP system based on demand and the availability of solar PV, battery power, natural gas fuel rates, and utility power rates. Thus optimizing operating costs.

Because Huron currently has a NYPA allocation for 5 MW of hydropower it is likely that Huron will continue to use this non-greenhouse gas emitting, low cost energy source from the grid in parallel with purchasing energy services from the microgrid.

NYSEG and EML will continue to own and control distribution systems that they currently own and control. The Microgrid LLC can provide NYISO, NYSEG, and EML ancillary energy services and emergency services.

3.1.6 Operation Type

Indicate which party/customers will purchase electricity during normal operation. During islanded operation? If these entities are different, describe why.

During normal operation Huron will be billed for electricity and thermal services from the microgrid. Huron will then bill energy costs to their tenants similar to how they currently are billed for energy services from NYPA and NYSEG and then bill their tenants. In terms of electricity, the Huron role will not change, just the source of their supplier. In terms of thermal, Huron will now purchase thermal energy instead of purchasing natural gas and then operating a boiler system.

During islanded mode NYSEG and EML will purchase electricity from the Microgrid LLC and then provide services to the NYSEG Endicott Rail and EML South Street substations' customers. This will include a number of critical facilities which will benefit from increased reliability and uptime.

3.1.7 Contracts

What are the planned or executed contractual agreements with critical and non-critical load purchasers?

Huron will enter into a bilateral contract with the Microgrid LLC. The agreement will specify the roles and responsibilities including rented space, electricity rates, thermal heating rates, and emergency services.

Huron will continue to enter into lease contracts with tenants. These lease contracts will include utility, energy services, and facilities considerations. For interested tenants specific levels of reliability services and their associated costs could be included.

Huron's demand response (DR) agreement will need to be renegotiated based on the higher level and speed of response for load management at Huron Campus associated with the control system. Some demand response may be associated with Huron and some may be associated with the Microgrid LLC. The allocation of this will depend on the final ownership structure and agreement between the Microgrid LLC and Huron.

The Village of Endicott, Endicott Trust may need to approve any plans to provide power to EML during an emergency and will need to approve any associated costs.

3.1.8 Solicitation of Customers

How does the applicant plan to solicit and register customers (i.e. purchasers of electricity) to be part of their project?

Huron will be the primary customer. Other customers will be NYISO, NYSEG, and Endicott Municipal Light (EML). Individual residences and businesses will not be directly solicited and registered as customers, their relationship will continue to be with their current energy provider.

The NYSEG, EML, and Endicott Trust for the Village of Endicott will be engaged. Endicott Trust may need to provide an approval for the Microgrid LLC to provide power to EML in an emergency. Customers of EML will not be direct decision makers, however, community engagement may be key to gaining Endicott Trust support.

3.1.9 Energy Commodities

Are there any other energy commodities (such as steam, hot water, chilled water) that the microgrid will provide to customers?

The microgrid will provide thermal energy in the form of steam to the Huron Campus and its tenants via the combined cycle combined heat and power (CHP) plant. The campus has existing thermal distribution and the CHP system will be located close to the thermal distribution system.

3.2 Value Proposition

This section describes the value the microgrid is expected to provide directly to its participants, to the community at large, the local electric distribution utility, and the state of New York by the following sections.

3.2.1 Benefits and Costs

What benefits and costs will the community realize by the construction and operation of this project?

The Endicott Community Microgrid will provide green energy infrastructure including MW scale solar PV and energy efficiency. It will support resilience during emergencies that impact grid operations, and will enhance economic resilience by supporting business development on the Huron campus and beyond. The microgrid project can also catalyze greater community participation in clean energy solutions.

The Southern Tier Regional Economic Development Council has been awarded Governor's Cuomo's Upstate Revitalization Initiative called the Southern Tier Upstate Revitalization Initiative (URI), which includes an Endicott innovation district focusing on manufacturing. Jobs for residents, a stronger tax base, and economic activity are all key to the economic resiliency for the Village of Endicott. The potential for community revitalization based on economic development at Huron is great. The microgrid will:

- Ensure cost competitive energy rates that offer renewable energy (sustainability) and resiliency (high uptime) which will support the continued success of existing businesses
- Attract new energy and technology companies
- Provide infrastructure for energy technology innovation
- Create the foundation for a smart energy hub serving as a demonstration and validation site for emerging technologies
- Catalyze workforce development by leveraging existing aged infrastructure and emerging tech for educational and training opportunities, including engineering and business students, tradespeople seeking hands-on experience, and k-12 and the broader community

The microgrid has the capacity, distribution, and control required to provide emergency electricity to NYSEG Endicott Rail and Endicott Municipal Light (EML) South Street substations and the customers that they support. The EML South St. Substation feeds the Village of Endicott Fire Station, Police Station, Waste Water Pumping Station, Storm Water Pumping, Village Office, and Library. The NYSEG Endicott Rail feeds the Union-Endicott School and UHS Walk-in Care. In addition to these critical facilities, the two substations feed power to approximately 1,800 households and 28 commercial customers. NYSEG and EML will purchase electricity from the microgrid during an emergency and will then sell electricity to their customers. This will allow the community to continue to have electricity during an emergency but not have increases in their electricity rates.

In addition to the critical facilities supported by the NYSEG and EML substations, Huron Campus is the host site of a wastewater treatment plant, as shown in the figure below courtesy of Huron Real Estate Associates. The plant serves Broome County's solid waste operations, processing approximately 50% of its landfill leachate every day. Without the Huron Wastewater plant, as much as 80,000 gallons per day have to be trucked north to the Ithaca Wastewater Plant, an 80-mile round trip, but the closest DEC-certified facility for raw leachate.

Figure 22: Huron Campus Wastewater Treatment Plant

The microgrid project will also help to engage the community in the energy economy, and take advantage of state and utility programs for energy efficiency and renewable energy. With 49% of the Endicott community being Low and Moderate Income (LMI) households, reducing utility bills through energy efficiency will be of great benefit. And New York State's commitment to ensuring LMI access to solar energy can help both residential and community solar PV systems to be developed in Endicott.

Huron's hosting of the community microgrid, plus its auditorium, cafeteria and event venues, offers a place for public gatherings to promote commercial and residential energy programs, job opportunities, and technology. The broad base of tenants at Huron makes it possible to leverage the services and expertise of professionals and companies working on the campus. For instance, BAE Systems holds weekly tutoring sessions for about 40 K-12 students, and is interested in expanding on-campus volunteer options for employees.

Many clean energy programs exist today, funded by a variety of private and public agencies. These, and new programs anticipated in 2016 and beyond, can serve the Endicott Community. They include:

- **Green Jobs Green NY**, NYSERDA – free or reduced cost residential energy assessments, installation services, low interest financing, and pathways to training for various green-collar careers.

- **K-Solar**, NYPA, State Dept of Education, NYSERDA – works with school districts to install solar PV to achieve substantial energy savings, and to incorporate energy education into their curriculums. SunEdison has been selected as the contractor for most of upstate, including Endicott.

- **Community Shared Solar**, Dept of Public Service, NYSERDA – new regulations were recently approved to support off-site "roofless" solar access, and other renewable generation systems for ratepayers who join a community solar farm or similar entity. 10 or more owner/subscribers, including residents, businesses, non-profits, municipalities and educational institutions can net-meter from a common array, allowing solar access for those who cannot go solar on-site.

- **Small Commercial Energy Efficiency Program**, NYSERDA – no-cost energy assessments to businesses and non-profit organizations, with follow-up assistance to implement recommendations.

- **Commercial and Industrial Energy Efficiency Rebates**, NYSEG – funding for HVAC, lighting and other building improvements, both small scale ($5 per LED bulb) to large scale ($.22/kWh saved through customized whole building renovations)

- **Commercial Energy Efficiency "direct install" programs**, NYSEG – up to 70% cost-share for lighting and commercial refrigeration retrofits, using sole source contractors and standardized products, for small and medium size business and non-profit facilities.

- **Rural Energy for America Program**, USDA – Because of the small population, Endicott small businesses are eligible for grants and loan guarantees to help pay for energy efficiency and renewable energy projects.

- **Commercial and Industrial Incentives and Technical Assistance**, NYSERDA – funding for energy improvements saving at least 250,000 kWh annually, and for feasibility studies, load management and efficiency analyses.

- **Economic Development Assistance for Commercial Energy Efficiency and Energy Infrastructure**, NYSEG – supplemental financial assistance and negotiated rate pricing for eligible manufacturing, high tech, healthcare and agricultural facilities.

- **MultiFamily Performance Program**, NYSERDA – expected to announce new simplified and streamlined operation in 2016 to assist building owners in making energy improvements to existing facilities.

- **76West clean energy business competition**, NYSERDA - to grow new business ventures in the Southern Tier with $10 million in prizes to be awarded in 2016 through 2020.

- **Energize NY financing**, Energy Improvement Corporation – property assessed clean energy financing for solar, other renewable energy and efficiency investments in commercial facilities. Expected to become available in Broome County in 2016.

Leveraging these, and other available programs, will bring new money into the Endicott community, while improving real estate assets and lowering monthly costs for residents and businesses. New distributed generation in the form of onsite and community solar systems, in addition to the core microgrid located at Huron Campus, will support resilience in cases of grid outages caused by emergencies and climate change.

3.2.2 Impact to Utility

How would installing this microgrid benefit the utility? (E.g. reduce congestion or defer upgrades)? What costs would the utility incur as a result of this project?

The microgrid will benefit the utility in three ways: 1) it will provide emergency electricity to NYSEG and EML customers, 2) it can provide ancillary services that will benefit NYISO, NYSET and EML, and 3) it will reduce the peak demand of Huron Campus by around 20 MW.

3.2.3 Proposed Business Model

Describe the proposed business model for this project. Include an analysis of strengths, weaknesses, opportunities and threats (SWOT) for the proposed business model.

The financial analysis was completed separating the microgrid into three components: the core microgrid, PV projects, and chiller replacement. The reason for this is that these three components may be owned by separate entities. The core microgrid would be owned by the Microgrid LLC, the PV project(s) could either be owned by a solar PV PPA provider, Huron, Huron tenant(s), the LLC, or community solar, and the chiller replacement would likely be owned by Huron.

Core Microgrid

The proposed business model has Huron as the primary customer of the Microgrid LLC purchasing both electricity and thermal energy. Huron has expressed interest in this relationship. The benefit to this is that there is only one primary customer relationship to manage.

The community will benefit from emergency electricity services but will not be a direct customer. Instead, NYSEG and EML will be customers, in the business model they are only customers in emergency cases and since emergencies are rare the business model does not rely on income from them.

NYISO programs are identified for participation in ancillary services and can supplement revenue by around 20%. In actuality, some of these services could potentially be purchased by NYSEG or EML if desired and there is some risk in whether the microgrid will be eligible to participate in the NYISO market.

The business model assumes that Huron is not willing to pay above market value for the electricity and thermal energy. Huron currently pays a mixed rate of NYSEG retail electricity and NYPA electricity. In the model, Huron purchases energy at their current rate mix with energy rate escalation applied at 2.1% annual for electric and 1.3% annual for natural gas. The project has a positive earnings before interest, taxes, depreciation, and amortization (EBITA) ranging from $ 5-12M depending on the assumptions made. However, it should be noted that depending on ownership tax and cost related benefits may assist in the project viability.

An analysis of public funding availability led to the assumption that $30.4M, or 39% of the required capital, could be available to the project. This includes $7M from NY Prize, $20M from the Southern Tier Upstate Revitalization Initiative, and $3.4M in CHP tax incentive.

With the assumption of public funding included, two scenarios are modeled, one based on current rate mix with NYPA included, and one where after 5 years Huron no longer has NYPA electricity in its rate mix – therefore increasing the market rate in year 6. The blue bars represent the cash flow when only traditional revenue is considered (revenue from Huron to the Microgrid LLC). The orange bars represent the cash flow for the total revenue, when both traditional revenue and total revenue (ancillary services + traditional revenue) are applied. Table 23 provides a summary of the 25-year average annual earnings (EBITA) which does not include the initial capital investment and the net present value (NPV) which is based on a 10% annual discount rate. This is an aggressive discount rate.

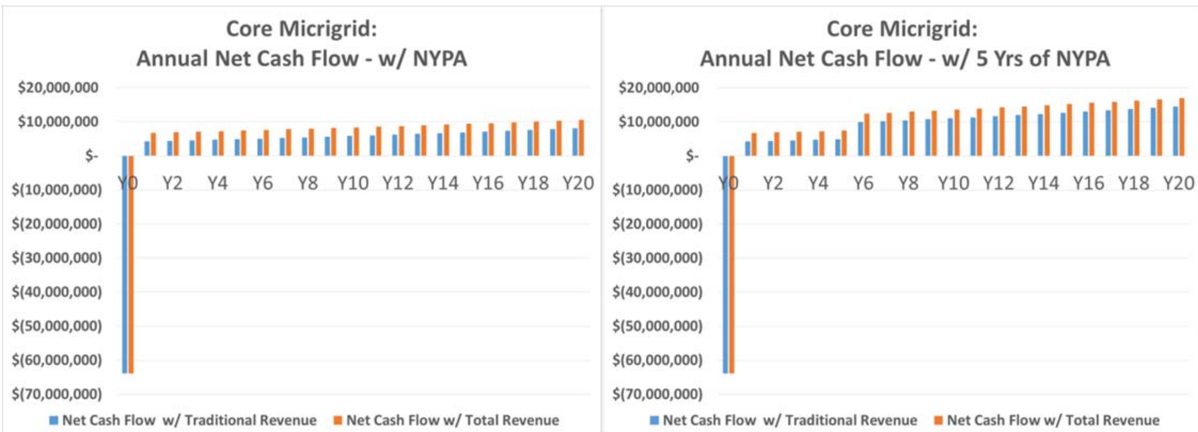

Figure 23: Core microgrid annual cash flow with NYPA rates (left) and excluding NYPA rates after 5 years (right).

Table 14: Core Microgrid Financial Metrics

Core Microgrid: Financial Metrics				
	Electricity Rate w/ NYPA Rate		Electricity Rate w/ NYPA for 5 Years	
	Traditional Revenue	Total Revenue	Traditional Revenue	Total Revenue
Capital Invested	$ (75,548,487.39)	$ (75,548,487.39)	$ (75,548,487.39)	$ (75,548,487.39)
Avg. EBITA	$ 6,546,308.36	$ 9,095,941.76	$ 11,274,877.56	$13,824,510.96
NPV	$ (24,706,726.79)	$ (1,563,602.39)	$ 4,626,061.76	$ 27,769,186.16
Simple Payback	15 years	11 years	9 years	11 years

Solar PV

The solar PV contributes to the microgrid by reducing net system emissions but does not substantially benefit system capacity and reliability. Ownership and management of solar PV can be either separate or included in the microgrid owned by the Microgrid LLC. Additionally, each of the three solar PV system could be owned by separate entities or the same entity. Therefore each solar PV system is assessed individually.

The solar PV cash flow analysis is after incentives. A nominal discount rate of 5.58% is applied. The solar PV is assumed to be able to be sold at NYSEG retail rates starting around $0.08 with a 2.5% annual increase. The system value is calculated over a 25 year period of time.

Table 15: Solar PV Financial Metrics

Solar PV: Financial Metrics			
	Brownfield	Clark St. Car Port	Building 53-48
Capital Invested	$2,483,070	$3,043,992	$2,585,350
NPV	577,718	$ 227,731	$ 373,097
Simple Payback	9 years	11 years	10 years

Chiller Replacement

The chiller replacement project costs around $5M in capital. It results in electricity bill savings of an average of $1M annually assuming NYPA rates remain and the overall electric rate increases at 2.1% annually. With a 10% discount rate, the net present value is $3.6M. No participation in ancillary services are required so total revenue is equal to traditional revenue. This project has financial viability for Huron to execute independent of the microgrid. The system value is calculated over a 25 year period of time.

Table 16: Chiller Replacement Financial Metrics

Chiller Replacement: Financial Metrics	
Capital Invested	$5,000,000.00
NPV	$4,451,576.79
Simple Payback	6 years

3.2.4 Unique Project Features

Are there any characteristics of the site or technology (including, but not limited to, generation, storage, controls, information technology (IT), automated metering infrastructure (AMI), other, that make this project unique?

The site is uniquely well positioned to host a combined heat and power system. The site has existing thermal distribution infrastructure and a significant thermal heat load associated with the heating and industrial processes at the Huron Campus. Additionally, it is located in the southern tier, 8 miles from Pennsylvania boarder. Endicott has a millennium pipeline tap and has access to natural gas at rates significantly below state averages.

The CHP plant is a high efficiency combined cycle CHP with a battery designed to black start if necessary. It has 28 MW of capacity and has the ability to provide cost effective, reliable power to both the campus and the community during an emergency.

The microgrid is heavily leveraging existing power distribution architecture enabling it to support the community at relatively low incremental cost. $6M out of $105M for the core microgrid system is associated with upgrades and new infrastructure for distribution and control systems.

3.2.5 Replicable

What makes this project replicable? Scalable?

The business park has existing infrastructure in place that can benefit from a combined heat and power (CHP) plant as part of a successful microgrid. There are many repurposed industrial sites and downtown area district heating systems in upstate NY that could potentially develop CHP using existing infrastructure. This project could serve as a demonstration pilot on how to effectively develop a CHP project to support a community microgrid.

3.2.6 Project Motivation

What is the purpose and need for this project? Why is reliability/resiliency particularly important for this location? What types of disruptive phenomenon (weather, other) will the microgrid be designed for? Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time.

The Village of Endicott has historically been prosperous, proud, and at the forefront of technological innovation. For decades IBM employed thousands in its design, testing and manufacturing operations, sited in the urban core of the community. The Huron Campus remains a commercial anchor in Endicott, and is home to large employers such as BAE Systems and i3 Electronics. But tremendous change has led to job losses, poverty, and urban blight in much of the community.

History

Since its founding over 100 years ago, Endicott has a proud history as a center of industrial innovation and business success, and led the nation and world in manufacturing and information technology for decades. It is one of two village municipalities within the larger Town of Union. The community was originally built by the Endicott-Johnson Shoe Company, whose workforce of 20,000 produced 52 million pairs of shoes and boots each year during World War II.

Endicott is also the birthplace, in 1911, of IBM - the global leader in "electromechanical data processing" for half a century. Through the 1940's, all IBM manufacturing, research, and development took place here, with company jobs across the region reaching 16,000 in the mid-1980s. The figures below shows a

1939 staff photo at the company's facilities in Endicott, where approximately 3,800 IBM employees worked, and the 1955 and 1960 images show expansion of the original IBM headquarters, which continued to construct new buildings through the 1980's, photos courtesy of IBM Archives.

Both IBM and the Johnson Shoe Company Corporate shared corporate prosperity with workers and created progressive programs for employee home ownership, medical care, education, profit-sharing, and cultural arts. Numerous small businesses, contractors and suppliers also developed in Endicott, a boomtown nicknamed The Magic City. For most of the twentieth century, the community and region thrived.

Figure 24: 1939 staff photo at the company's facilities in Endicott, NY

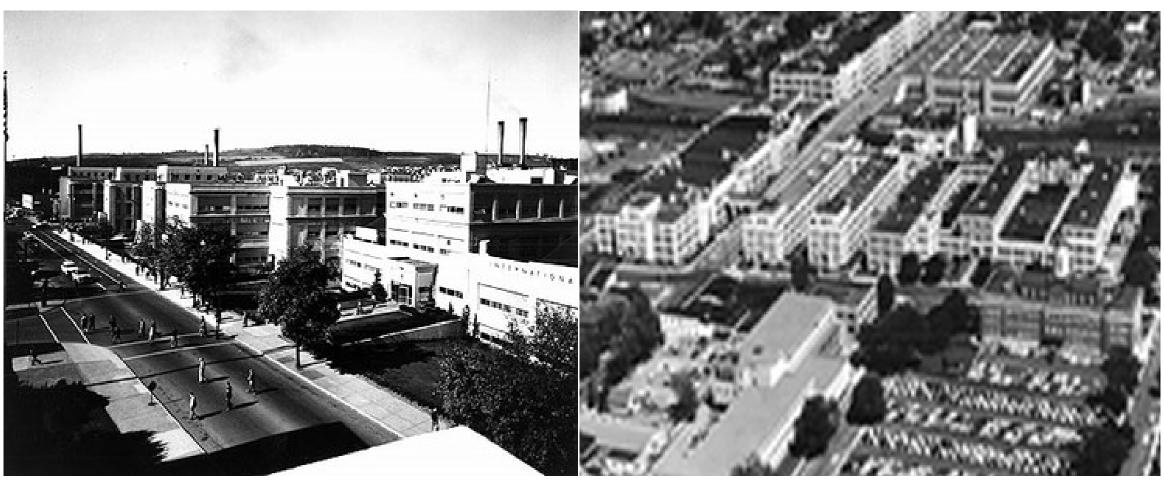

Figure 25: 1955 and 1960 images of expansion of the original IBM headquarters, Endicott, NY

Economic Challenge and Opportunity

Fast forward to 2015. The shoe company is gone, and IBM jobs number less than 1,000. Of 13,000 residents, 21% of the population lives in poverty and the median household income is just $32,599. Only 44% of homes are owner-occupied and the Fire Department reports that much of the multi-family housing stock is in need of repair. Endicott struggles with job losses, vacant industrial and commercial space, aging housing stock, and blight along the main corridors. The brightest light in Endicott shines from the former IBM facilities, now called the Huron Campus, where approximately 4,000 people work in high-tech manufacturing, engineering, data centers, call centers and professional services. The figure below shows parts of Huron Campus in current time, courtesy of Huron Real Estate Associates.

Figure 26: Huron Campus, Endicott, NY

As in the past, technology enterprises located at Huron, including BAE Systems, i3 Electronics, and the Center for Advanced Microelectronics Manufacturing (CAMM), serve clients around the world from state-of-the-art production floors, design centers, clean rooms and test labs. The rebuilding of BAE Systems after the 2011 flood is an amazing comeback story of commitment, creativity and capability (see news article in Appendix H). The Southern Tier Regional Economic Development Council is proposing to create an Endicott innovation district, supported by the recently awarded, Governor's Cuomo's Upstate Revitalization Initiative (http://regionalcouncils.ny.gov/content/southern-tier).

Floodwaters threaten community

Endicott's location along the flood-prone Susquehanna River is also a challenge. Extreme weather and flooding in 2006 and 2011 broke historical records and caused extensive power outages and infrastructure damage. The schools, fire and police personnel, and the Town of Union local government all responded, and long-term planning for recovery and resilience is underway.

Weather Underground reported:

Record rains due to the remnants of Tropical Storm Lee on September 8 brought a 1-in-200 to 1-in-500 year flood to the city's Susquehanna River. A flood 8.5 inches higher than the city's flood walls spilled over into the city that day, damaging or destroying over 7,300 buildings in Greater Binghamton. The *total damage to the county Binghamton lies in (Broome) and the downstream Tioga County is estimated at $1 billion. . . . In 2006, the Susquehanna River crested eleven feet over flood stage, the greatest flood since records began in 1846.*

The Susquehanna River Basin Commission calls the Susquehanna "one of the most flood prone watersheds in the nation." At 440 miles, it is the longest river on the American east. With an average daily volume of 22 billion gallons of water, the Susquehanna is the largest contributor of freshwater to the Chesapeake Bay.

Figure 27: 2006 and 2011 floods in Endicott, NY (http://www.erh.noaa.gov/).

The impacts of Susquehanna flood events in Endicott over the last decade have been devastating. For example, in 2011 the municipal power system was off-line for four days as critical substations were submerged in floodwaters. The lack of pumping capacity at the South Street well drew water storage tanks to dangerously low levels. Hundreds of residents were evacuated to Binghamton University. Businesses had to close until power and water were restored. Some, like Kmart, never re-opened. Already challenged, the community's economy has been hit hard with property damage, business interruptions, and the cost of rebuilding infrastructure. The Town of Union Community Plan for Recovery and Resilience was completed in Feb. 2015. Its vision statement declares in part:

"The hallmark of our response to extreme weather is a comprehensive green infrastructure system that protects neighborhoods and allows reuse of valuable commercial sites . . . "

Resiliency

The microgrid can operate and support the Huron Campus and community loads indefinitely as long as natural gas is not interrupted. If it is the CHP can operate on fuel oil for 9 days. After 9 days the microgrid would need to significantly curtail load as only the solar-battery system would be available to provide electricity and all thermal load would need to be curtailed.

3.2.7 Value Proposition

Describe the project's overall value proposition to each of its identified customers and stakeholders, including, but not limited, the electricity purchaser, the community, the utility, the suppliers and partners, and NY State.

Electricity purchaser – The primary electricity purchaser is Huron. Huron will have stable, competitive energy rates and reliable power and thermal energy to offer its tenants and for its own operations.

Community – The community will have electricity available during an emergency, indefinitely if natural gas is uninterrupted and for 9 days if it is interrupted. This will include a substantial number of critical facilities. The community will experience no rate increases.

Utility – NYSEG and EML will have the ability to purchase electricity from the microgrid when transmission or distribution feeding EML Endicott Rail is interrupted, thereby maintaining power to its customers. In an area where natural gas is readily available, there will be an increase in natural gas demand and a reduction in electricity demand.

NY State – New York State will have a microgrid project fully capable of reliable island, black-start capabilities that supports both a community and economic development. The scale of the microgrid is around 30 MW and is at a scale that can have impact on the regional energy.

3.2.8 Financial Impact to Purchaser

What added revenue streams, savings, and/or costs will this microgrid create for the purchaser of its power?

Huron will have reduced energy cost risks and more reliable power which will help them to maintain and attract tenants. The efficiency and renewable features of the microgrid can help tenants meet sustainability goals. This could increase their overall income and reinvigorate the local economy.

3.2.9 State Objectives

How does the proposed project promote state policy objectives (e.g. NY REV, RPS)?

This project supports REV by demonstrating distributed energy resources that can reduce capacity requirements and system upgrades to transmission systems. The microgrid is designed on the 30 MW scale and is at a level that can have meaningful impact.

Three proposed solar PV projects support the renewable portfolio standard and provide over 5.6 MWdc of rated capacity and 6624 MWh of renewable energy.

3.2.10 New Technology

How would this project promote new technology (including, but not limited to, generation, storage, controls, IT, AMI, other)? What are they?

In collaboration with SUNY Binghamton University, the microgrid will act as a testbed where new and emerging technologies can be demonstrated and validated.

3.3 Project Team

The Contractor shall address no less than each of the following items below in describing the structure of the project team and the roles, strengths and resources of its members and other necessary partners.

This section provides a description of the project team.

3.3.1 Local Partners

Describe the current status and approach to securing support from local partners such as municipal government? Community groups? Residents?

For Phase 1, the project team included TRC, Taitem Engineering, Huron and Binghamton Regional Sustainability Coalition (BRSC) as project partners. The stage 2 project team is currently under development. In phase 2, SUNY Binghamton University, Endicott Municipal Light (EML), and NYSEG will be invited to join the project team. Huron and Endicott Municipal Light are key customers of the microgrid whose support of the project will be crucial to project success. They have both expressed support and interest in the project. Binghamton Regional Sustainability Coalition is a non-for-profit and will be a participant in community engagement. SUNY Binghamton University is a local university and will connect the microgrid to research, emerging technology, workforce education, and community economic development.

3.3.2 Team Members

What role will each team member (including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners) play in the development of the project? Construction? Operation?

The stage 2 project team is currently under development. Existing team member entities and key potential member entities are identified below. Additional teaming partners are anticipated to be added as appropriate.

Table 17: Core Existing and Potential Project Team

Endicott Community Microgrid Project Team		
Organization/Entity	**Role Type**	**Role Description**
TRC	Applicant	Project development, audit grade engineering
Taitem Engineering	Contractor	Solar PV engineering, energy efficiency engineering, community engagement lead
Huron Real Estate Associates	Customer, partner, potential owner, host site	Primary microgrid customer, partner and/or potential partial microgrid owner, DER site owner
Endicott Municipal Light (EML)	Customer	Owner of distribution systems fed power by microgrid in an emergency
NYSEG	Utility, customer	Owner of distribution systems that will feed power and natural gas to/from microgrid, customer of microgrid during an emergency
SUNY, Binghamton University	Local University	Technology Innovation, Economic Development, Community engagement,
Binghamton Regional Sustainability Coalition (BRSC)	Contractor	Community engagement

3.3.3 Public/ Private Partnerships

Are public/private partnerships used in this project? If yes, describe this relationship and why it will benefit the project.

The microgrid will involve public/private collaboration and contracts. This will ensure the project is mutually beneficial while maintaining appropriate business separation to avoid conflicts of interest.

3.3.4 Applicant Financial Strength

Describe the financial strength of the applicant. If the applicant is not the eventual owner or project lead, describe the financial strength of those entities.

TRC, the applicant and project lead, is a pioneer in groundbreaking scientific and engineering developments since the 1960s, TRC is a national engineering, consulting, and construction management firm providing integrated services to the environmental, energy, and infrastructure markets. A publicly held corporation listed on the New York Stock Exchange (NYSE:TRR)—NYSE's oldest environmental firm—TRC includes over 3,000 technical professionals and support personnel at more than 110 offices throughout the U.S. TRC has a $434M annual revenue.

3.3.5 Qualifications

For identified project team members, including, but not limited to, applicant, microgrid owner, contractors, suppliers, partners, what are their qualifications and performance records?

About TRC

TRC provides comprehensive services to the energy industry from generation to consumption including: energy generation, power transmission & distribution, energy efficiency, demand response, end-use energy management, renewable energy, and environmental protection. TRC has participated in three NY Prize Microgrid Feasibility Assessments: Endicott Community Microgrid, Brownsville-Van Dyke Community Microgrid, and Town of Huntington Microgrid and acts as the technical advisor to the State of Connecticut Microgrid Pilot Program.

TRC

- Incorporated in 1969
- 3,000 employees in 110+ U.S. offices
- Ranked 32nd in ENR's Top 500 Design Firms (2013)
- $434 Million annual revenue
- Proven track record resulting in a repeat business ratio of greater than 80%
- Award-winning Corporate Safety Program

TRC has deep project execution qualifications in the multi-disciplinary fields required to develop a successful micro-grid project. This section highlights specific projects that TRC has executed which highlight expertise in: microgrid development and community planning, power delivery engineering, distributed energy resources, and community engagement.

<u>State of Connecticut Microgrid Pilot Program</u>

TRC is a technical advisor to the Connecticut Department of Energy and Environmental Protection (DEEP), Connecticut Light & Power (CLP), and United Illuminating (UI) for the State of Connecticut Microgrid Pilot Program. The program awarded $24M in 11 microgrid projects through March 2015. The program is currently preparing to commence a third round of awards.

TRC helped establish the project feasibility application process and has supported the evaluation of project plans based on criteria including safety, technical feasibility, societal benefits, economic benefits, financial considerations, configuration of power distribution to customers, and project costs. TRC works closely with DEEP and the Connecticut utilities to select technically viable and economically justifiable microgrid projects for which funding is awarded by DEEP. Successful projects will leverage clean and green energy sources to maintain critical services for cities and towns across the state. Leveraging and developing its microgrid expertise, TRC has:

- Developed the program's technical standards

- Established project evaluation and scoring methods
- Supported the evaluation process
- Presented at educational seminars and webinars

Examples of projects that have received funding from the Connecticut microgrid program: Campus Microgrid Pilot, Wesleyan University, Campus Microgrid Pilot, University of Hartford, Campus Microgrid Pilot, Bridgeport University, Municipal Microgrid Pilot, Hartford Park Street, Municipal Microgrid Pilot, and Town of Woodbridge.

About Taitem Engineering

Taitem Engineering, PC, ("Taitem") is a consulting firm based in Ithaca, New York, specializing in mechanical, electrical, and structural design, energy studies, and energy research. Our clients include public and private entities and our projects encompass facilities in all sectors, such as higher education, commercial, industrial, healthcare, multifamily, as well as federal, state, and municipal governments. Our LEED projects include the first net-zero building in New York City and other LEED Platinum, Gold, and Silver certified buildings. Taitem's design work is enhanced by a strong renewables component, with personnel certified in solar and geothermal technologies. We have been selected as a PV installer for both the Solarize Tompkins and Solarize Southern Tier East community initiatives. In addition, we provide quality assurance, technical review, and outreach services to multiple NYSERDA programs.

Founded in 1989 and growing steadily since, Taitem has earned B-Corporation status, meeting rigorous standards of social and environmental performance, accountability, and transparency. Taitem Engineering, PC is a New York S Corporation, and its staff of 47 includes nine licensed professional engineers, six LEED-accredited professionals, certified energy managers, certified commissioning professionals, a master plumber, and a master electrician. "Taitem" stands for "technology as if the earth mattered," reflecting the firm's commitment to the environment.

3.3.6 Contractors and Suppliers

Are the contractors and suppliers identified? If yes, who are they, what services will each provide and what is the relationship to the applicant? If no, what types of team members will be required and what is the proposed approach to selecting and contracting?

Contractors are identified in section 3.3.2 above. Technology suppliers are intentionally not identified. The reason is to ensure that the project can select technology solutions that most competitively meet the requirements and needs of the project. Relationships with suppliers are currently being developed and will be included in the design phase as appropriate.

3.3.7 Financers and Investors

Are the project financiers or investors identified? If yes, who are they and what is their relationship to the applicant? If no, what is the proposed approach to securing proposed financing? Will other members of the project team contribute any financial resources?

At this phase of the project the overall project has been assessed for financial feasibility to ensure that the project can be of interest to financers and investors. Potential developers and investors are in the process of being engaged. Input and feedback is being solicited.

3.3.8 Financers and Investors

Are there legal and regulatory advisors on the team? If yes, please identify them and describe their qualifications. If no, what is the proposed approach to enlisting support in this subject area?

There are legal and regulatory advisors on the team and additional staff available with expertise as the project moves forward. The two advisors on the team are currently Shirly Anderson and Elizabeth Weatherby.

Shirly Anderson: Ms. Anderson has a Certificate in Regulatory Economics from the State University of NY at Albany. Ms. Anderson has 39 years of experience in the energy industry. Her background includes extensive program oversight; implementation and coordination experience for utility directed energy efficiency and demand side management programs; as well as deployment activities regarding NYSERDA sponsored programs targeting multifamily buildings and residential energy users. Ms. Anderson has developed effective negotiation, coordination and collaboration skills in her 30 years of progressively responsible Staff work at the NYS PSC. Commission. She has provided expert testimony, testifing as an expert witness before the NYS Public Service Commission in 10 utility rates cases and generic policy cases. She also testified as an expert witness in a proceeding before the Missouri Public Service Commission. Ms. Anderson was part of a panel that presented testimony to the Department of Energy in Washington, DC. Ms. Anderson testified before the New York City Council in favor of allowing electrical submetering in multifamily buildings to become eligible for J-51 tax credits.

Liz Weatherby: Ms. Weatherby is an environmental scientist with professional experience in environmental assessment and permitting coordination for power generation, electric transmission and infrastructure projects supporting a variety of clients in the power generation and transmission industry. Proven experience in environmental assessment and permitting services for power generation, electric transmission and renewable energy projects across many states, including New York, New Jersey, Pennsylvania and Connecticut.

3.4 Creating and Delivering Value

The Contractor shall describe the mechanics of ensuring that expected value is delivered to project participants, by addressing no less than the following items below:

3.4.1 Technology Selection

How were the specific microgrid technologies chosen? Specifically discuss benefits and challenges of employing these technologies.

The Phase 1 project team is technology agnostic and developed the design approach based on the unique site requirements and opportunities. In order to develop realistic cost estimates vendor quotes were solicited for products that met the requirements of the specified technical approach. While these products represent viable solutions which demonstrate the technical and financial feasibility of the project, the project team retains the intention to compete technology and sourcing selection to provide an optimal technical and cost solution for the microgrid.

A primary benefit of the approach is that all technologies selected are currently commercially available and selection of specific products can be competed. This ensures that vendor selection can be competitive and that the solution is viable in the near term.

3.4.2 Existing Assets

What assets does the applicant and/or microgrid owner already own that can be leveraged to complete this project?

Existing asset owners are listed in Table 18 and include Huron, EML, and NYSEG.

Table 18: Existing Assets by Owner

Existing Assets by Owner	
Huron Real Estate Associates	• Existing thermal distribution system to enable CHP • Existing investment in energy efficiency • Existing building management systems • Exiting solar thermal system • Existing participation in demand response
Endicott Municipal Light (EML)	• Existing substations and distribution systems
NYSEG	• Existing substations and distribution systems

3.4.3 Balance of Generation and Load

How do the design, technology choice, and/or contracts ensure that the system balances generation and load?

The microgrid architecture, technology selection, and design were based off of an in-depth analysis of historic load data to ensure right sizing of systems. The CHP system can be operated for optimal economic dispatch which will assess the appropriate value and level of generation. Huron Real Estates Associates is the owner of Huron Campus and will be purchasing energy services from the Microgrid LLC. This ensures that Huron Real Estates Associates will have financial motivation to continue to enact energy efficiency investments in order to reduce costs for themselves and their tenants. The CHP and microgrid system will provide a draw to additional tenants which will ensure that the Microgrid LLC continues to have a customer for its energy generation even as Huron Real Estates Associates continues to invest in energy efficiency. The Microgrid LLC can also pursue participating in energy markets and ancillary services to supplement income.

3.4.4 Permitting

What permits and/or special permissions will be required to construct this project? Are they unique or would they be required of any microgrid? Why?

The base project does not require unique permitting as opposed to the permitting that would be required of its parts: CHP, solar PV, battery, and substation upgrades. NYSEG and EML will need to give permission and partner on any upgrades to their distribution systems. Because the CHP and solar PV have the most significant permitting requirements and considerations they are described in detail below.

Considerations for Licensing of the CHP Project

There are two licensing frameworks for a new generation facility in the State of New York. The process a project will follow is triggered depends on the new facility's anticipated generating capacity.

A new major generating facility of 25 megawatts (MW) or greater would trigger review by the New York State Board on Electric Generation (Siting Board) under Article 10 of the Public Service Law and the issuance of a Certificate of Environmental Compatibility and Public Need (CPCN). The Siting Board consists of representatives of five New York State Agencies (i.e., Public Service Commission [PSC], Department of Environmental Conservation [DEC], Department of Health [DOH], Department of Economic and NYSERDA) as well as two members nominated by the 'host' municipality or county and approved by the Governor.

Alternatively, a new facility less than 25 MW would be reviewed under the State Environmental Quality Review Act (SEQRA). Under SEQRA, the lead agency could be any agency involved in the permitting of a discretionary approvals for a project (i.e., DEC air or wetlands permit, local zoning and land development approvals) but typically, as in the case of the proposed combined heat and power (CHP) project, it is anticipated that the host municipality or county IDA would take the role of lead agency and coordinate the SEQR process.

A summary of the key differences between Article 10 and SEQR is provided below.

Table 19: Article 10 and SEQR Summary

Article 10 and SEQR Summary		
	Article 10 **(25 MW or greater)**	**SEQR** **(under 25 MW)**
Statutory Authority	Article 10 of the Public Service Law	Sections 3-0301(1)(b), 3-0301(2)(m) and 8-0113 of the Environmental Conservation Law
Implementing Regulations	16 NYCRR Part 1000	6 NYCRR Part 617
Lead Reviewing Agency	NYS Board on Electric Generation (Siting Board)	Village of Endicott (Anticipated Lead Agency)
Approval Issued	Certificate of Environmental Compatibility and Public Need (CPCN)	SEQR Negative Declaration or Preparation of Environmental Impact Statement (EIS) and SEQR Finding (depends on total anticipated impact from a project)

Overall anticipated review time	26-30 months	12-20 months
Additional approvals required	Federal approvals and Federally-delegated approvals from DEC are required (i.e., air and water permits) and must be obtained in addition to the Article 10 CPCN Local approvals are preempted (PSL 172) as are other state agencies and non-delegated DEC programs	Required Project specific Federal, state and local approvals are predicated on project engineering design, site characteristics, etc.

Based on the current plans, the CHP project may trigger review through the Article 10 process. The major considerations for the project are the total duration and costs associated with the Article 10 process. If the size of the facility can be reduced to less than 25 MW, it is anticipated that the CHP project, with its minimal anticipated impacts, may obtain a Negative Declaration from the lead agency through the submittal of the SEQR Long Form and avoid the need for a full environmental impact assessment.

Considerations for the PV Project

Three types of solar PV system have been assessed for feasibility: roof mounted, ground mounted - carport, and brownfield ground mounted.

In regards to the solar portion of the Project, there are a few things to consider when determining whether to go roof mount or ground mount, especially when looking at a brownfield site. From an environmental perspective, there is no impact to sensitive resources with a roof mount but an engineering integrity study would be conducted to ensure the roof could handle the additional weights. Rooftop approvals principally are building permits (e.g., structural, electrical, mechanical) but will also likely trigger a SEQR, with the local municipality or county IDA taking lead agency authority. In addition, rooftop mount will require approved access for emergency and maintenance personnel, as well as an interconnection agreement with the electric distribution/transmission system and any associated easement agreements.

In general, ground mounted solar systems require excavation and concrete foundations, which will increase installation time and cost, as well require different precautions (i.e., fencing) to protect the system from damage and trespassing. Environmental permitting for ground mounts are site specific (e.g., wetlands, floodplains, local zoning/land development) but will trigger SEQR, as well will require approved access for emergency and maintenance personnel. The ground mount system will also require an interconnection agreement with the electric distribution/transmission system and any associated easement agreements.

When considering installation on a brownfield, you must consider what the original contamination source was and the current status of the cleanup. There was no information in the DEC Environmental Site Remediation Database in regards to the Endicott foraging site. However, an article from the local newspaper indicates that the site once contained "petroleum, cadmium, arsenic, lead and barium which were removed after a DEC environmental review". There is no confirmation that the site has been completely removed of all containments, and what the ongoing monitoring involves. The design will need to consider whether anything in the soil will have corrosive properties to comprise the integrity of the foundations as well as whether stormwater would need to be contained due to potential contamination. If the cleanup is completed and closed, then the site is just as if a new greenfield site is used but you may have deed restrictions place on the property. To move forward with the Endicott site for consideration for the PV Project, you will need to confirm status of DEC/EPA review and closure of the clean-up efforts and whether there are any restrictions related to construction on the site. The Broome County Environmental Management Council (EMC) may be a resource for additional information.

3.4.5 Developing, Constructing, and Operating

What is the proposed approach for developing, constructing and operating the project?

TRC is the applicant and lead project developer at this stage in the process. The project developer role may shift as the project matures as appropriate to the project and the Microgrid LLC's business model. The project may develop where one entity is responsible for development, construction, and operation of the full system or that the Microgrid LCC contracts with separate entities to provide a range of these roles either for the full microgrid system and/or at the subsystem level. At this stage in the project the goal has been to develop a viable project that can be transitioned as appropriate.

3.4.6 Community Benefits

How are benefits of the microgrid passed to the community? Will the community incur any costs? If so, list the additional costs.

This project has a significant community benefit with minimal community costs. The community will have power availability in the case of an emergency including both critical facilities, residences, and businesses. They will experience increase economic opportunities and security associated with job growth and retention. They will not pay for system standby or demand charges because the community resilience component of the project in terms of cost relatively low and will be paid for by state grant funding such as NY Prize and the Southern Tier Upstate Revitalization Initiative (URI).

The only negative cost to the community is not financial but is the environmental impact of increased site emissions associated with CHP. However, the combined-cycle CHP system is designed to be highly efficient and the solar PV does offset some net emissions as compared to sourcing from grid electricity.

3.4.7 Utility Role

What will be required of the utility to ensure this project creates value for the purchaser of the electricity and the community?

NYSEG and Endicott Municipal Light (EML) have a key role in the microgrid. In order for the microgrid to be able to island and power community loads during an emergency. The Utility and MUNY will need to agree to some substation level upgrades and alterations. Additionally, they will need to agree that during an outage of power provided to the Endicott Rail Substation that they will to continue to operate the systems as desribed in the technical section of this report. They will need to agree to purchase electricity in an emergency from the Microgrid LLC and deliver and sell it to their customers.

3.4.8 Technology Readiness

Have the microgrid technologies (including but limited to: generation, storage, controls) been used or demonstrated before? If yes, describe the circumstances and lessons learned.

The microgrid technologies are commercially available products that have been demonstrated and validated. Specific selection of vendors and products will occur as the project matures. The senior engineer designing this project also acts as a technical advisor to the State of Connecticut Microgrid Pilot Program and has developed the program's technical standards, established project evaluation and scoring methods, and supported the evaluation process. This expertise has been used to develop a viable project. Some key design considerations have been: requirements based engineering, efficient system design, selection of requirements that can be competed, and cost effective technologies.

3.4.9 Operational Scheme

Describe the operational scheme, including, but not limited to, technical, financial, transactional and decision making responsibilities that will be used to ensure this project operates as expected.

The technical and financial operational approaches are fully described in the Section 2 and Section 3.1 – 3.2 of this report. In summary, Microgrid will operate based on optimal economic dispatch when grid-paralleled and will sell services to Huron Real Estates Associates and into the ancillary services market. The economic driver to be a financially viable company will ensure that the system will be operated to compete and perform. Legally binding agreements will be in place that ensure that the community is provided with access to power during grid islanded emergency conditions in exchange for grant funding that will cover the cost of the investment associated with islanding and feeding power to the community.

3.4.10 Billing and Metering

How does the project owner plan to charge the purchasers of electricity services? How will the purchasers' use be metered?

The Microgrid LLC will charge Huron Real Estates Associates for electricity and thermal heat at a comparable level to the rates they can obtain in the market. This will include some combination of energy rates and demand charges as agreed upon by the two entities. A bilateral contract to this affect will be required for the microgrid to be viable. The Microgrid LLC can meter Huron at the substation level and bill them accordingly. Huron will continue to bill tenants in a manner similar to how they currently bill tenants for energy and facilities services.

The Microgrid LLC will charge NYSEG and EML based on substation level metering.

3.4.11 Business Replication

Are there business/commercialization and replication plans appropriate for the type of project?

The business model concept is to site DER at a commercial/industrial campus or other type of campus, such that it can operate based on economic dispatch during grid-parallel mode and provide competitive energy services to the campus. Then at the substation level, provide upgrades distribution systems so that the DER can feed power to community substations and therefor power community loads in an emergency. Thus enabling a community to benefit from the DER without directly making significant investments in DER. The microgrid is owned by an entity which must be able to operate and make a profit during normal operations. Any upgrades required to support community loads are paid for via a mixture of public funds such as grants. This is a highly replicable approach because campus style DER and microgrids have historically been successful and this approach builds off of and expands upon that successful model.

3.4.12 Participant Barriers

How significant are the barriers to market entry microgrid participants?

The only potential market barrier is that both Huron and EML currently benefit from NYPA hydro power allocations which provide artificially low market rates for electricity.

3.4.13 Barrier Busting

Does the proposer demonstrate a clear understanding of the steps required to overcome these barriers?

The Microgrid LLC will not attempt to compete with NYPA allocations. This is the primary reason that the microgrid business model does not include revenue associated with selling energy services to EML during normal operating conditions. Only a portion of Huron power is covered by the NYPA allocation and it is anticipated that Huron will continue to leverage its NYPA allocation for as long as it exists.

3.5 Financial Viability

The Contractor shall describe the case for financial viability for development and operation of the microgrid by addressing no less than the following items below:

3.5.1 Revenue Streams and Savings

What are the categories and relative magnitudes of the revenue streams and/or savings that will flow to the microgrid owner? Will they be fixed or variable?

Table 20: Microgrid Revenue Streams

Microgrid Revenue Streams ($2016)		
Item	**Annualize Revenue**	**25 Year Total**
Core Microgrid - Traditional Services	$ 15,474,605.73	$ 386,865,143.22
Core Microgrid - Ancillary Service	$ 2,549,633.40	$ 63,740,835.00
Core Microgrid Total	***$ 18,024,239.13***	***$ 450,605,978.22***
PV – Endicott Forging Brownfield	$ 191,821.00	$ 4,795,515.00
PV – Clark Street Car Port	$ 198,156.00	$ 4,953,897.00

PV – Building 53-48 Roof Mounted	$	182,101.00	$	4,552,518.00
PV Total	***$***	***572,078.00***	***$***	***14,301,930.00***
Total Chiller Replacement	***$***	**1,084,485.95**	***$***	**21,689,718.96**
Microgrid LLC Total	***$***	**18,596,317.13**	***$***	**464,907,908.22**
Huron Total	***$***	**1,084,485.95**	***$***	**21,689,718.96**
Microgrid Total	***$***	**19,680,803.08**	***$***	**486,597,627.18**

Key Assumptions:

- Assuming Huron NYPA allocation is in place and the Core Microgrid and Chiller cash flow is based on the current rate mix. Assumes the Solar PV is competing with NYSEG market rates.
- Assuming 2.1% annual electric rate escalation and 1.3% annual natural gas rate escalation in market rate available.
- Ancillary services and rates are based on the assumption that the microgrid can participate in current NYISO services and programs at current rates. Those rates are applied as a fixed rate although there is uncertainty in future rates.
- Assuming the Microgrid LLC owns the core microgrid (CHP, battery, distribution, control and communications) and the three proposed solar PV projects.
- Assuming that Huron Real Estate Associates owns the chiller replacement project.

3.5.2 Project Incentives

What other incentives will be required or preferred for this project to proceed? How does the timing of those incentives affect the development and deployment of this project?

For the project to be profitable to the Microgrid LLC grants and incentives have been considered.

NY Prize Stage III funding has been estimated to be valued around $7M. The project will need to continue into further project stages and compete for NY Prize Phase III selection.

Southern Tier Upstate Revitalization Initiative (URI) has been identified as a potential funding source. The URI was awarded to the region this year and will provide $100M/year over the next 5 years to invest in economic development. One of the key economic development areas is Endicott, NY and the primary commercial/industrial area in Endicott is Huron Campus. The microgrid was listed in proposed projects in the URI proposal and applications will be made to the URI with a target of $20M in grant funding.

3.5.3 Project Capital and Operating Costs

What are the categories and relative magnitudes of the capital and operating costs that will be incurred by the microgrid owner? Will they be fixed or variable?

Table 21: Microgrid Cost Based on 5 Year NYPA Schenario

Microgrid Costs: 5 Year NYPA Scenario ($2016)				
Item		**Capital Cost**		**Annual Operating Cost**
Combined Cycle CHP	$	85,826,023.29	$	8,928,297.37
Battery	$	14,807,186.10		
Power Distribution	$	2,254,621.54		
Controls & Communication	$	3,727,863.00		
Core Microgrid Total	***$***	***105,948,487.39***	***$***	***8,928,297.37***
PV – Endicott Forging Brownfield	$	2,483,070.00	$	23,699.00
PV – Clark Street Car Port	$	3,043,992.00	$	23,999.00
PV – Building 53-48 Roof Mounted	$	2,585,350.00	$	22,333.00
PV Total	***$***	***8,112,412.00***	***$***	***70,031.00***
Total Chiller Replacement	***$***	***5,000,000.00***		-
Microgrid LLC Total	***$***	***114,060,899.00***	***$***	***8,998,328.37***
Huron Total	***$***	***5,000,000.00***		-
Microgrid Total	***$***	***119,060,899.39***	***$***	***8,998,328.37***

Key Assumptions:

- 2016$
- Year 1 = 2017
- Annual operating costs based on an annual average over a 25 year financial cash flow analysis
- PV capital costs are based on initial investment after incentives.
- The chiller replacement will result in no net increase in operational cost.

3.5.4 Profitability

How does the business model for this project ensure that it will be profitable?

The business model has assessed risk and investigated the impact of various scenarios. Under all scenarios considered the net 25 year cash flow was positive and the simple payback was in the range of 6-15 years depending on the system and assumptions made.

3.5.5 Financing Structure

Describe the financing structure for this project during development, construction and operation.

The financing structure is dependent on the next stage of project development.

3.6 Legal Viability

The Contractor shall describe the legal terms and conditions and other requirements necessary to develop and operate the microgrid by addressing no less than the items below:

3.6.1 Project Ownership Structure

Describe the proposed project ownership structure and project team members that will have a stake in the ownership.

The core microgrid will be owned by the Microgrid LLC. The Microgrid LLC may be partly owned by Huron Real Estates Associates or it may be owned by a third party investor. Energy efficiency projects will be owned by the microgrid customer achieving the efficiency project. Solar PV project ownership may vary between Huron, the Microgrid LLC, solar PV PPA vendors, and community solar. NYSEG and EML systems will continue with the same ownership that they currently have. Contracts will be in place between the different stakeholders in the microgrid.

3.6.2 Project Ownership

Has the project owner been identified? If yes, who is it and what is the relationship to the applicant? If no, what is the proposed approach to securing the project owner?

The Microgrid LLC owner and ownership structure has not been identified. The applicant is the project developer and does not have an interest in the ownership of the Microgrid LLC. The applicant will work with the stakeholders to identify a Microgrid LLC owner whose interests align with and can be synergistic with the stakeholders. The main stakeholders being Huron, Village of Endicott community, EML, and NYSEG.

3.6.3 Site ownership

Does the project owner (or owners) own the site(s) where microgrid equipment/systems are to be installed? If not, what is the plan to secure access to that/those site(s)?

The Huron Real Estates Associates owns the sites where microgrid equipment and systems will be installed except for upgrades at utility owned substations. The Microgrid LLC will develop an agreement with Huron to lease space for the microgrid and will develop an agreement with the utility regarding system upgrades and operations.

3.6.4 Customer Privacy

What is the approach to protecting the privacy rights of the microgrid's customers?

The Microgrid LLC will have contracts in place with Huron, EML, and NYSEG to ensure confidentiality. The Microgird LLC will likely have no need for Huron, EML, and NYSEG's individual customer's data.

3.6.5 Regulatory Considerations

Describe any known, anticipated, or potential regulatory hurdles, as well as their implications that will need to be evaluated and resolved for this project to proceed. What is the plan to address them?

Permitting of the CHP as described in section 3.4.4 may cause project delays. The project will investigate the Article 10 and consider approaches that would reduce permitting delays and cost.

The ability to participate in NYISO ancillary service markets has risk. If permission could be given to participate in the market while behind the meter, that would greatly reduce project profitability risk. Otherwise other opportunities to provide ancillary services will be investigated such as the interest of NYSEG to agree to procure services.

The project is contingent on NYSEG to participate in the microgrid, support upgrades, share operational information, and coordinate islanding operations. Currently, the plan is to engage with NYSEG and solicit interest in agreeing to be a stakeholder in support of the microgrid.

4. Cost Benefit Analysis

The following sections 4.1 - 4.4 are directly copied from the Cost Benefit Analysis (BCA) conducted by Industrial Economics as part of this study. As such, table and figure labels within this section are labeled separately from the rest of this report.

The results presented in section "4.3 Results" represent results that do not take into account unique features of the proposed microgrid project such ancillary service benefits, fuel costs, and emissions damages. Inclusion of consideration of these features are crucial to gaining a more accurate representation of the true BCA. Section "4.4 Appendix – Sensitivity Analysis" includes these considerations. The results in the sensitivity analysis most accurately reflect the project and they should be considered as the project BCA results. Additionally, the proposed microgrid was developed with the capability to island and black-start which contributed significantly to the system approach and cost. Evaluating the project benefit under scenario 1 without including the benefit of these services does not accurately reflect the cost-benefit of the microgrid. The sensitivity analysis - scenario 2 results did take into account the value of the resiliency capabilities. In these results the cost-benefit ratio was 1.0 and the internal rate of return of 7.3%. In addition, it should be considered that this microgrid is being developed to result in economic growth which can create significant secondary benefits to the community, which are not included in this analysis.

4.1 Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the Village of Endicott has proposed development of a microgrid that would serve four local substations:

- The Robble Substation and the Clark Substation, both of which serve the Huron Campus, a multi-building commercial and industrial business park.
- The Endicott Municipal Light (EML) South Street Substation, which serves a mix of 800 residential homes, 8 commercial entities, and public service facilities.
- The New York State Electric and Gas (NYSEG) Endicott Railway Substation, which serves a mix of 1,000 residential homes, 20 commercial entities, and public service facilities.

The microgrid would be powered by four new distributed energy resources – a 28.7 MW natural gas unit and three photovoltaic arrays with nameplate capacities of 1.6 MW, 1.7 MW, and 2.3 MW. The natural gas unit would incorporate combined heat and power (CHP) systems that would produce thermal energy as well as electricity. In addition, the microgrid would incorporate existing backup units, including:

- 100 kW and 20 kW diesel backup units currently installed at the fire and police stations, fed by the EML South Street Substation;
- 5.8 MW and 900 kW diesel backup units currently installed on the Huron Campus; and
- A 20 kW natural gas backup unit currently installed on the Huron Campus.

The village anticipates that the new natural gas unit and photovoltaic systems would produce electricity for the grid during periods of normal operation. In contrast, the existing backup units would produce power only during an outage, when the microgrid would operate in islanded mode. The system as designed would have sufficient generating capacity to meet average demand for electricity from the four substations during a major outage. Project consultants also indicate that the system would have the capability of providing ancillary services to the grid.

To assist with completion of the project's NY Prize Stage 1 feasibility study, IEc conducted a screening-level analysis of the project's potential costs and benefits. This report describes the results of that analysis, which is based on the methodology outlined below.

4.2 Methodology and Assumptions

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

Costs represent the value of resources consumed (or benefits forgone) in the production of a good or service.

Benefits are impacts that have value to a firm, a household, or society in general.

Net benefits are the difference between a project's benefits and costs.

Both costs and benefits must be measured relative to a common baseline - for a microgrid, the "without project" scenario - that describes the conditions that would prevail absent a project's development. The BCA considers only those costs and benefits that are incremental to the baseline.

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

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.1 It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

The BCA considers costs and benefits for two scenarios:

Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).

Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[2]

In addition to examining the two scenarios with the model's default assumptions, the BCA conducts a sensitivity analysis for both scenarios. This analysis tests the sensitivity of the model's results to

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[1] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO_2 emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO_2, NO_x, and $PM_{2.5}$, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

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

assumptions about ancillary service benefits, fuel costs, and emissions damages. The appendix to this report describes the methodological changes incorporated into the sensitivity analysis and summarizes its results.

4.3 Results

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 1.5 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 1. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 1.5 DAYS/YEAR
Net Benefits - Present Value	-$123,000,000	$594,000
Benefit-Cost Ratio	0.7	1.0
Internal Rate of Return	-7.4%	7.2%

4.3.1 Scenario 1

Figure 1 and Table 2 present the detailed results of the Scenario 1 analysis.

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

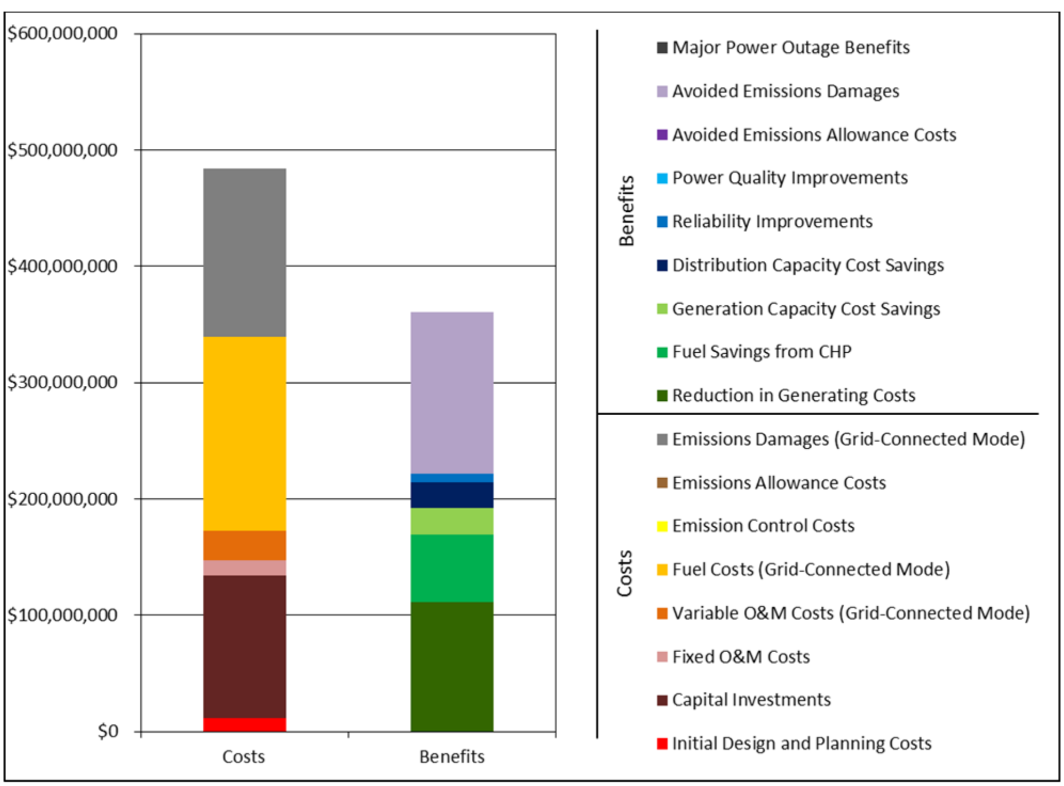

Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$12,000,000	$1,060,000
Capital Investments	$123,000,000	$9,490,000
Fixed O&M	$12,900,000	$1,140,000
Variable O&M (Grid-Connected Mode)	$25,600,000	$2,260,000
Fuel (Grid-Connected Mode)	$167,000,000	$14,700,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$144,000,000	$9,420,000
Total Costs	**$484,000,000**	
Benefits		
Reduction in Generating Costs	$111,000,000	$9,820,000
Fuel Savings from CHP	$57,700,000	$5,090,000
Generation Capacity Cost Savings	$23,600,000	$2,080,000
Distribution Capacity Cost Savings	$21,500,000	$1,890,000
Reliability Improvements	$7,470,000	$659,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$61,100	$5,390
Avoided Emissions Damages	$139,000,000	$9,080,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$361,000,000**	
Net Benefits	**-$123,000,000**	
Benefit/Cost Ratio	**0.7**	
Internal Rate of Return	**-7.4%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $12.0 million. The present value of the project's capital costs is estimated at approximately $123 million, including costs associated with installing the 28.7 MW natural gas unit with CHP capabilities; the 1.7 MW, 1.6 MW, and 2.3 MW photovoltaic systems; generator paralleling equipment; substation equipment; energy storage equipment; and controls and telecommunications equipment. The present value of fixed operation and maintenance (O&M) costs over a 20-year operating period is estimated to be approximately $12.9 million.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's primary generator. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's State Energy Plan (SEP), adjusted to reflect recent market prices.[3, 4] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $167 million.

The project will also have variable O&M costs associated with operating the natural gas unit with CHP capabilities. The project team estimates that it will cost approximately $12.52 per MWh of electricity produced by the microgrid. Given the microgrid's projected annual electricity production, this would translate to variable O&M costs of approximately $2.3 million annually. The present value of the project's variable O&M costs over a 20-year operating period is estimated to be approximately $25.6 million.

The analysis of variable costs also considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the new natural gas unit are estimated at approximately $9.4 million annually. The majority of these damages are attributable to the emission of CO2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $144 million.[5]

Avoided Costs

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

[4] The analysis presented in the appendix tests the sensitivity of the BCA's results to a change in fuel prices, reflecting the project team's assessment of the availability of low-cost, stranded supplies of natural gas in the Endicott area.

[5] The analysis presented in the appendix tests the sensitivity of the BCA's results to the treatment of emissions damages for $PM_{2.5}$ and PM_{10}.

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. In the case of the proposed microgrid, one of the primary sources of cost savings would be a reduction in demand for electricity from bulk energy suppliers, with a resulting reduction in generating costs. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $111 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. The reduction in demand for electricity from bulk energy suppliers would also reduce emissions of CO2 and particulate matter from these sources, and produce a shift in demand for SO2 and NOx emissions allowances. The present value of these benefits is approximately $139 million.[6]

The microgrid's CHP system could deliver additional cost savings over the microgrid's 20-year operating period. The fuel savings provided by the CHP system would lead to avoided fuel costs with a present value of approximately $57.7 million.

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.[7] The project team estimates the project's impact on demand for generating capacity to be approximately 27.7 MW per year. Based on this figure, the BCA estimates the present value of the project's generating capacity benefits to be approximately $23.6 million over a 20-year operating period. Similarly, the team estimates that the project will help to avoid or defer an otherwise necessary investment in approximately 51.85 MW of distribution capacity. Based on this figure, the BCA estimates the present value of the project's distribution capacity benefits to be approximately $21.5 million over a 20-year operating period.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, including frequency support and voltage support, to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the markets for ancillary services are highly competitive, and that projects of this type would have a relatively small

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

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

chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing these services.[8]

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $659,000 per year, with a present value of $7.5 million over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[9]

- System Average Interruption Frequency Index (SAIFI) – 1.03 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 118.2 minutes.[10]

The estimate takes into account the number of residential customers the project would serve; the number of small and large commercial or industrial customers the project would serve; the distribution of commercial or industrial customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among commercial or industrial customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[11] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.7; i.e., the estimate of project benefits is approximately 70 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

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[8] The sensitivity analysis presented in the appendix reports BCA results that include the Endicott team's estimate of the value of the ancillary services the project could provide.

[9] www.icecalculator.com.

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

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

4.3.2 Scenario 2

Benefits in the Event of a Major Power Outage

The estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[12,13]

The proposed microgrid project would serve four substations during an extended outage. These substations in turn serve a mix of facilities, including public service facilities, commercial entities, and residential homes. In the BCA model, several factors influence the costs that facilities would incur during an outage, including the following:

Whether or not backup generation currently exists at the facility;

The ability of the facility to operate when using backup power;

The ability of the facility to operate during a complete loss of power;

The cost of operating existing generators;

The extent to which the facility incurs costs for emergency measures (e.g., evacuation); and

The economic value of the services that the facility would cease to provide during an outage.

Table 3 summarizes these parameters for the different sets of facilities that will be served by the microgrid:

Fire and Police Services: The Endicott Fire Station and Police Station, both served by the EML South Street Substation, share two existing diesel backup generators. During a power outage, these stations would both lose 50 percent of their service capabilities while on backup power and 75 percent of their service capabilities during a complete loss of power. In addition, these facilities would need to evacuate

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

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

at a combined cost of $34,000. The analysis calculates the impact of an outage on these facilities using standard FEMA methodologies for fire and police services.

- **Emergency Medical Services:** The project team indicates that the microgrid would serve a United Health Services Primary Care facility that provides emergency medical services. This facility has no existing backup capabilities and would not maintain service during a power outage. The analysis calculates the impact of an outage on emergency medical services using standard FEMA methodologies.

- **Electric Services:** The microgrid would serve single-family and multi-family homes for the 13,083 residents of the Village of Endicott. The analysis calculates the impact of an outage on residential electric services using standard FEMA methodologies.

- **Wastewater Services:** This facility group includes a wastewater plant on the Huron Campus and two large municipal sewage pumps that are part of the Endicott municipal wastewater treatment system. During a power outage, the Huron Campus wastewater plant has an existing backup generator that is capable of supporting the plant's full load. If this backup generator were to fail, however, the Huron Campus wastewater plant would lose all of its service capabilities. If that occurred, it would be necessary to truck as much as 80,000 gallons of wastewater per day to an alternative treatment plant at an estimated daily cost of $2,456. Similarly, the two large municipal sewage pumps that are part of the Endicott municipal treatment system have no backup source of power. As a result, an outage would cause the treatment system to lose 40 percent of its service capabilities. The analysis incorporates this information into its assessment of the impact of an outage on wastewater services, which is calculated using standard FEMA methodologies.

- **Water Services:** The microgrid would serve a facility that provides municipal water services to the Village of Endicott. This facility has no backup capabilities and would lose service during a power outage. The analysis calculates the impact of an outage on water services using standard FEMA methodologies.

- **Huron Campus Substations:** As mentioned above, the Robble and Clark Substations serve the Huron Campus, which is a multi-building commercial and industrial business park. The analysis uses the ICE calculator to estimate the collective value of service provided by these facilities. This value of service estimate (about $2.8 million per day) reflects extensive power usage and the fact that the Huron Campus facilities engage in manufacturing. This campus has existing natural gas and diesel backup units that would allow it to maintain some of its service capabilities during a power outage. An additional consideration is that the proposed microgrid would support stormwater pumps, one of which is critical to avoiding flooding on this campus. Over the last 10 years, there have been two major floods that have each caused upwards of $10 million dollars in damage. For Scenario 2, the analysis assumes that the microgrid would support these pumps and prevent flooding damages at an expected value of $2 million in avoided damages per year.

- **EML South Street and NYSEG Endicott Railway Substations:** The EML South Street and NYSEG Endicott Railway Substations serve a combined 28 large commercial facilities. The overall value of service estimate for these facilities (about $3.2 million per day) is based on ICE Calculator estimates and reflects their extensive power usage. These commercial facilities do not have existing backup generation and would lose service during a power outage.

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.[14]

[14] The 28.7 MW natural gas CHP unit serving the Huron Campus has the capability to operate on both natural gas and distillate fuel oil. There is sufficient fuel storage on-site to operate this unit at full capacity for up to nine days before additional fuel oil would be needed. This dual-fuel capability provides increased reliability for the microgrid and would allow it to maintain service even during a power outage event that interrupts the supply of natural gas.

Table 3. Summary of Major Power Outage Parameters, Scenario 2

CATEGORY	FACILITIES INCLUDED	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
		VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY
Fire and Police Services	Endicott Fire Station; Endicott Police Station	FEMA methodologies		50%	75%	$0	$263	$34,000	$0
Emergency Medical Services	United Health Services Primary Care	FEMA methodologies		100%	100%	$0	$0	$0	$0
Electric Services	Single-Family and Multi-Family Residential Homes	FEMA methodologies		100%	100%	$0	$0	$0	$0
Wastewater Services	Huron Wastewater Plant; Two Sewage Pumps for Endicott Treatment System	FEMA methodologies		20%	70%	$0	$2,506	$0	$2,456
Water Services	Water Service Provider	FEMA methodologies		100%	100%	$0	$0	$0	$0
	Two large commercial	$2,836,824	ICE	70%	100%	$0	$16,216	$2,000,000	$0

CATEGORY	FACILITIES INCLUDED	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
		VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY
Huron Campus Substations	facilities								
EML South Street and NYSEG Endicott Railway Substations	28 large commercial facilities	$3,210,048	ICE	100%	100%	$0	$0	$0	$0

Summary

Figure 2 and Table 4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 1.5 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 1.5 Days/Year; 7 Percent Discount Rate)

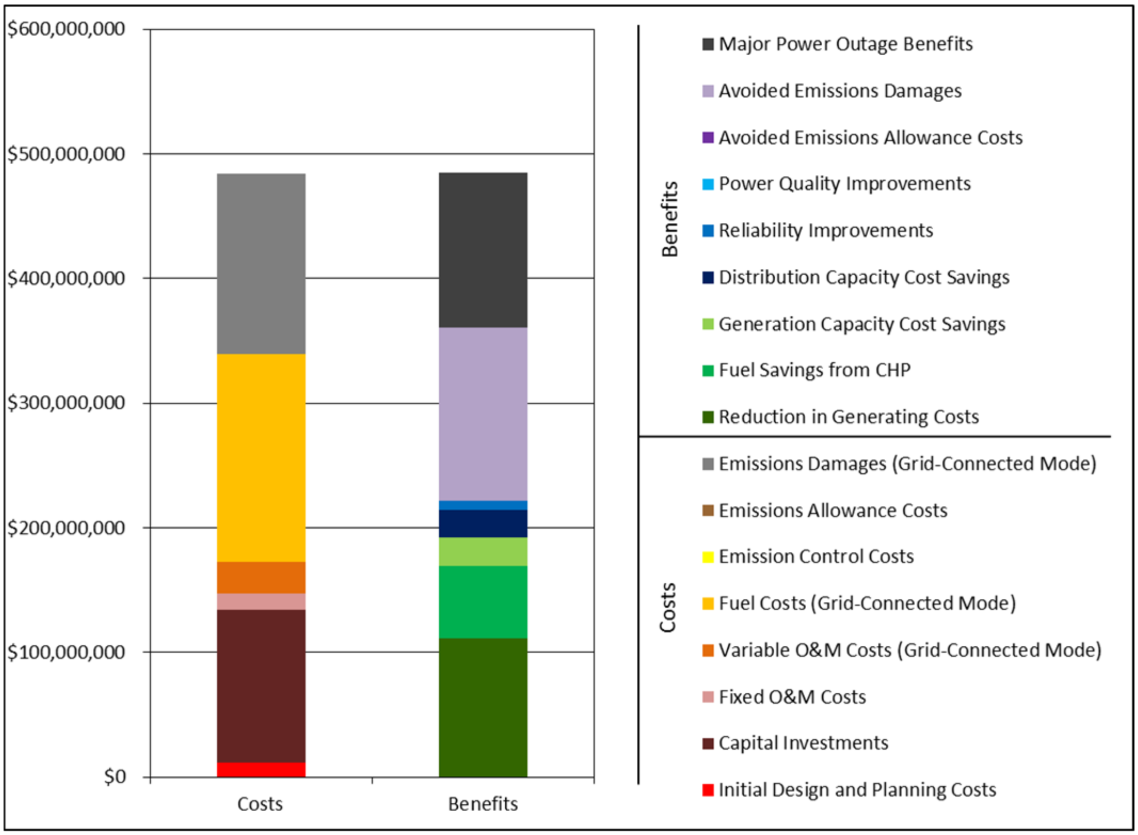


Table 4. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 1.5 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$12,000,000	$1,060,000
Capital Investments	$123,000,000	$9,490,000
Fixed O&M	$12,900,000	$1,140,000
Variable O&M (Grid-Connected Mode)	$25,600,000	$2,260,000
Fuel (Grid-Connected Mode)	$167,000,000	$14,700,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$144,000,000	$9,420,000
Total Costs	**$484,000,000**	
Benefits		
Reduction in Generating Costs	$111,000,000	$9,820,000
Fuel Savings from CHP	$57,700,000	$5,090,000
Generation Capacity Cost Savings	$23,600,000	$2,080,000
Distribution Capacity Cost Savings	$21,500,000	$1,890,000
Reliability Improvements	$7,470,000	$659,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$61,100	$5,390
Avoided Emissions Damages	$139,000,000	$9,080,000
Major Power Outage Benefits	$124,000,000	$10,900,000
Total Benefits	**$485,000,000**	
Net Benefits	**$594,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.2%**	

4.4 Appendix – Sensitivity Analysis

In addition to examining the two scenarios with the model's default assumptions, upon TRC's request IEc also completed an additional BCA to examine additional scenarios that test the sensitivity of the model's results to alternative assumptions about ancillary service benefits, fuel costs, and emissions damages. Due to the unique nature of this project as well as the extraordinarily low energy costs due to NYPA hydroelectric power, the results presented in this section more accurately reflect the costs and benefits of the proposed project. Table A1 summarizes the changes incorporated into this analysis, which include:

- **Ancillary Service Benefits –** By default, the model does not attempt to quantify the potential benefits of ancillary services provided by the microgrid. This approach is based on discussions with NYISO, which indicated that the markets for ancillary services are highly competitive, and that most NY Prize projects would have a relatively small chance of being selected to provide support to the grid. The Endicott team believes that its project has sufficient scale to compete successfully in the ancillary services markets, particularly given the project's high voltage connection to the grid. The sensitivity analysis incorporates the team's estimate of the value of the ancillary services the project would provide: approximately $2.55 million per year.[1]

- **Fuel Costs –** The model's default assumption for natural gas prices in 2016 is approximately $6.34 per MMBtu. This assumption is based on the State Energy Plan's natural gas price projections, adjusted by a multiplier that reflects the average commercial natural gas price in New York State in October 2015 (the most recent month for which data were available). The model applies the same multiplier to adjust the price forecast for all subsequent years of the analysis. In comparison, the Endicott team reports that the Huron Campus is currently able to purchase natural gas at a rate of approximately $2.70 per MMBtu; this rate reflects the site's access to low-cost supplies of gas from Pennsylvania. To capture the potential impact of lower gas prices on the results of the BCA, the sensitivity analysis adjusts the fuel price multiplier to equate the model's estimate of 2016 natural gas prices to the rate currently available to the facilities the Endicott project would serve (i.e., approximately $2.70 per MMBtu). The model applies the same multiplier to adjust the price forecast for each subsequent year of the analysis, on the assumption that rates in the Endicott area would remain low throughout the project's assumed 20-year operating life.

- **Emissions Damages –** By default, the model uses the project team's reported emissions rates for PM2.5 and PM10 to estimate the environmental damages associated with emissions of distributed energy resources that serve the microgrid. As the team notes, however, the model assumes no baseline emissions of PM2.5 and PM10 for the overall grid, and therefore does not estimate the PM emissions damages that might be avoided as a result of the microgrid's operations. To test the implications of this potential inconsistency, the sensitivity analysis ignores the projected emissions of

[1] The project team indicates that its estimate of annual ancillary service benefits is based on current market prices. The sensitivity analysis holds this estimate constant over the project's presumed 20-year operating life. Note that this estimate is likely to overstate the social benefits of the ancillary services that the project could provide, since it reflects the team's estimate of potential revenues from ancillary services, not the cost savings that would be realized from displacing the market's marginal provider.

PM2.5 and PM10 from the distributed energy resources that the microgrid would incorporate, thus placing the evaluation of PM emissions from all sources on an equal footing.

Table A1. Changes Incorporated into Sensitivity Analysis

COST OR BENEFIT CATEGORY	ORIGINAL ASSUMPTION	SENSITIVITY ANALYSIS ASSUMPTION
Ancillary Service Benefits - Annualized Value	$0	$2,550,000
Fuel Costs - 2016 Natural Gas Price[1]	$6.34 / MMBtu	$2.66 / MMBtu
Emissions Damages - $PM_{2.5}$ Emissions Rate	0.00004 tons / MWh	0 tons / MWh
Emissions Damages - PM_{10} Emissions Rate	0.00004 tons / MWh	0 tons / MWh
Notes: [1]The analysis incorporates similar adjustments in natural gas prices throughout the 20-year operating period.		

4.4.1 Sensitivity Analysis Results

Table A2 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the sensitivity analysis scenarios. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.2 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table A2. Sensitivity Analysis BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SENSITIVITY ANALYSIS SCENARIO 1: 0 DAYS/YEAR	SENSITIVITY ANALYSIS SCENARIO 2: 0.2 DAYS/YEAR
Net Benefits - Present Value	-$13,100,000	$6,730,000
Benefit-Cost Ratio	0.96	1.0
Internal Rate of Return	5.4%	7.3%

4.4.2 Scenario 1

Figure A1 and Table A3 present the adjusted results for the Scenario 1 sensitivity analysis. The analysis yields a benefit/cost ratio of 0.96; i.e., the estimate of project benefits is approximately 96 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Figure A1. Present Value Results, Sensitivity Analysis for Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

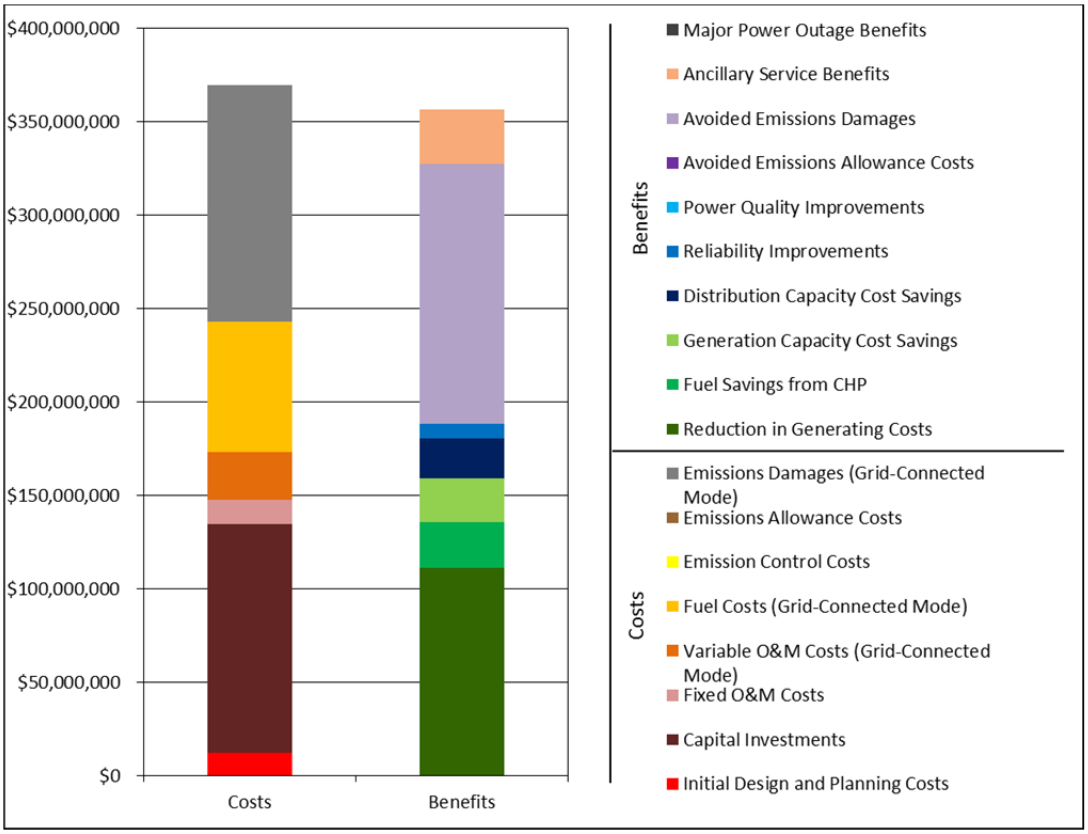


Table A3. Detailed BCA Results, Sensitivity Analysis for Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$12,000,000	$1,060,000
Capital Investments	$123,000,000	$9,490,000
Fixed O&M	$12,900,000	$1,140,000
Variable O&M (Grid-Connected Mode)	$25,600,000	$2,260,000
Fuel (Grid-Connected Mode)	$69,900,000	$6,170,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$126,000,000	$8,250,000
Total Costs	**$369,000,000**	
Benefits		
Reduction in Generating Costs	$111,000,000	$9,820,000
Fuel Savings from CHP	$24,200,000	$2,130,000
Generation Capacity Cost Savings	$23,600,000	$2,080,000
Distribution Capacity Cost Savings	$21,500,000	$1,890,000
Reliability Improvements	$7,490,000	$662,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$61,100	$5,390
Avoided Emissions Damages	$139,000,000	$9,080,000
Ancillary Service Benefits	$28,900,000	$2,550,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$356,000,000**	
Net Benefits	**-$13,100,000**	
Benefit/Cost Ratio	**0.96**	
Internal Rate of Return	**5.4%**	

4.4.3 Scenario 2

Figure A2 and Table A4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.2 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure A2. Present Value Results, Sensitivity Analysis for Scenario 2 (Major Power Outages Averaging 0.2 Days/Year; 7 Percent Discount Rate)

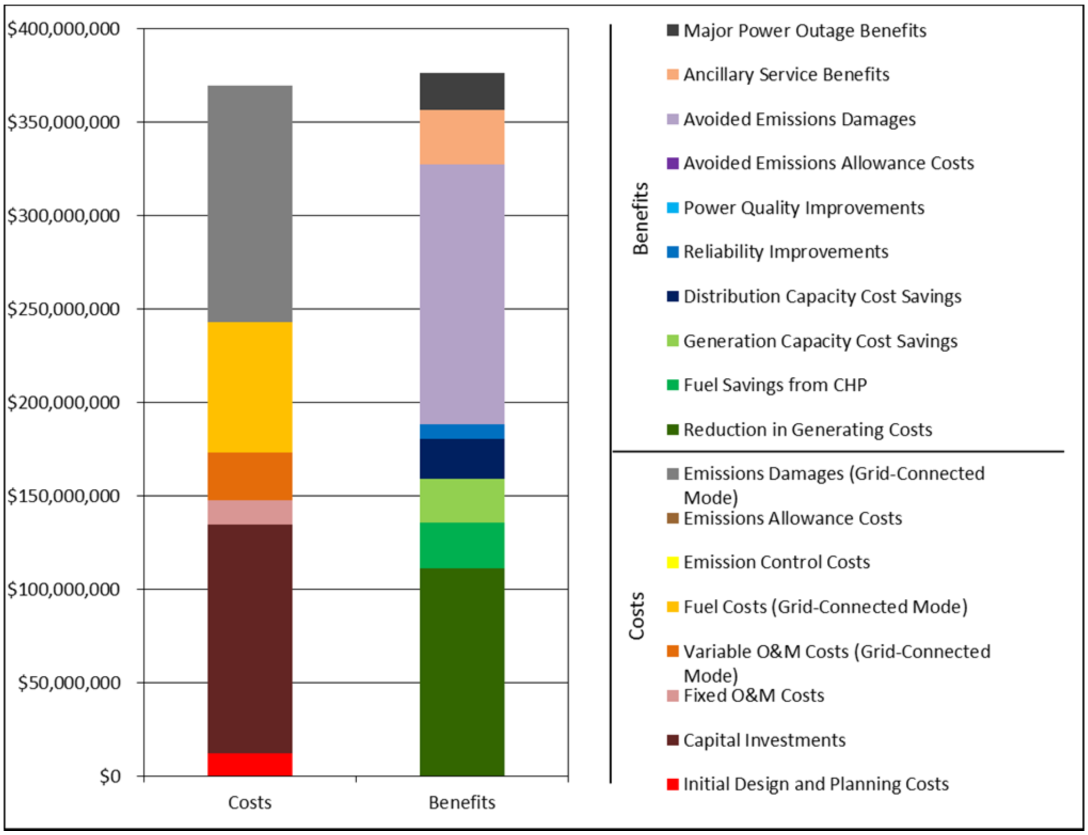


Table A4. Detailed BCA Results, Sensitivity Analysis for Scenario 2 (Major Power Outages Averaging 0.2 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$12,000,000	$1,060,000
Capital Investments	$123,000,000	$9,490,000
Fixed O&M	$12,900,000	$1,140,000
Variable O&M (Grid-Connected Mode)	$25,600,000	$2,260,000
Fuel (Grid-Connected Mode)	$69,000,000	$6,170,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$126,000,000	$8,250,000
Total Costs	**$369,000,000**	
Benefits		
Reduction in Generating Costs	$111,000,000	$9,820,000
Fuel Savings from CHP	$24,200,000	$2,130,000
Generation Capacity Cost Savings	$23,600,000	$2,080,000
Distribution Capacity Cost Savings	$21,500,000	$1,890,000
Reliability Improvements	$7,490,000	$662,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$61,100	$5,390
Avoided Emissions Damages	$139,000,000	$9,080,000
Ancillary Service Benefits	$28,900,000	$2,550,000
Major Power Outage Benefits	$19,900,000	$1,760,000
Total Benefits	**$376,000,000**	
Net Benefits	**$6,730,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.3%**	

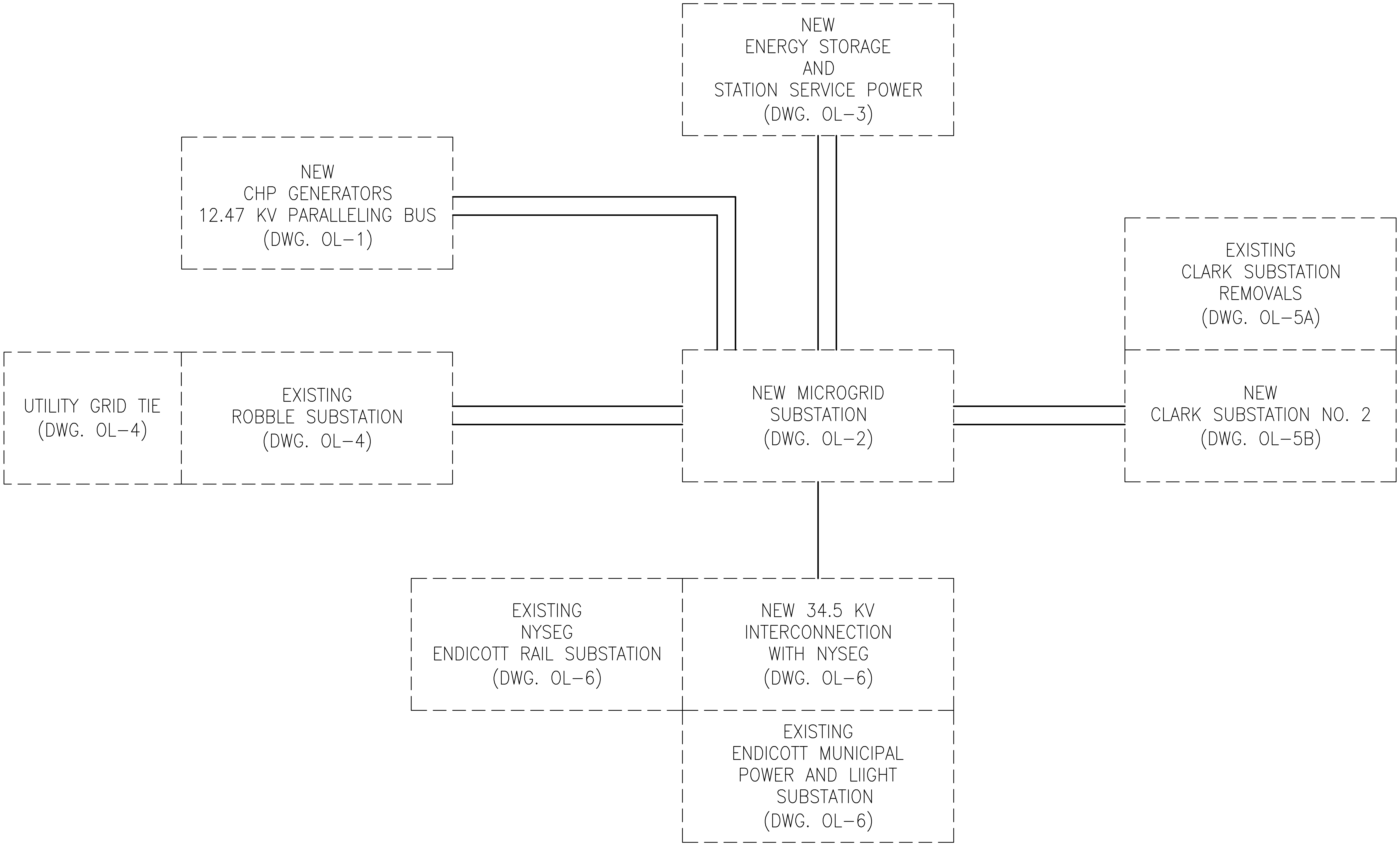
5. LESSONS LEARNED & RECOMMENDATIONS

While the Endicott microgrid is both financially and technically feasible, there were substantial issues that arose as a result of the low electric costs as previously discussed. The low cost of electric lead to lower than expected economic benefits for the CHP portion, mitigated somewhat by the low cost of natural gas in the area. If the NYPA hydropower allocations decrease in the future, the project's ROI would significantly increase. Additionally, there is risk associated with the projects ability to participate in the NYISO ancillary market. While the project's ROI is limited by the current price of electric, the project provides other benefits as well such attracting commercial and industrial development in the area that will benefit from the increase in resiliency for the area.

6. Conclusion

The Endicott Community Microgrid is a technically and commercially viable project with significant benefit to the local community. It is located in a community that is being targeted for economic development, has experienced record flooding in recent years, and is positioned to receive highly favorable natural gas rates. The Endicott Community Microgrid will increase community resiliency and support economic growth while meeting NY Prize and REV goals for grid resiliency and sustainability.

Appendix A: Electrical One Line Diagrams



TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 123456

REV	DESCRIPTION	DATE	DES	CHK	APP
B	TASK 2 SUBMISSION, REVISED 34.5 KV INTERCONNECTION	11−30−15	WFM	CP	
A	FOR INTERNAL REVIEW	.	.	.	.

Endicott Community Microgrid

WFM DESIGNED
.WFM DRAWN
. CHECKED
. APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID

ELECTRICAL DISTRIBUTION
KEY PLAN

11−30−2015 DATE
NOT TO SCALE SCALE

TRC

OLKP

REV. B

LEGEND

- (24) VOLTS/HZ
- (25) SYNCH CHECK
- (25G) GENERATOR SYNCH CHECK & AUTO SYNCHRONIZER
- (27) GENERATOR UNDERVOLTAGE
- (27S) BUS UNDERVOLTAGE
- (32) DIRECTIONAL POWER
- (40) LOSS OF FIELD
- (50N) NEUTRAL OVERCURRENT
- (51) TIME OVERCURRENT
- (59) GENERATOR OVERVOLTAGE
- (59S) BUS OVERVOLTAGE
- (59N) NEUTRAL OVERVOLTAGE
- (64F) FIELD GROUND
- (64G) STATOR GROUND
- (77) FIELD GROUND DETECTOR
- (87) CURRENT DIFFERENTIAL
- (87N) NEUTRAL CURRENT DIFFERENTIAL
- (81) OVER/UNDER FREQUENCY
- (86) LOCK OUT

VCB — DRAW OUT VACUUM CIRCUIT BREAKER

CURRENT TRANSFORMER

POTENTIAL TRANSFORMER

TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
C	REVISED STG-1 CAPACITY, TASK 2 SUBMISSION	11-30-15	WFM	CP	
B	NUMBERED ALL BREAKERS, ADDED NEW FEEDER BREAKERS 52-8 & 52-9				
A	FOR INTERNAL REVIEW	.	.	.	.

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
CP CHECKED
APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID

GENERATOR PARALLELING BUS
ONE-LINE DIAGRAM

11-30-2015 DATE
NOT TO SCALE SCALE

TRC

OL-1

REV. C

LEGEND

- (24) VOLTS/HZ
- (25) SYNCH CHECK
- (25G) GENERATOR SYNCH CHECK & AUTO SYNCHRONIZER
- (47) PHASE IMBALANCE
- (27) UNDERVOLTAGE
- (59) OVERVOLTAGE
- (87) CURRENT DIFFERENTIAL
- (81) OVER/UNDER FREQUENCY
- (86) LOCK OUT
- (BF) BREAKER FAILURE

CURRENT TRANSFORMER

POTENTIAL TRANSFORMER

VCB — OUTDOOR SUBSTATION TYPE VACUUM CIRCUIT BREAKER

TRC 102 WEST STATE ST, 2ND FL. ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
C	TASK 2 SUBMISSION	11-30-15	WFM	CP	
B	ADDED INTERLOCK W/GEN BUS, ADDED BREAKER FAIL, CHANGED FEEDER ASSIGNMENTS		WFM	CP	
A	FOR INTERNAL REVIEW	.	.	.	.

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
CP CHECKED
. APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID

.

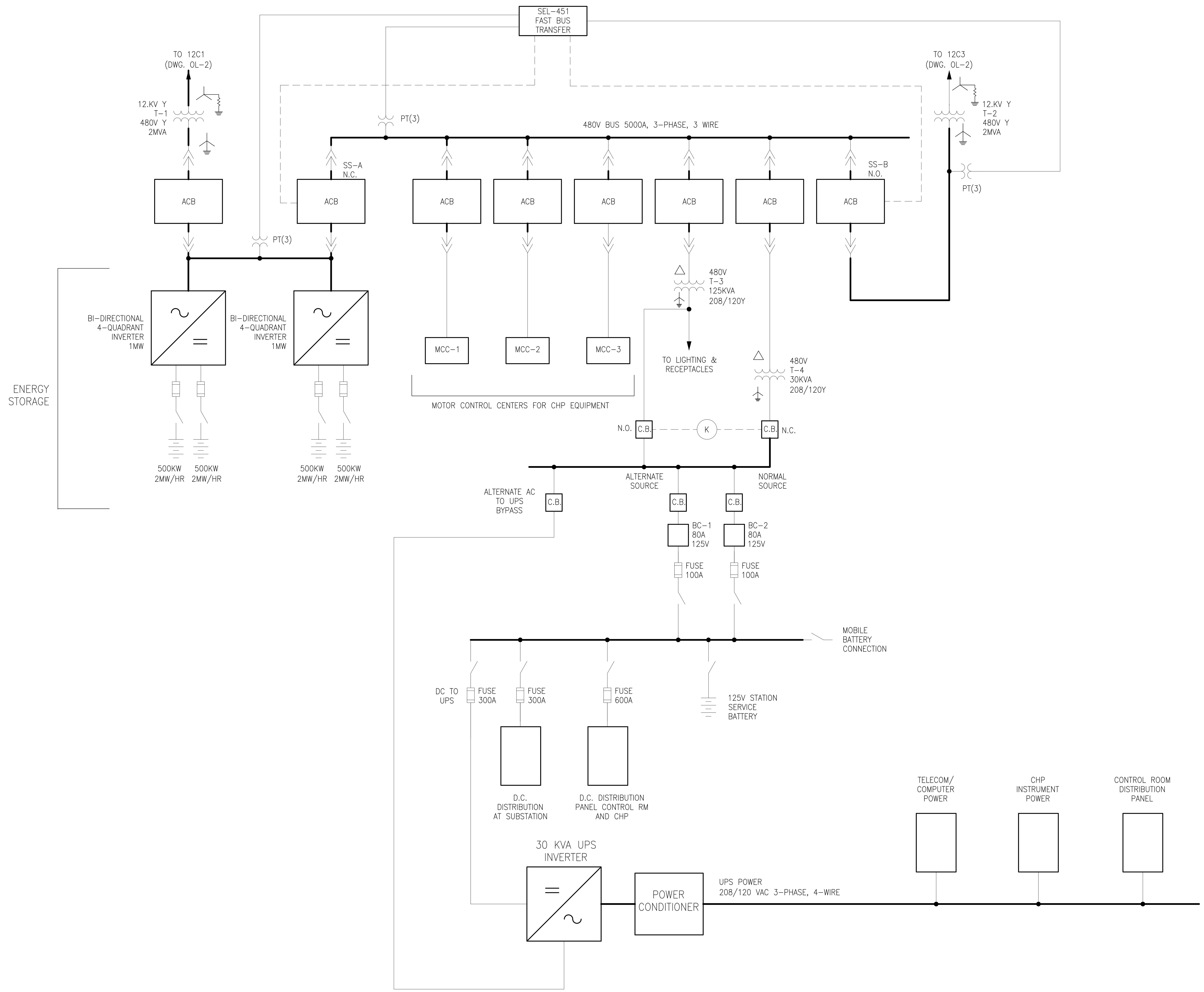
NEW MICROGRID SUBSTATION ONE-LINE DIAGRAM

11-3-2015 DATE
NOT TO SCALE SCALE

TRC

OL-2

REV. C



TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
A	FOR INTERNAL REVIEW	.	WFM	CP	.

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
CP CHECKED
. APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID

.

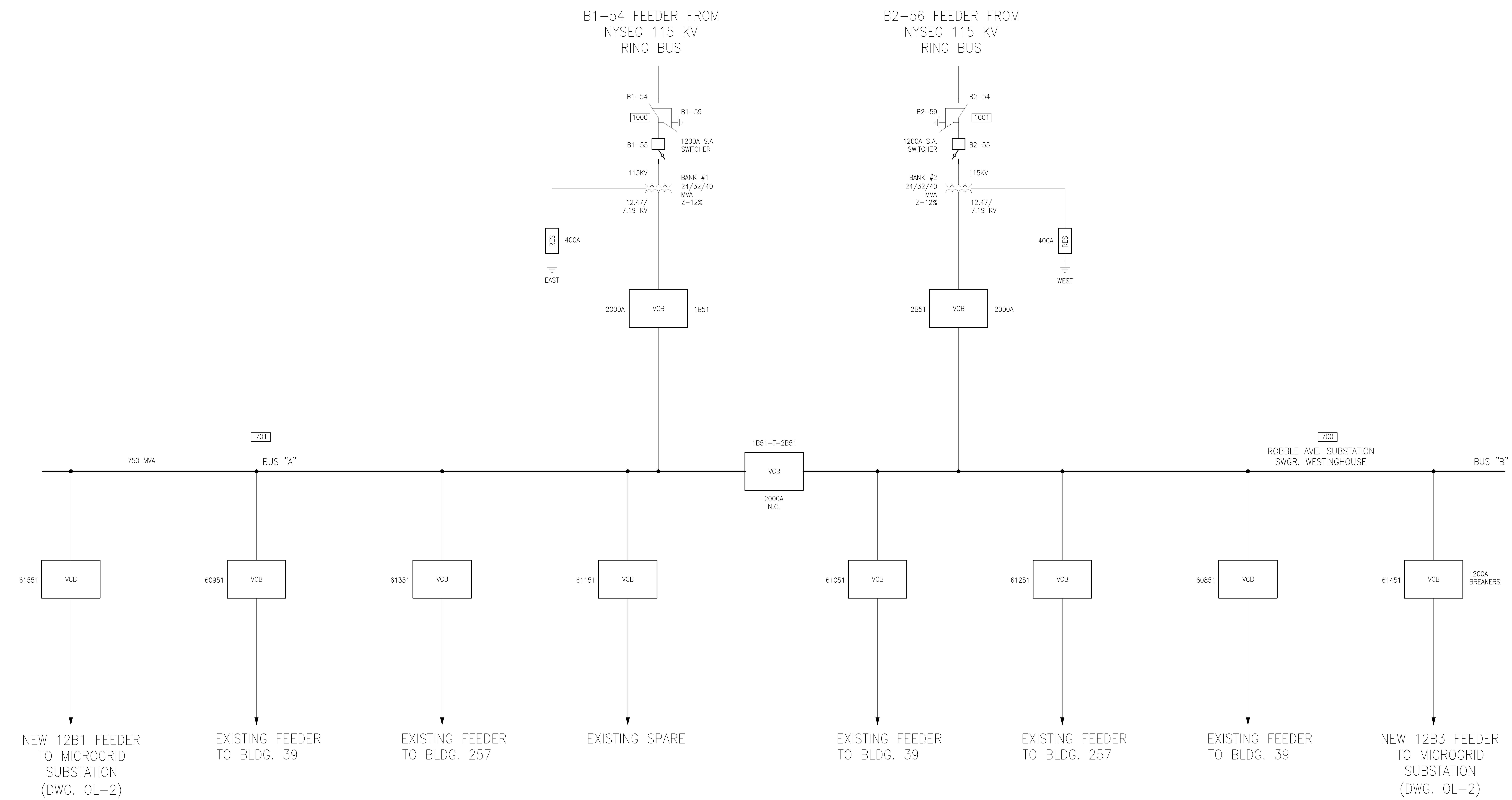
STATION SERVICE
ONE-LINE DIAGRAM

11-30-2015 DATE
NOT TO SCALE SCALE

TRC

OL-3

REV.
B



TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
	TASK 2 SUBMISSION	11–30–15	WFM		
A	FOR INTERNAL REVIEW	.	WFM	CP	.

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
CP CHECKED
. APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID

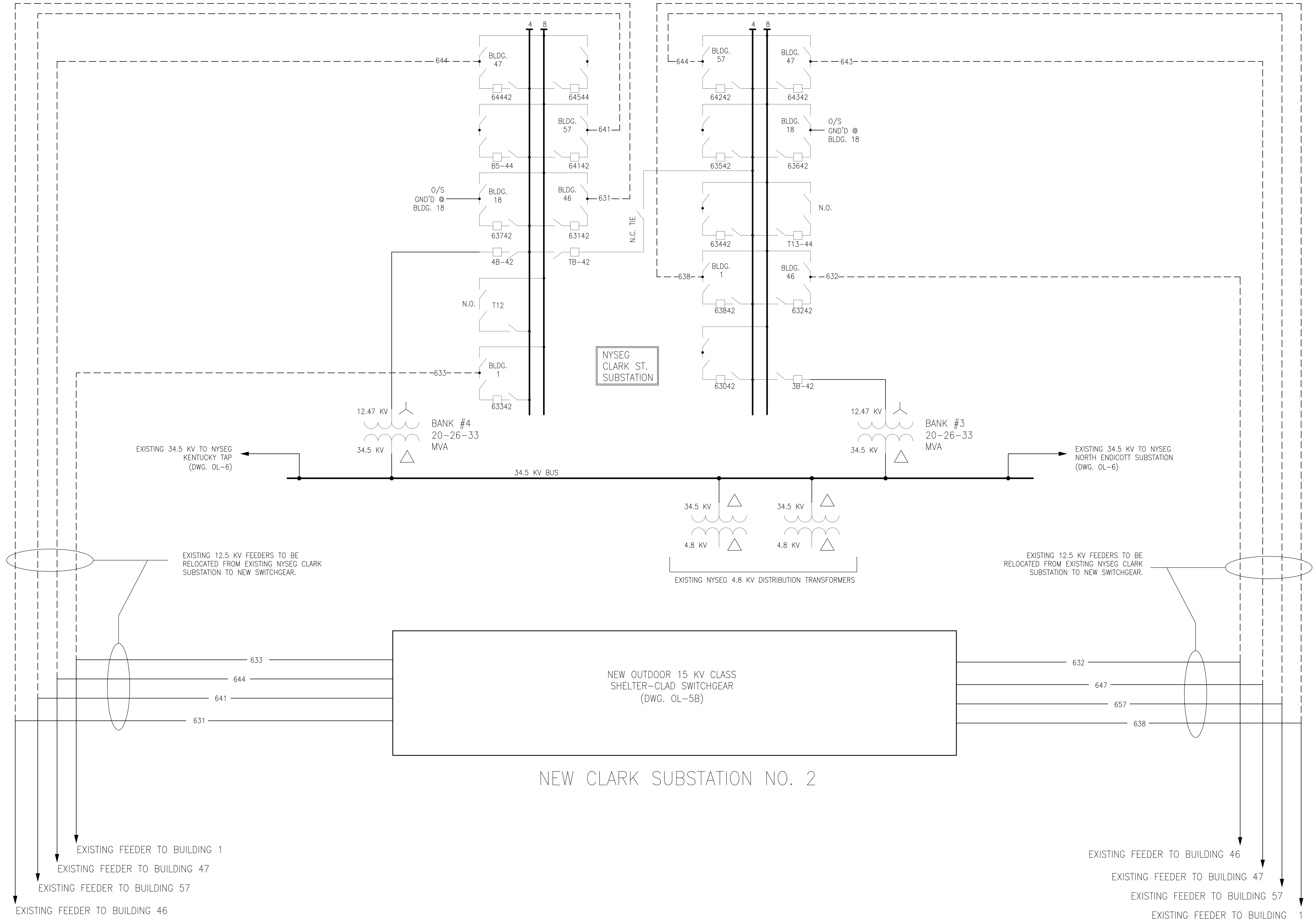
ROBBLE SUBSTATION
ONE–LINE DIAGRAM

11–30–2015 DATE
NOT TO SCALE SCALE

TRC

OL–4

REV. B



TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
B	TASK 2 SUBMISSION	11-30-15	WFM		
A	FOR INTERNAL REVIEW	-	WFM	CP	-

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
CP CHECKED
- APPROVED
REVIEW 1
REVIEW 2

11-30-2015 DATE
NOT TO SCALE SCALE

ENDICOTT COMMUNITY MICROGRID

CLARK SUBSTATION (NYSEG)
ONE-LINE DIAGRAM

TRC

OL-5A

REV. B

TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
B	ADDED CONNECTION TO PV SYSTEM , TASK 2 SUBMISSION	11-30-15	WFM		
A	FOR INTERNAL REVIEW	-	WFM	CP	-

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
CP CHECKED
- APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID

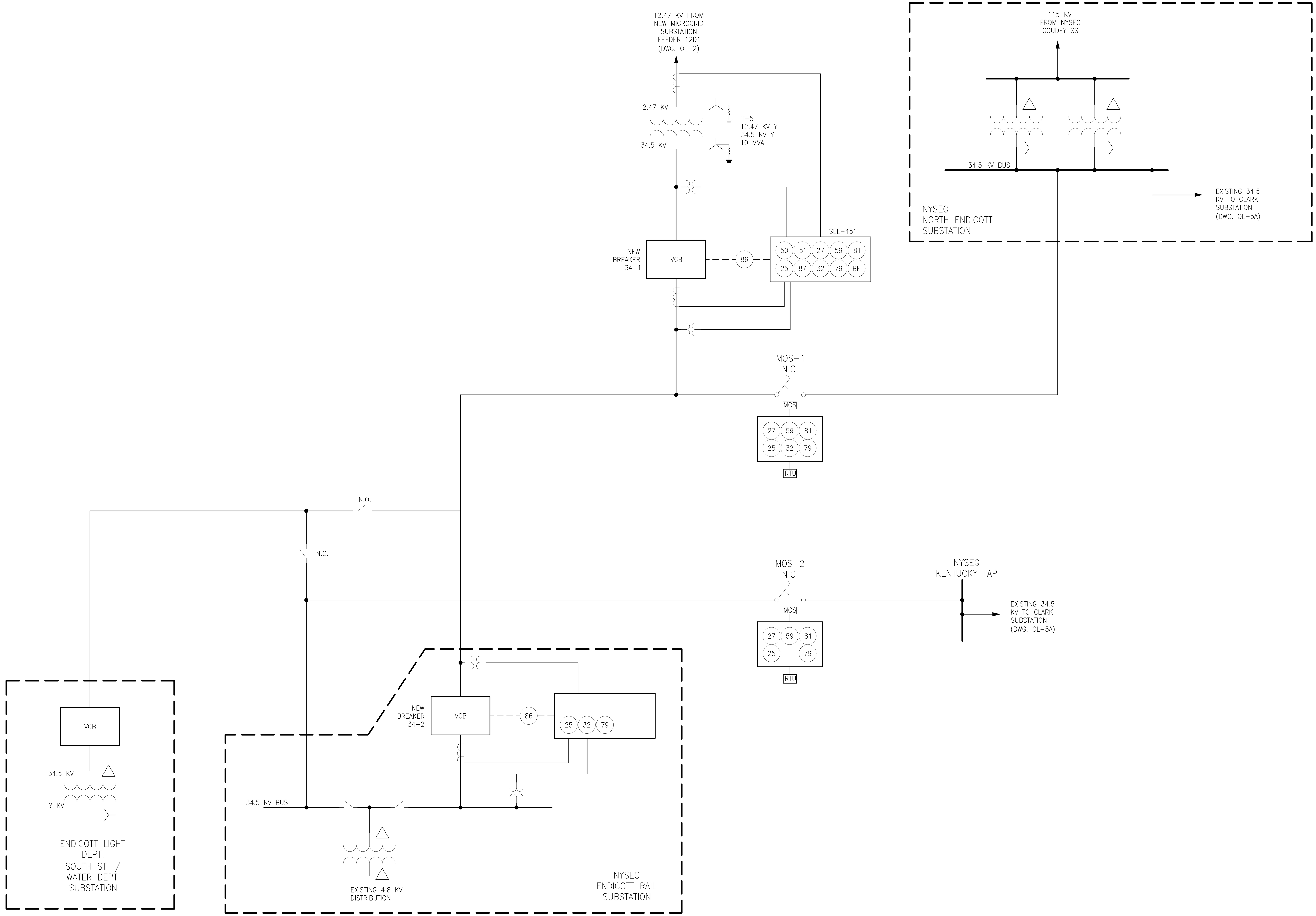
NEW CLARK SUBSTATION NO. 2
ONE-LINE DIAGRAM

11-30-2015 DATE
NOT TO SCALE SCALE

TRC

OL-5B

REV. B



TRC 102 WEST STATE ST, 2ND FL. ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
B	REMOVED CB AT ENDICOTT NORTH, ADDED MOS-1 & 2, TASK 2 SUBMITTAL	11-30-15	WFM		
A	FOR INTERNAL REVIEW	-	WFM	CP	.

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
CP CHECKED
. APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID
12D1 FEEDER
34.5 KV INTERCONNECTION
ONE-LINE DIAGRAM

11-30-2105 DATE
NOT TO SCALE SCALE

TRC

OL-6

REV. B

Appendix B: Thermal Flow Diagram

TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 123456

REV	DESCRIPTION	DATE	DES	CHK	APP
B	TASK 2 SUBMITTAL	11–30–15	WFM		
A	FOR INTERNAL REVIEW	.	WFM	.	.

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
. CHECKED
. APPROVED
REVIEW 1
REVIEW 2
11–30–2015 DATE
NOT TO SCALE SCALE

ENDICOTT COMMUNITY MICROGRID

CHP THERMAL PROCESS
FLOW DIAGRAM

TRC

FD–1

REV. B

Appendix C: Control Architecture Diagrams

TRC 102 WEST STATE ST, 2ND FL. ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
B	TASK 2 SUBMISSION	11-30-15			
A	FOR INTERNAL REVIEW	.	.	.	.

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
. CHECKED
. APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID

.

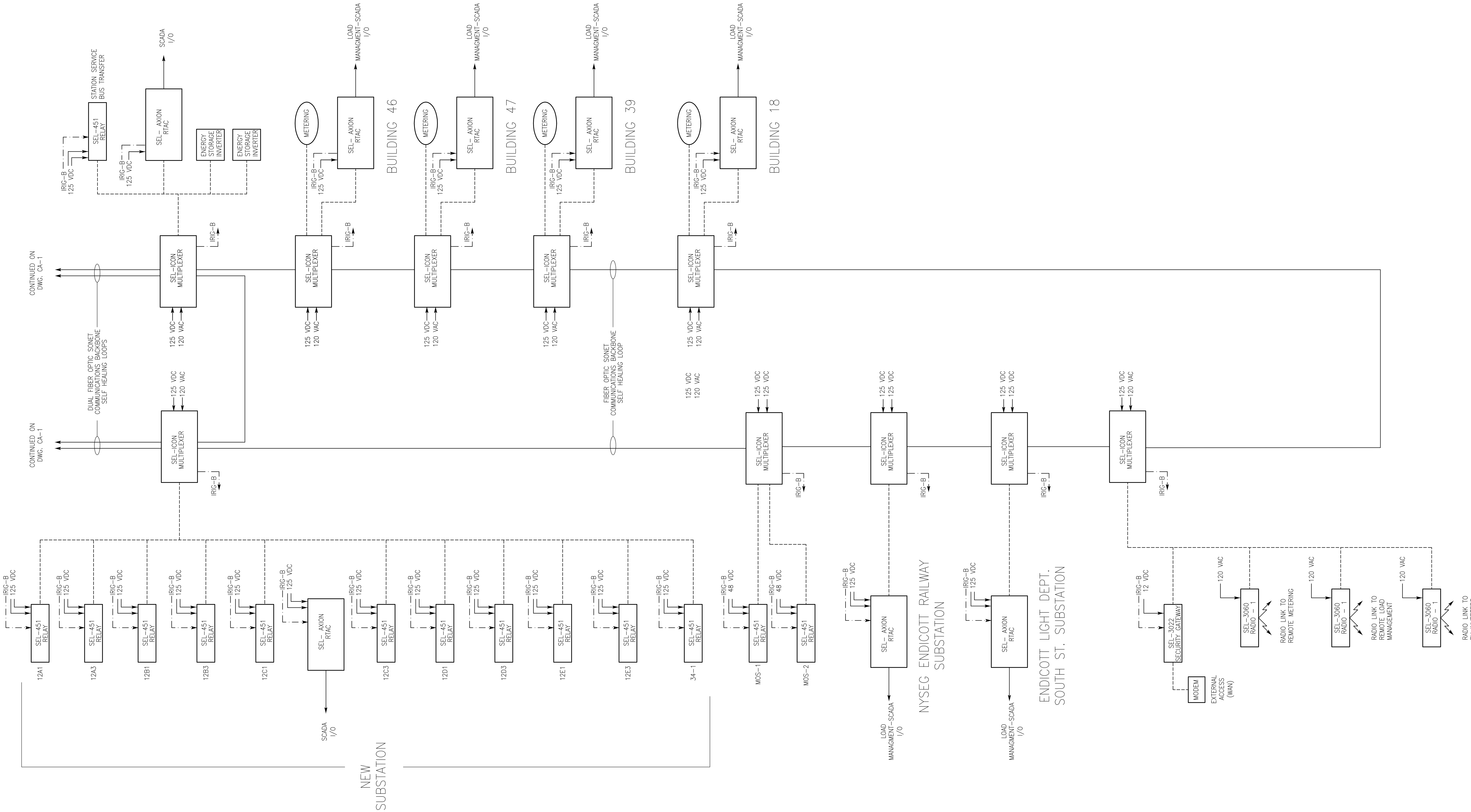
CONTROL SYSTEM ARCHITECTURE
ONE-LINE DIAGRAM

11-30-2015 DATE
NOT TO SCALE SCALE

TRC

CA-1

REV. B



TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
A	FOR INTERNAL REVIEW	.	.	.	.

Endicott Community Microgrid

WFM	DESIGNED
.	DRAWN
.	CHECKED
.	APPROVED
	REVIEW 1
	REVIEW 2

ENDICOTT COMMUNITY MICROGRID

.

CONTROL SYSTEM ARCHITECTURE DIAGRAM

00/09 DATE

NOT TO SCALE SCALE

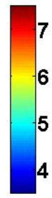
TRC

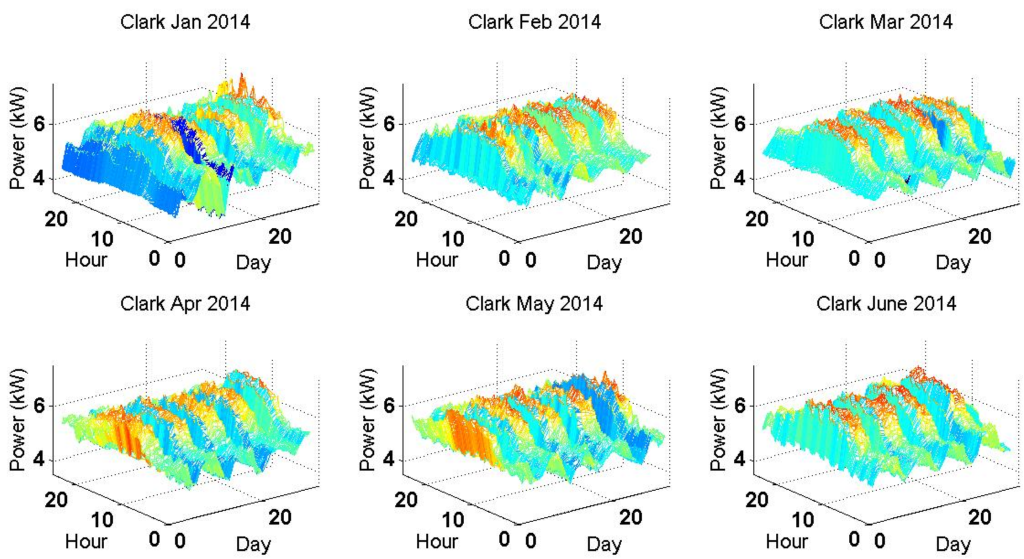
CA-2

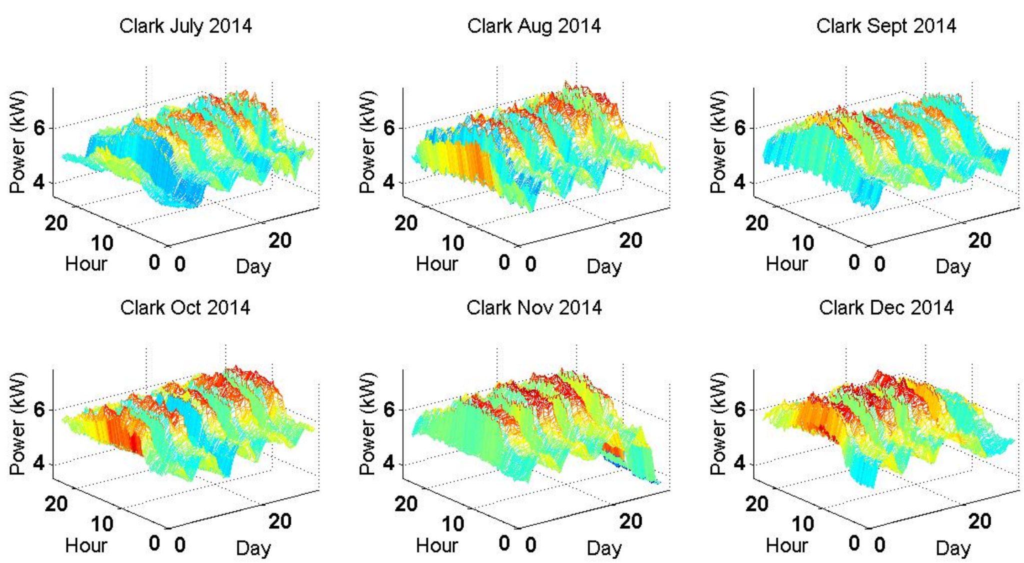
REV. A

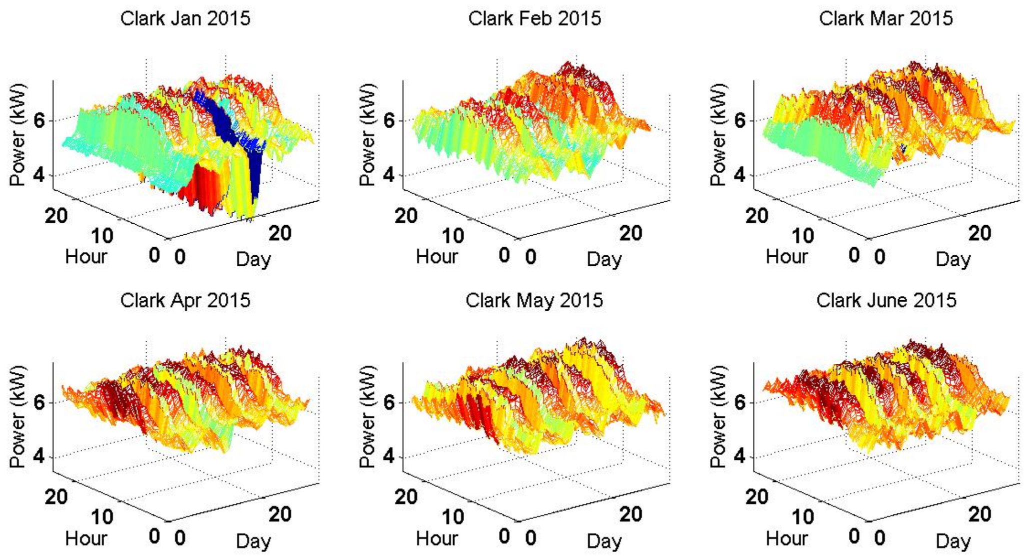
Appendix D: Load Profile

Scale used for Clark Substation graphics:

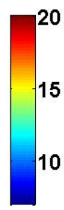




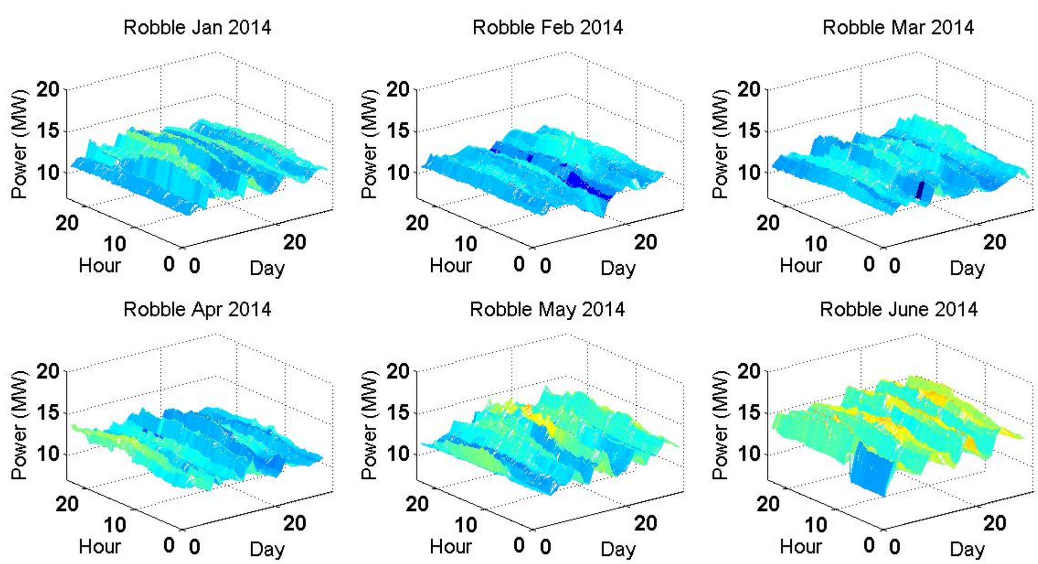


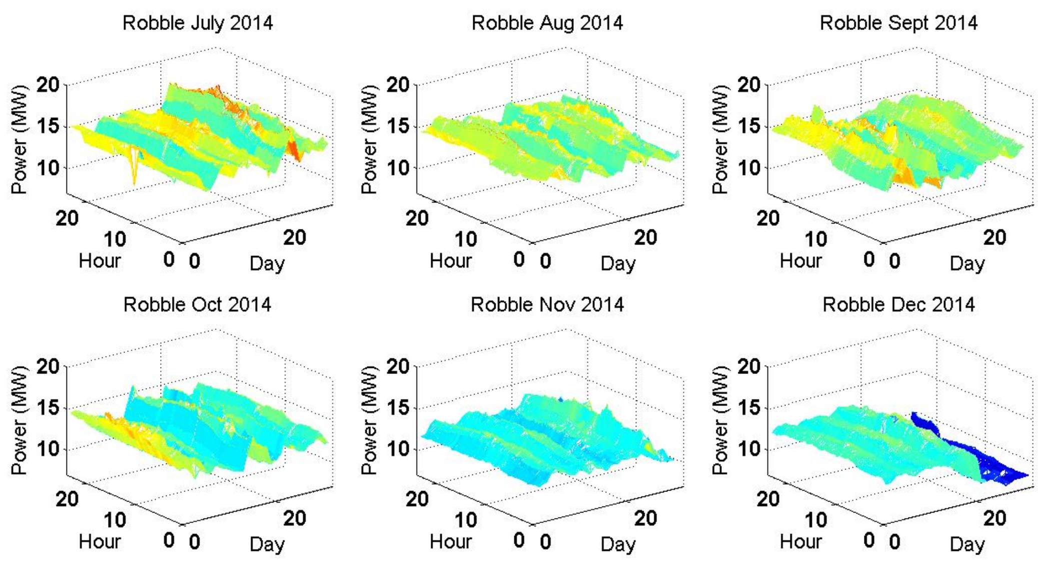


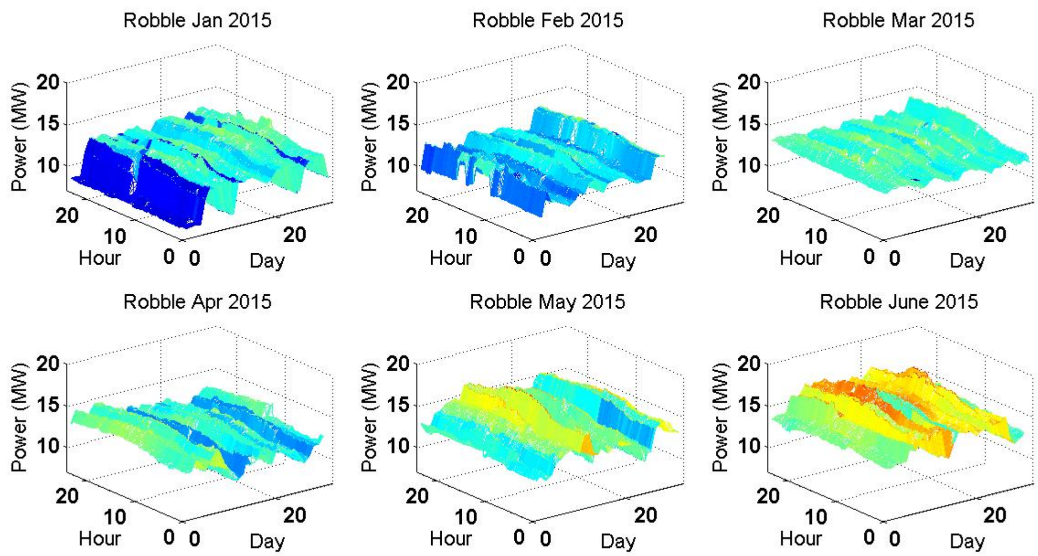
Robble Substation Load



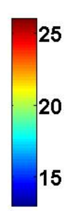
Scale used for Robble Substation graphics:



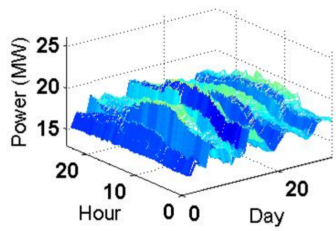




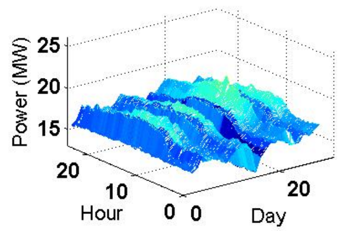
Huron Coincident Load = Clark + Robble Substations

Scale used for Huron coincident load graphics: 

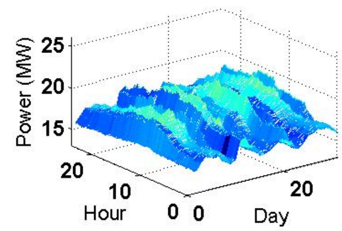
Huron Coin. Jan 2014



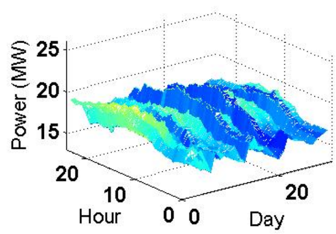
Huron Coin. Feb 2014



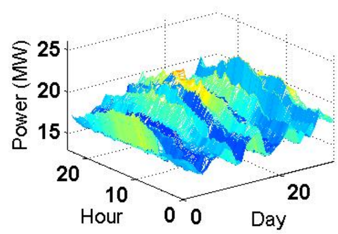
Huron Coin. Mar 2014



Huron Coin. Apr 2014



Huron Coin. May 2014



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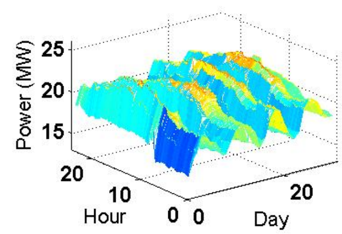

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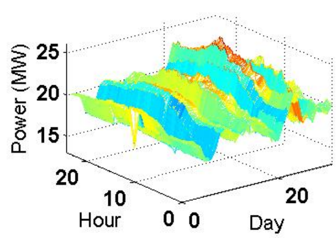

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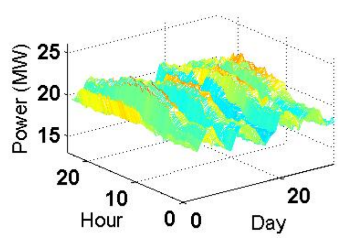

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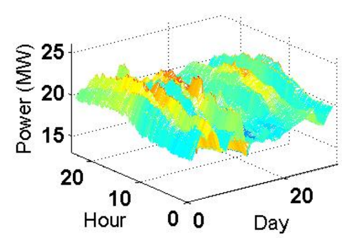

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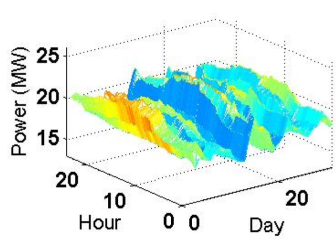

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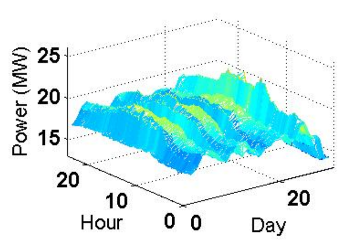

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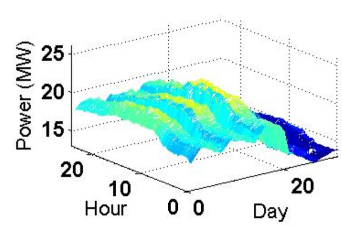
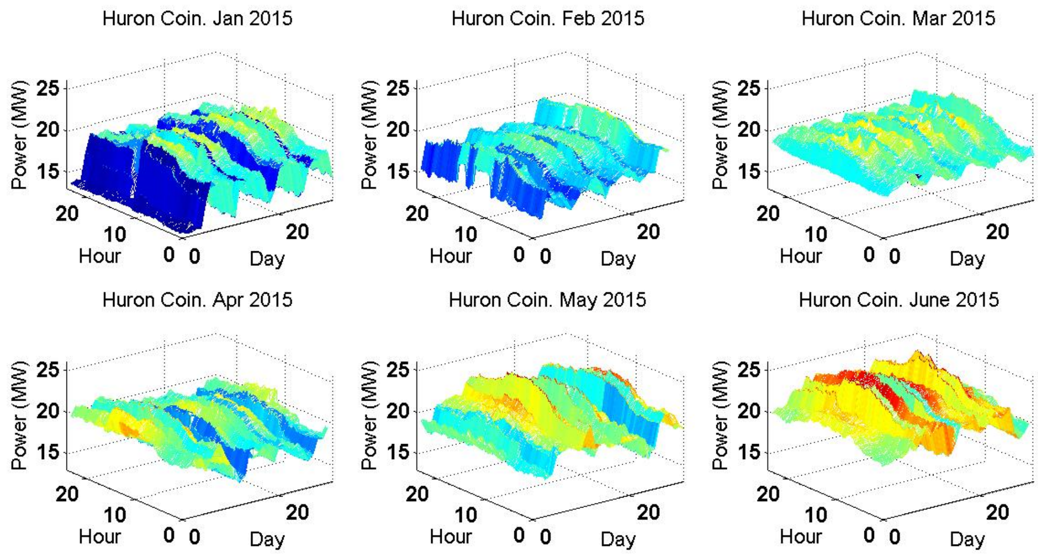
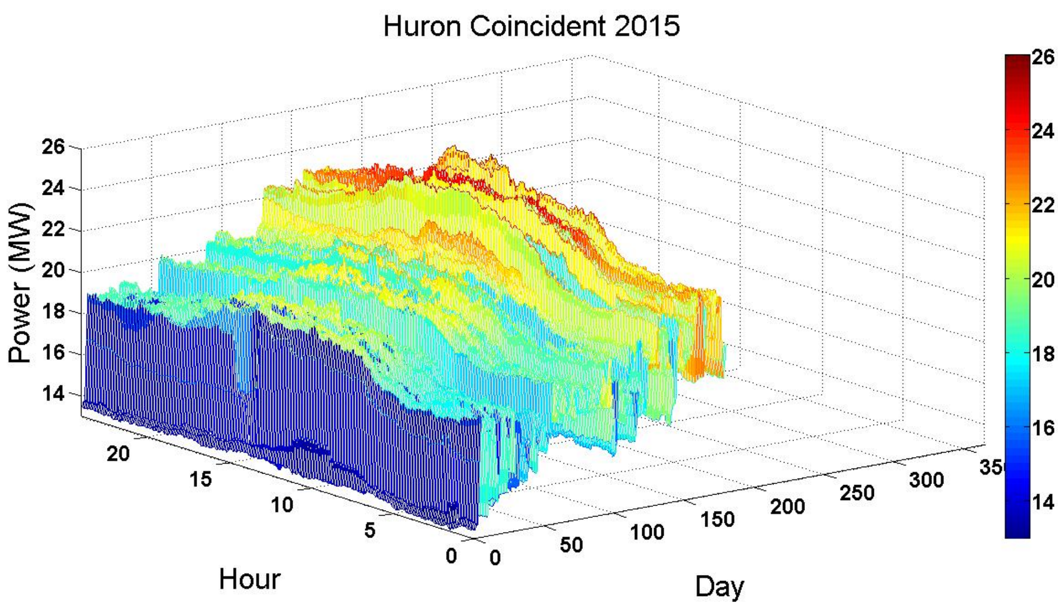
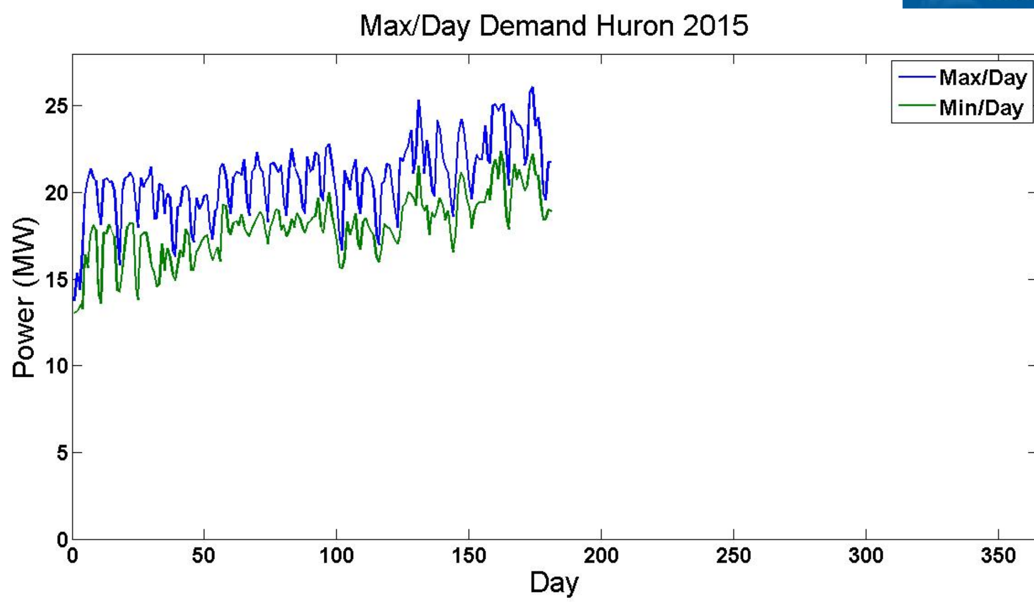


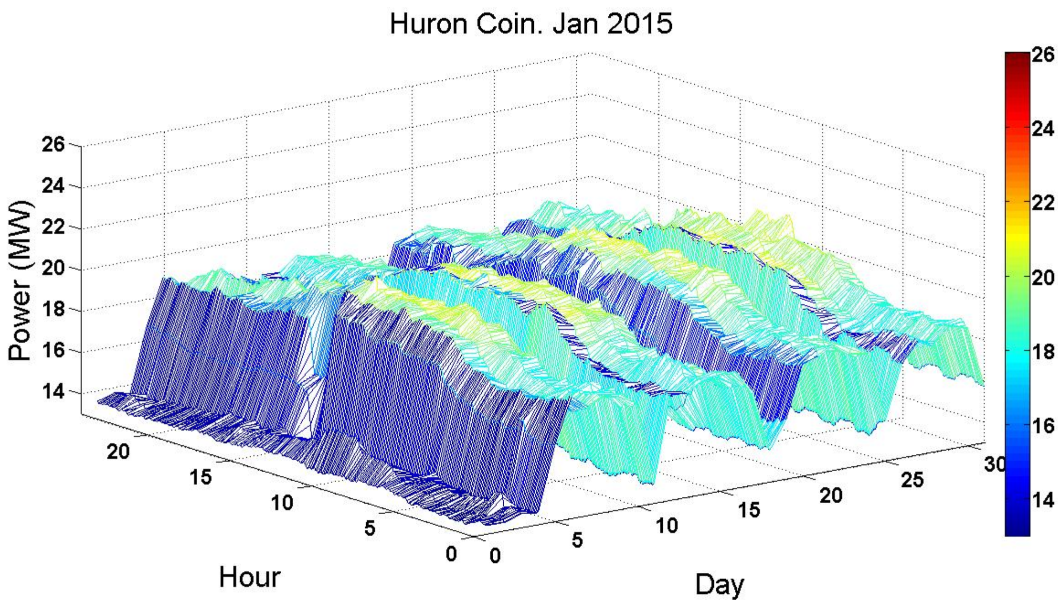




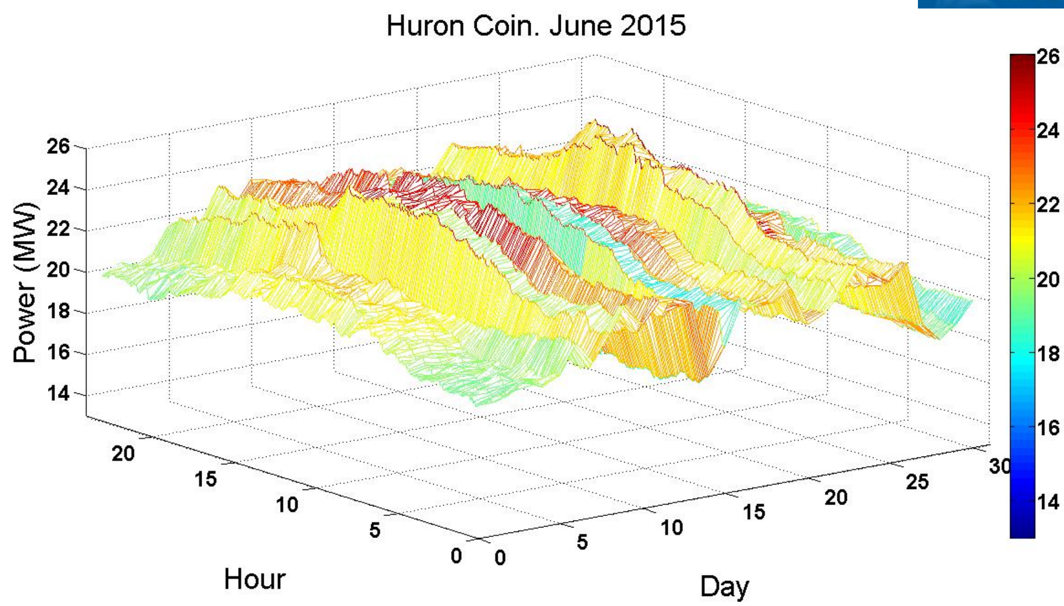
Huron Campus coincident demand in 2015; data stops after June 2015.



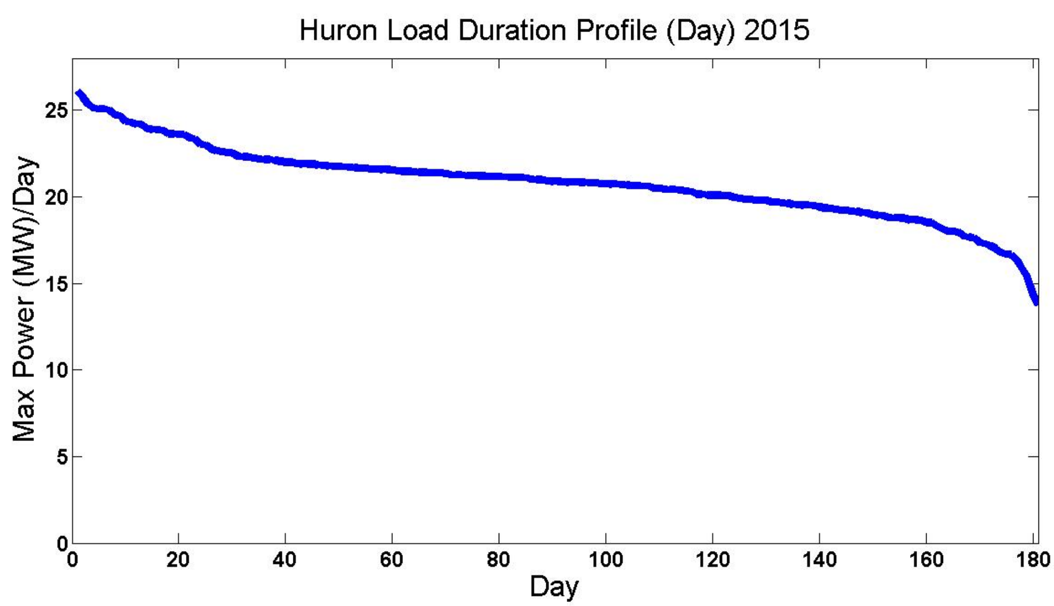
Huron coincident minimum and maximum load by day for 2015.



Huron Campus coincident demand in January 2015.



Huron Campus coincident demand in June 2015.



Huron load duration profile using the PEER approach, graphing the frequency of the peak/day demand.

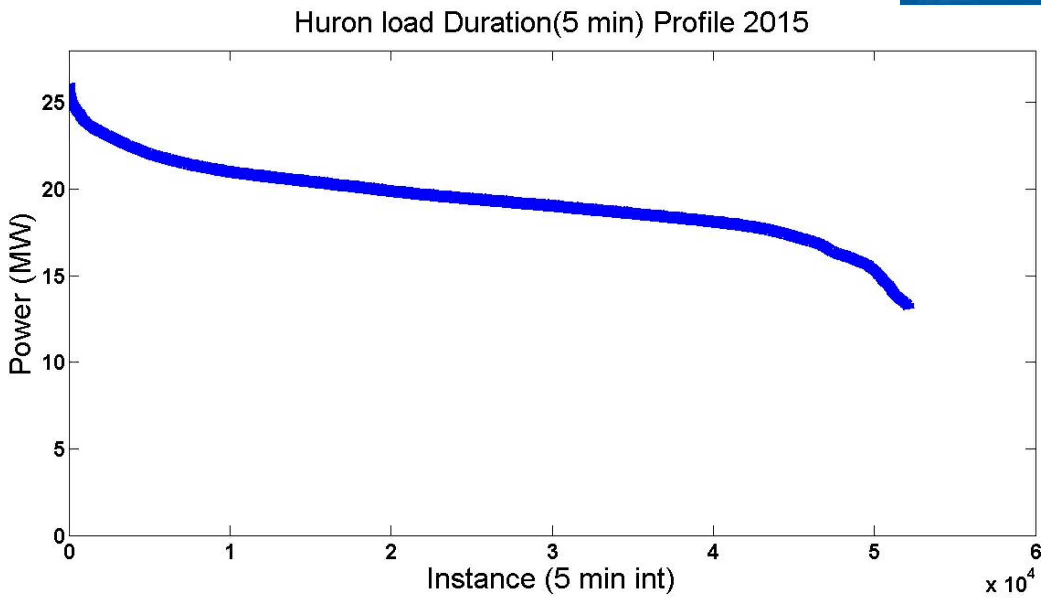


Figure X: Huron load duration profile graphing the frequency of every demand data point for 2015.

Appendix E: Efficiency

Chiller replacement spreadsheet analysis:

Chiller Replacement					
	Maximum Chiller Output (tons)	Minimum Chiller Output (tons)	Max. Bin Temperature (°F)	Min. Bin Temperature (°F)	Maximum Load (tons)
Existing Chiller	9,500	2,500	87.00	47.00	9,500
New Chiller	9,500	2,500	87.00	47.00	9,500

	Chiller Part Load De-rating (Tons/°F)	Ton Curve Intercept (Tons)
Existing Chiller	175.00	-5725.00
New Chiller	175.00	-5725.00

	Existing Chiller				
Bin Temperature (Degree Fahrenheit)	Annual Hours of Operation (hours/year)	Operating Tons at Bin Temperature (tons)	Chiller Output (Tons)	Chiller Efficiency (kW/ton)	Annual Electrical Usage (kWh/year)
92	5	10,375	9,500	1.157	54,957
87	61	9,500	9,500	1.157	670,475
82	154	8,625	8,625	1.157	1,536,770
77	324	7,750	7,750	1.157	2,905,198
72	498	6,875	6,875	1.157	3,961,239
67	645	6,000	6,000	1.157	4,477,545
62	886	5,125	5,125	1.157	5,253,594
57	831	4,250	4,250	1.157	4,086,193
52	722	3,375	3,375	1.157	2,819,291
47	767	2,500	2,500	1.157	2,218,525
	Sum of Annual Usage of Existing Chiller (kWh/year)				27,983,786
	New Chiller				
Bin Temperature (Degree Fahrenheit)	Annual Hours of Operation (hours/year)	Operating Tons at Bin Temperature (tons)	Chiller Output (tons)	Chiller Efficiency (kW/ton)	Annual Electrical Usage (kWh/year)
92	5	10,375	9,500	0.531	25,223
87	61	9,500	9,500	0.531	307,715
82	154	8,625	8,625	0.531	705,301
77	324	7,750	7,750	0.531	1,333,341
72	498	6,875	6,875	0.531	1,818,011
67	645	6,000	6,000	0.531	2,054,970
62	886	5,125	5,125	0.531	2,411,138
57	831	4,250	4,250	0.531	1,875,359
52	722	3,375	3,375	0.531	1,293,914
47	767	2,500	2,500	0.531	1,018,193
	Sum of Annual Usage of New Chiller (kWh/year)				12,843,164

Energy Savings (kWh/year)	15,140,622	Energy Rate ($/kWh)	0.056

	Peak Demand (kW)
Existing Chiller	8,793
New Chiller	4,036

Peak Demand Reduction (kW): 4,758

Demand per Month (kW)

Month	Max. Bin Temp. (°F)	Demand For Existing Chiller (kW)	Demand for New Chiller (kW)
April	67	5,553.5	2,548.8
May	82	7,983.2	3,663.9
June	87	8,793.1	4,035.6
July	87	8,793.1	4,035.6
August	87	8,793.1	4,035.6
September	77	7,173.3	3,292.2
October	67	5,553.5	2,548.8
November	62	4,743.7	2,177.1
December	57	3,933.8	1,805.4
Sum of Demand		52,643.0	24,160.5

Demand Rate ($/kW): 0.00

Estimated Cost Savings ($/year): $847,875

Existing Chiller Performance

Chiller #	Year Built	Energy Source	Estimated COP*	# of hours in 2015	Tons Capacity	Electric Tons.hr	Steam Tons.hr	Average kW/ton	Chiller electric kW (each)	Electricity Use for Chiller (kWh/yr)
1	1969	Electric	3.75	2,053.25	3,500	7,186,375		1.156988	4,049	8,314,552
2	1970	Electric	3.75	0.00	3,500	0		1.156988	0	0
3	1980	Steam		3,938.25	3,500		13,783,875		0	0
4	1982	Electric	4.1	2,544.50	2,250	5,725,125		1.156988	2,603	6,623,902
5	1982	Electric	4.1	1,274.25	2,250	2,867,063		1.156988	2,603	3,317,158
6	1985	Electric	4.2	2,836.75	3,000	8,510,250		1.156988	3,471	9,846,259

Weighted Average COP	3.95
De-grading in the Efficiency**	0.3
kW/ton	1.157
Total Chiller Plant Electricity Use (kWh/yr)	28,101,871

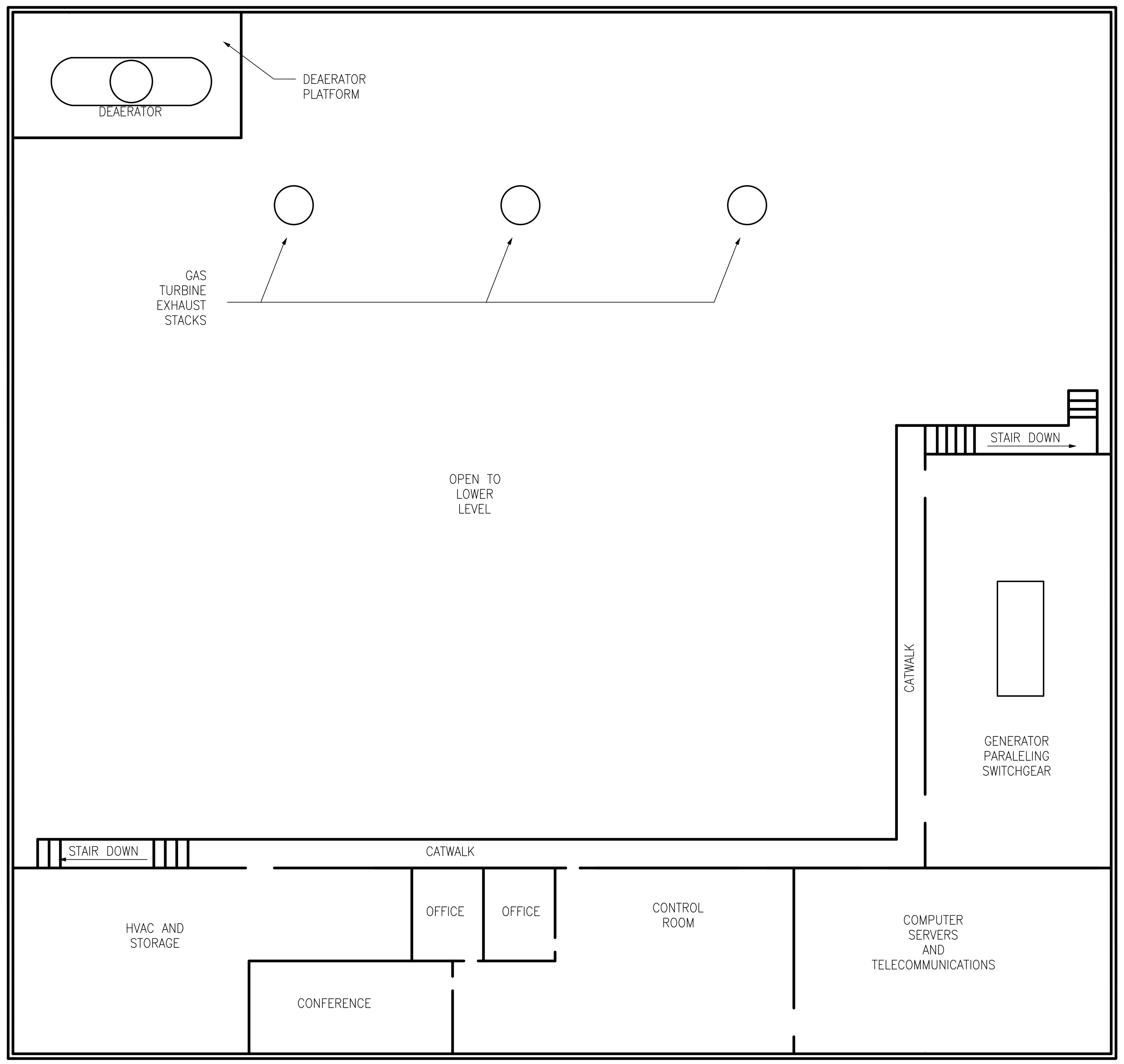
* : (based on the Chiller Efficiency Factsheet from HVAC HESS)

**: (based on '5 Threats to Chiller Efficiency' article published by James Piper at facilitiesnet.com)

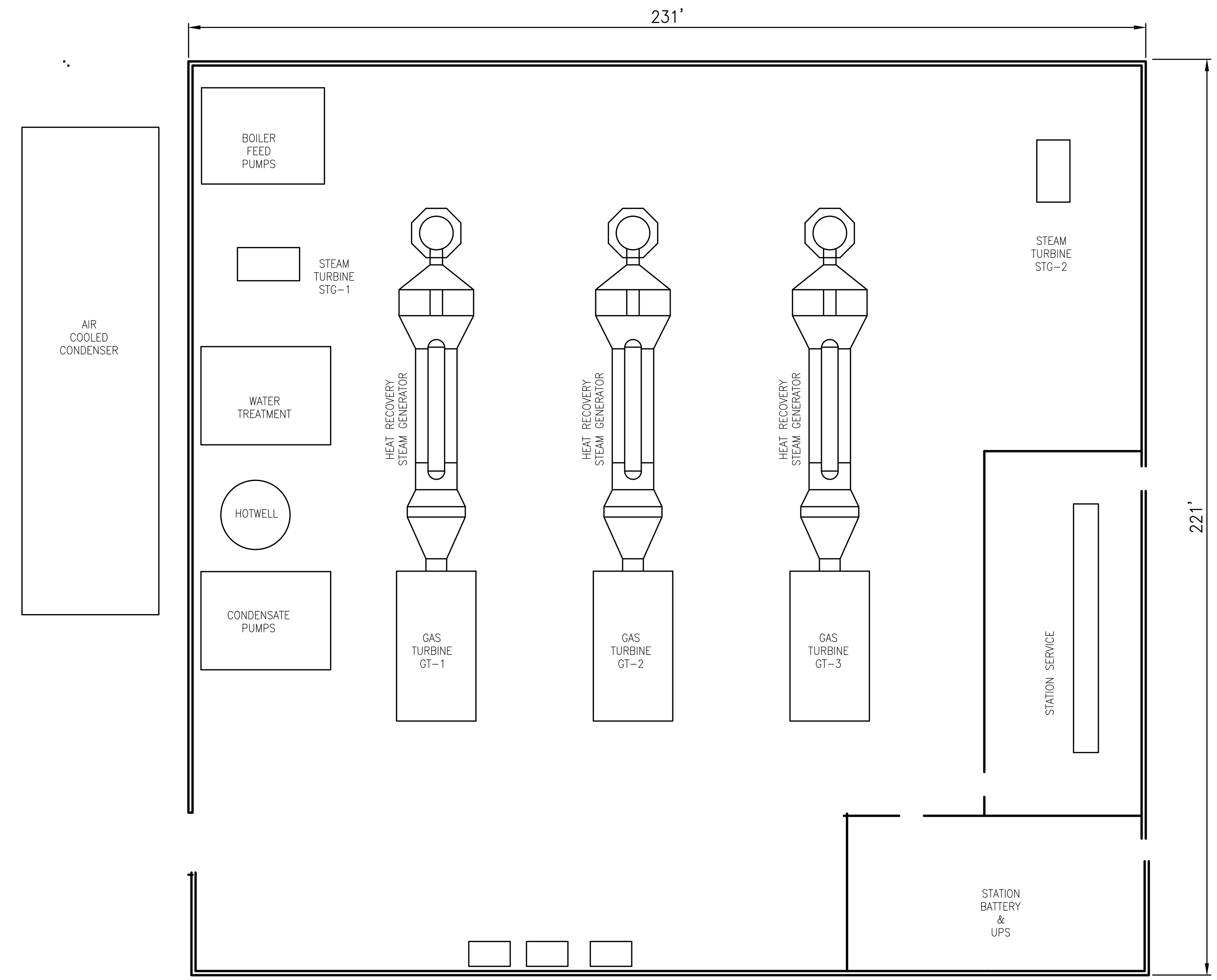
Initial Cost and Simple Payback for Chiller Replacement

	Material (Each)	Labor (Each)	Overhead & Profit (Each)	Installed Cost (Each)	Quantity	Total Demolition Cost	Total Replacement Cost	Simple Payback
1500 ton Chillers (7)	$595,000	$24,300	$74,316	$693,616	7	$54,800	$4,910,112	5.5

Appendix F: CHP Layout Diagram



MEZZANINE LEVEL



LOWER LEVEL

TRC 102 WEST STATE ST, 2ND FL.
ITHACA, NY 14850

PROJECT NO: 238162

REV	DESCRIPTION	DATE	DES	CHK	APP
B	TASK 2 SUBMISSION	11-30-15	WFM		
A	FOR INTERNAL REVIEW	-	WFM	-	-

Endicott Community Microgrid

WFM DESIGNED
WFM DRAWN
- CHECKED
- APPROVED
REVIEW 1
REVIEW 2

ENDICOTT COMMUNITY MICROGRID
CHP FACILITY
EQUIPMENT LAYOUT PLAN

11-30-2015 DATE
1"=20' SCALE

TRC

LP-1

REV. B

Appendix G: Solar PV

Methods and Assumptions

All power ratings regarding solar PV in this report are nominal power DC ratings and do not represent usable AC power out of the inverter.

Installed system costs by site are estimated to range from $1.43 / Watt to greater than $2.50 / Watt based on system size and array type. These costs were calculated after the NYSERDA rebate was applied, but before any tax related incentives (e.g., Federal Investment Tax Credit, accelerated depreciation). These costs are based on current material prices and the available rebates as of November 2015.

The actual rebates will be determined following NYSERDA's review and approval of Commercial and Industrial Megawatt Block Incentive Program applications. Additional incentives may be available through the Federal Investment Tax Credit and accelerated depreciation of the solar asset. Because these incentives are dependent on ownership model and tax liability we have not applied them to the estimated system cost. If applicable, these tax related incentives will improve overall system financials.

The Huron Campus has a number of sites with excellent solar access at each location. The array locations were ranked based on anticipated installation costs, solar resource, project logistics, and capacity (in kW). The three highest ranked sites are examined in more detail and considered prime candidates for development.

Evaluations are based on site visits, client consultations, satellite imagery, and computer modeling. Huron Campus has a mix of roof mount and ground mount locations that are identified as numbered sites. Sites #1 through #9 are discrete locations, while site #10 is a combination of multiple smaller sites that may be developed if additional generating capacity is desired. A full site plan is available in Appendix G which identifies the array locations evaluated during the feasibility phase. Sites were ranked based on the following criteria:

Installation cost (1 – 5): System cost less than $1.80 / W = 5, greater than $2.50 / W = 1

Solar resource (1 – 5): Total solar resource fraction (TSRF) > 0.95 = 5, TSRF < 0.8 = 1

Project Logistics (1 – 5): Standard installation requirements (e.g., standard permitting, no custom racking) = 5, complex installation = 1

Capacity (1 – 5): System size > 1.5 MW = 5, system size less than 200 kW = 1

Detailed site scoring and location specific information is also found in Appendix G.

Site Evaluation

Location / Building #	Brownfield	Carport - Clark St	Carport - Adams Ave	Bldg 53/48
Number of modules	5688	5760	7632	5360
Module type	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305
Array size (kW)	1735	1757	2328	1635
est. prod (MWh/y)	2113	1958	2591	1920
Inverter type	KACO XP500U-TL	KACO XP500U-TL	KACO XP500U-TL	KACO XP500U-TL
Racking type	Schletter PV Max	Schletter Park@Sol (or equivalent)	Schletter Park@Sol (or equivalent)	Schletter IsoTop or equivalent
Proposed tilt	30	10	10	20
Array spacing (if applicable)	2x	3x	3x	2x
Notes	1) Site will need remediation, most contamination is oil or petroleum based 2) Foundations still litter site, a lot of clean & grub required 3) Demo monitoring well houses or work around structures? 4) Site controlled by Village and State 5) Huron owns mortgage, and will need to foreclose on old site, take responsibility for existing site issues; ready to do so when time is right	1) needs restriping to accommodate carport layout 2) demo existing streetlights and include carport mounted lighting 3) provide snow, rain, sun shelter which client appreciates	1) demo existing streetlights and include carport mounted lighting 2) provide snow, rain, sun shelter which client appreciates	1) Need new roof 2) Some foam over decking 3) penetrating system is preferred, okay to install over existing skylights 4) great solar resource

Location / Building #	Bldg 57	Bldg 57A	Bldg 250	Bldg 256	Bldg 40/42	various
Number of modules	2790	928	448	1216	928	2500
Module type	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305	Hanwha Q-Cells Q.Pro L-G3 305
Array size (kW)	851	283	137	371	283	763
est. prod (MWh/y)	912	337	160	399	302	817
Inverter type	SMA Sunny TriPower 60	SMA Sunny TriPower 60	SMA Sunny TriPower 60	SMA Sunny TriPower 24	SMA Sunny TriPower 60	SMA Sunny TriPower 60
Racking type	PanelClaw	Schletter IsoTop or equivalent	Schletter Windsafe or equivalent	PanelClaw	PanelClaw	PanelClaw
Proposed tilt	10	20	30	10	10	10
Array spacing (if applicable)	2x	3x	3x	2x	2x	2x
Notes	1) BAE building 2) need new membrane roof, but okay for load 3) structural and mechanical layout available except for 57A 4) good solar access	1) Metal roof, low loading 2) anticipated attachment directly to framing member intersections 3) possible need for structural reinforcement	1) Standing seam, good roof 2) Shade on south half of roof due to Bldg 47A 3) Install only on North side	1) Open roof 2) redo membrane	1) need to redo roof and remove gravel 2) Full structural plans available with roof layout 3) Roof load 75psf 4) pyranometers on site for historical irradiance data if desired	1) Multiple smaller roofs are possible for additional power output 2) Smaller size, more cost 3) Solar resource varies

Site #	Description	# modules	Projected Cost	System size (kW)	System Size Score	Installed Cost, $/W	Installed Cost Score	Solar Resource (TSRF)	Solar Resource Score	Logistics	Logistics Score	Total score
9	Bldg 53/48	5360	$2,585,300	1635	5	$ 1.58	5	0.93	4	reroofing	4	15
1	Brownfield	5688	$2,483,100	1735	5	$ 1.43	5	0.96	5	Mortgage transfer, site remediation, demolition	3	14
2	Carport - Clark St	5760	$3,044,000	1757	5	$ 1.73	5	0.95	4	streetlight demo and repainting	3	14
3	Carport - Adams Ave	7632	$3,950,200	2328	5	$ 1.70	5	0.95	4	streetlight demo and repainting	3	14
5	Bldg 57	2790	$1,684,900	851	3	$ 1.98	3	0.93	4	reroofing	4	13
4	Bldg 40/42	928	$ 636,800	283	2	$ 2.25	2	0.93	4	reroofing	4	12
8	Bldg 256	1216	$ 827,100	371	2	$ 2.23	2	0.92	4	reroofing	4	12
7	Bldg 250	448	$ 327,900	137	1	$ 2.40	2	0.92	4	reroofing	4	11
6	Bldg 57A	928	$ 636,800	283	2	$ 2.25	2	0.93	4	reroofing&structural	3	11
10	various	2500	$1,913,900	763	1	$ 2.51	1	0.87	3	reroofing, multiple small sites	3	10

Appendix H: BAE New Article

Valued partnership 'shines' after Susquehanna River floods Johnson City, NY

Cus

- E
- S

By Chris Round, global marketing manager, Europlacer

A little over one year after flood waters devastated BAE Systems' Johnson City facility, Bob Opeka praises Europlacer North America for the support the company provided during the recovery effort.

As storms pushed over the Northeast portion of the United States on September 8, 2011, small towns were threatened with rain and consequent flooding. The Village of Johnson City, NY (approximately 15,174 residents) was overcome when the nearby Susquehanna River breached, resulting in significant flood damage there and across the region.

One local resident who was interviewed at the time said, "In 2005, we had the 100-year flood and, in 2006, we had the 500-year flood. "What year flood is this?"

Helicopters were busy rescuing residents from their rooftops, as highways that had just opened after Tropical Storm Irene were promptly closed again. All surrounding rivers were filled to new, historically high levels. In nearby Wilkes-Barre, PA, the Susquehanna River had reached a record 42.66 ft., almost two feet higher than the National Weather Service had predicted.

BAE Systems, Johnson City, NY, September 8, 2011

Johnson City, NY's manufacturing facility was home to a division of BAE Systems, a large, global company that makes a broad range of products for the military, cyber intelligence, commercial aviation, security, commercial transit bus and defense industries. As flood waters poured into the region, employees were fearful for their homes, personal belongings, and livelihoods. Additionally, the engineering and manufacturing teams at BAE Systems were concerned about the technical ramifications of an impending disaster, given the inherently precise equipment used in their manufacturing processes.

"Honestly, this is not a time I wish to relive or rethink. It took endless hours of hard work and dedicated people coming together to eventually return to a normal set of business conditions," said Bob Opeka, SMT process owner at BAE Systems.