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Notice

City of Utica Community Microgrid Feasibility Study

NYSERDA Agreement with the City of Utica, NY
Number 64594

Prepared for:

New York State Energy Research and Development Authority

Project Manager

John Love

and

City of Utica, NY

City Mayor

Robert M. Palmieri

Project Director

Jack Spaeth

Executive Director

Utica Industrial Development Agency

Prepared by:

Joseph Technology Corporation, Inc.

Project Manager

Dr. Ishai Oliker, P.E.

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Executive Summary

The goal of the project was to study the feasibility of building and operating a community Microgrid (MG) system for the purpose of maintaining electric and thermal services for the participating customers/facilities at the City of Utica, NY at times when weather events or other emergencies severely disrupt the capacity of the local electric distribution and transmission system to serve essential customer needs.

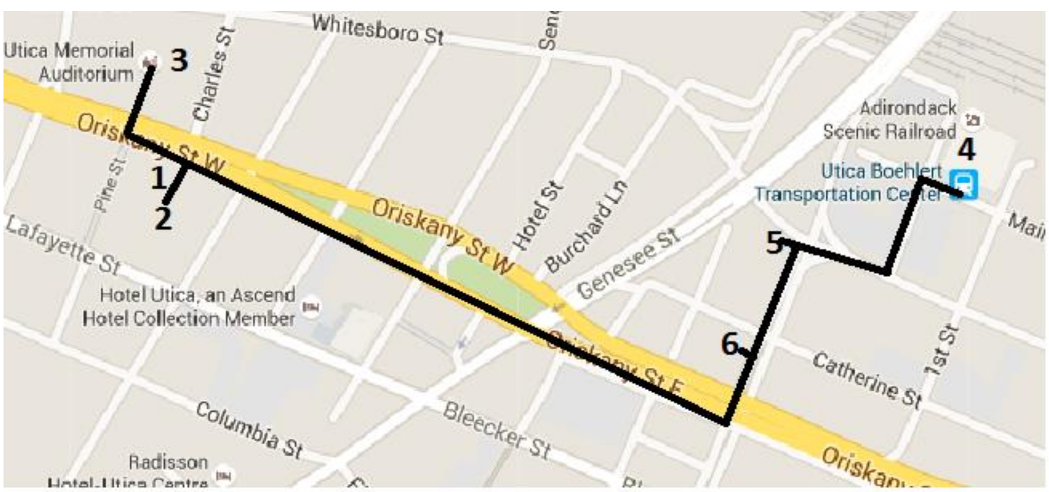
1.Development of MG Capabilities

There is a major bottleneck in the New York electric transmission system between Utica and Hudson Valley areas. This congestion first appeared in the mid-1990s and has been increasing over the past 25 years as electric demand has grown. US DOE have repeatedly identified congestion as a national concern and designated this area as one of only two areas in the country that are Critical Congestion Areas. The winters in Utica are very cold and snowy, as the area is susceptible to Lake Snow effect. The available historic information indicates that creation of the MG districts is of prime importance to the City of Utica and the National Grid.

The project team identified 13 critical customers dispersed in the City within a maximum distance of two (2) miles. The critical customers are clustered within two (2) groups: one downtown group of commercial customers is located south of the major railroad truck system crossing the City, and the second group of industrial customers is located to the north of the railroad truck system. The project team surveyed all critical customers, obtained information on their operation, existing equipment, electric and thermal energy consumption and loads and available back-up electric equipment.

The project team in close cooperation with the NYSERDA Project Manager decided to select for feasibility analysis the downtown group of six most important to community critical customers forming a continuous MG (Figure S-1).

Figure S-1: Location of MG Critical Customers in the City of Utica, NY



1-City Court House; 2-City Police Station; 3-Memorial Auditorium; 4-Boehlet Train Station; 5-Federal Building; 6-Observer-Dispatch Newspaper

The proposed MG includes customers providing essential services to the community and must be in operation during any emergency situation. The impact of the MG critical facilities on the City of Utica operation is described in Table S-1. Table S-2 presents the MG customers' existing and proposed generation capacities, electric and thermal loads and consumption.

Table S-1: Impact of MG Critical Facilities on the City of Utica Operation

No.	Name of Critical Facility	Shut-down of Electric and Heat Service in Emergency Situations
1	City Court House	Reduce the capabilities of maintaining public order and crime fighting
2	City Police Station	
3	Memorial Auditorium	Shut down the potential public shelter
4	Boehlert Train Station	Disrupt the regional train operation
5	Federal Building	Disrupt the operation of local federal authority
6	Observer-Dispatch Newspaper	Disrupt the regional newspaper operation

Table S-2: MG Customers Current and Proposed Electric and Thermal Generation Capacities, Electric and Thermal Loads and Consumption

No.	Name of Customers	Address	Area,sq.ft	Electric Peak,kW	Annual Aver. Electric Load,kW	Annual Electric Consump.,kW	Montly Aver. Electric Consump.,kWh	Weekly Aver. Electric Consump.,kWh	Annual Gas Consump., MMBtu	Existing Thermal Capacity,MBtu/hr	Existing Back-up Generation	MG Electric Gener.,kW	MG Thermal Gen.,MBtu/hr
1	City Court House	200 Elizabeth Street	36,634	404		1,324,914	110,410	25,479	9,804	2x850	100kW Gas Fired	2x335kW CHP	2,816
											by Kohler	Gas Fired Recip.	
2	City Police Station	413 Oriskany Street	30,000	Comb.w/Court		Comb.w/Court			Comb.w/Co	Comb.w/Court		Units	
3	Memorial Auditorium	400 Oriskany Street	62,340	687		3,017,882	251,490	58,036	6,234	2x3,350	250kW Gas Fired		
											by Cummins		
4	Boehlert Train Station	321 Main Street	115,704	255		1,293,900	107,825	24,883	6,891	2x3,100	57kW+15kW gas	4x400kW Gas	
											Fired, Onon	Fired Recip.Units	
5	Federal Building	10 Broad Street	77,637	267		562,500	46,875	10,817	3,631	3x1,200		1x150kW PV Solar	
6	Observer-Dispatch Newspaper	221 Oriskany Plaza	47,318	148		649,681	54,140	12,494	3,159	1x3,780		1x250kW Electric	
										1x800		Battery	
		Total	369,633	1,761	1,344	6,848,877	570,740	131,709	29,719	22,800		2,493	2,816

The combined MG annual electric load duration curve was constructed based on interval and monthly electric meter readings obtained from the National Grid for the six customers (Figure S-2).The combined MG thermal load duration curve was constructed based on the monthly gas bills obtained from the MG customers and the annual outdoor temperatures recorded for Utica (Figure S-3). The combined peak electric load of the MG is 1,761kW and the peak occurs in the summer (caused by air conditioning load).The peak heating load takes place in the winter.

2.Preliminary Technical Design and Configuration

Based on detail electric and heat load analysis it was decided to select for the MG the following DER's equipment: 2x335 kW CHP high efficiency reciprocating units to be installed at the basement of the Court House and 4x400 kW electric generating reciprocating units installed at the basement of the Train Station. The CHP units will supply the base load with about 85% of annual energy consumption and the non-CHP units will provide the intermittent, peak and back-up loads. In addition it is also proposed to install a 150 kW solar PV system at the roof of the Train Station and a 250 kW electric storage facility at the basement of the Station. The DER's will be integrated with the existing hot water boilers and chillers which will supplement the heat and cooling supply from the CHP units. The MG one-line equipment diagram is presented in Figure S-4 and the electric diagram is presented in Figure S-5.

The MG system will operate continuously in parallel with the National Grid at normal conditions. However in case of emergency and failure of the National Grid electric supply, the MG plant will disconnect from the grid and operate in the islanded mode.

Integration of the MG plant with utility electric distribution system will require conformance with utility requirements, which are described in National Grid / *DG Installation Process Guide per NY SIR* / July 2011 ver. 1.0: Distributed Generation Installation Process Guide for Connections to National Grid Distribution Facilities per the New York Standardized Interconnection Requirements (the NY SIR).

Figure S-2: Combined Annual Electric Load Duration Curve for the MG six customers

The interconnection of the MG to the National Grid will offer the opportunity, when economically feasible, to participate in regional energy markets (i.e., sell excess power, purchase supplemental power or participate in demand response programs).The selected MG will:

- Serve multiple physically separated critical facilities located in relatively close proximity and forming a separate island.
- The MG primary generation source will be CHP and DG facilities.
- The combination of generation resources will provide MG on-site power in both grid-connected and islanded mode.
- Will be able to automatically separate from grid on loss of NG utility service and restore to grid after

normal power is restored.

Figure S-3: Combined Annual Thermal Load Duration Curve for the MG six Customers

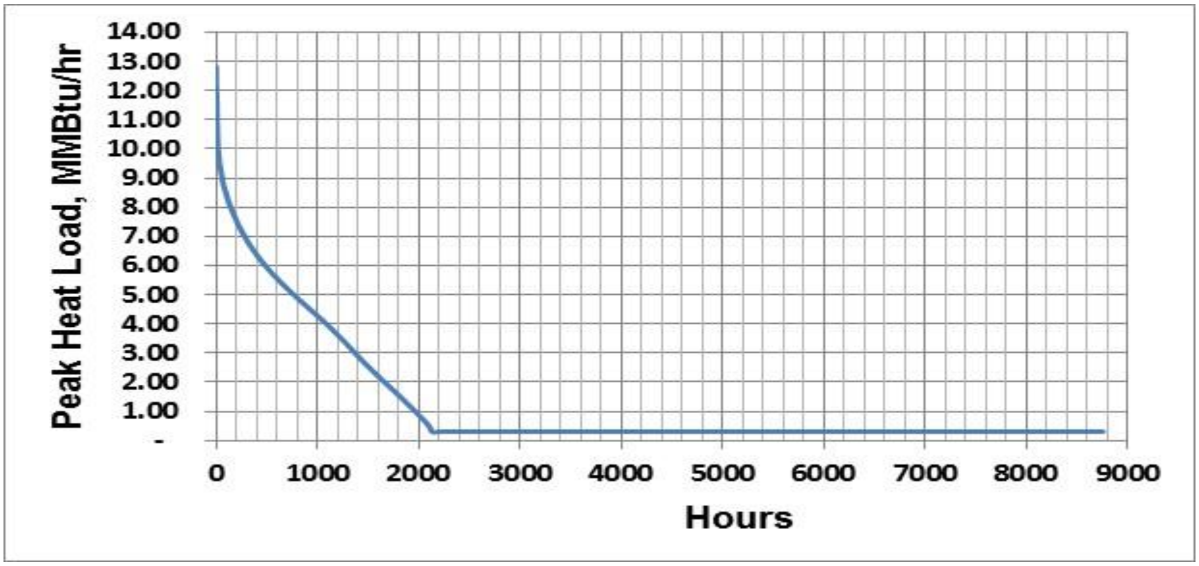
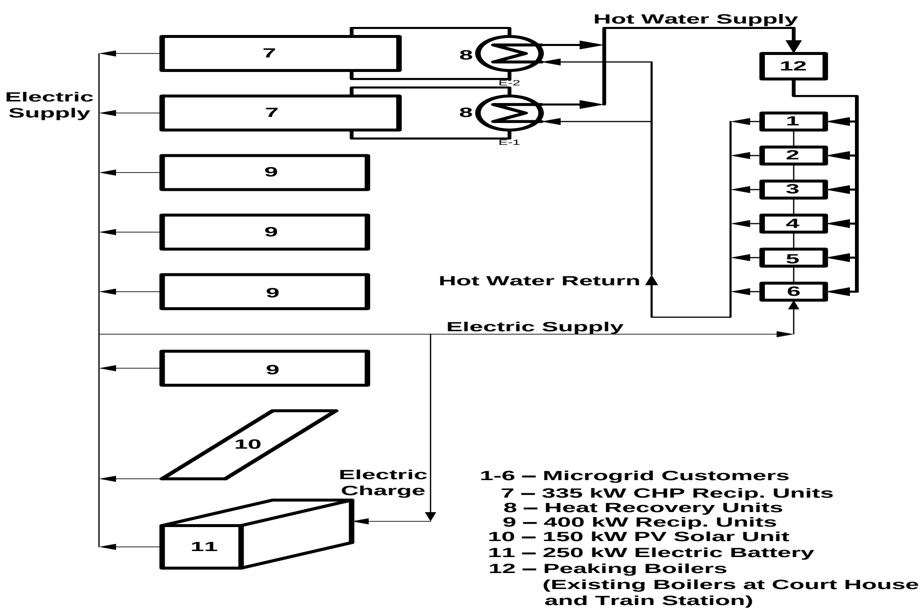


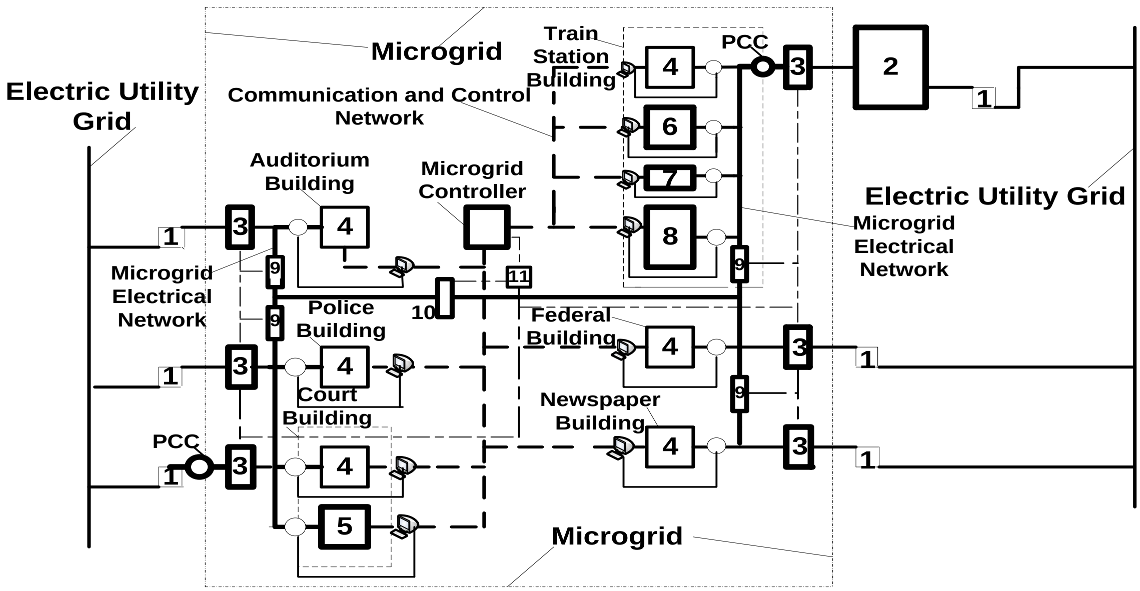
Figure S-4: MG One-line Equipment Diagram



- Comply with manufacturer's requirements for scheduled maintenance intervals for all generation.
- Provide power to a diverse group of critical facilities connected directly to the MG.
- Include an uninterruptible fuel supply or minimum of one (1) week of fuel supply on-site.

- Have black-start capability.

Figure S-5: MG One Line Electric Diagram



1- Utility Meter. 2-Utility Transformer. 3-Islanding Breaker. 4-Building Swichgear. 5-CHP Recip.Units. 6- Electric Recip.Units. 7-Solar PV Unit. 8- Electric Storage. 9-Isolation Breaker. 10-Synchronizing Isolation Breaker. 11-Breaker Control Network.PCC-Point of Common Coupling.
Local Control Agent. Local Protection Element

Currently the City Court House, the City Police Station and Memorial Auditorium are supplied with underground low voltage AC primary feeders with 120/208 Volts. The Boehlert Train station is supplied with an underground AC primary 4.16 kV feeder. At the Train Station the feeder is connected to three (3) transformers owned by the utility. The transformers are connected to the Train Station switchgear equipped with 120/208V breakers. The Federal Building and the Newspaper Building are supplied with underground low voltage AC primary feeders with 120/208 Volts.

The proposed MG DER's will generate 480V electricity. The electricity will be distributed throughout the MG underground electric distribution system (Figure S-5). At each of the MG customers a smart meter, a new advanced circuit breaker (fast switch capable to sense conditions on the National Grid and rapidly connect and disconnect the MG breakers) and a 480V:120/208V step-down transformer and switchgear will be installed. The switch gear will be connected to a local MG controller and the existing switchgear which currently provides the electric supply of the customer. No utility electric distribution system will be used for the MG.

The operation and management of the MG will be controlled and coordinated via both local MG controllers, and a central controller, which executes the overall control of the MG and coordinates the operation and protection requirements of the micro-source controllers. The central controller will provide executive control functions over aggregate system operation, including the individual micro-source controllers, DERs and power conditioning equipment. The central controller will ensure that power quality and reliability on the MG are maintained through power-frequency control, voltage control, and protection coordination. The central controller will also manage economic dispatch of

MG resources, including use of macro-grid power, which it will determine through an optimization process. The central controller is designed to operate in an automated fashion under several different operating modes (i.e., normal grid-connected mode or island mode), but has the capability of manual override if necessary.

The MG will use the SEL's MG Controller which is equipped with the SEL-3530 Real-Time Automation Controller (RTAC). The RTAC has the ability to optimize and balance electrical demand with DER's, schedule the dispatch the resources, provide synchronization and Volt/VAR/frequency controls, preserve grid reliability and cybersecurity, interact with, connect to, and disconnect from the utility grid (using fast switches), provide ancillary services (grid-connected, real-power-related, and reactive-power-related),black start, self-healing of the MG distribution system, user interface and data management, two-way communication, supervisory control and data acquisition (SCADA), and have interoperability in order to improve the grid's power quality and resilience, while reducing overall cost. The RTAC will also communicate with fast switches to enable quick intentional islanding and automatic re-synchronization of MG systems with the macro-grid. The MG fast switches will detect conditions both on the utility and MG sides and make rapid decisions about whether to maintain connected to the macro-grid or to seamlessly separate and institute islanded operations. With a fast switch, MGs could electrically isolate themselves within milliseconds, preventing the need to trip connected generation. A similar process will occur when the macro-grid comes back on-line and the MG reconnects – generation is tripped for a time period before re-synchronization can occur with the utility system.

Two communications systems have been investigated: the fiber optic cables between each of the buildings and the wireless system. The final communications system will be defined during the design stage.

Two of the six MG customers (the Train Station and the Memorial Auditorium) currently have Building Energy Management Systems (BEMS). It is proposed to install the MG control system at the Train Station. The existing BEMS systems will be integrated with the MG controller responsible for providing optimum supply and return temperatures of the MG central hot water system. The hot water supply temperature will be modulated in accordance with outdoor temperature sensors by specially developed algorithm. The existing individual cooling systems will be also controlled by the central MG controller. The BEMS will allow to implement a number of energy efficiency measures which will result in reduction in the electric and thermal demand and substantial savings in electric and thermal energy consumptions.

The MG controller has the capability to perform the following functions:

- Automatically connecting to and disconnecting from the grid
- Load shedding
- Black start and load addition
- Performing economic dispatch and load following
- Demand response
- Storage optimization
- Maintaining frequency and voltage
- PV observability and controllability; forecasting
- Coordination of protection settings
- Selling energy and ancillary services
- Data logging features.

The MG DER's have redundant electric and thermal capacity to meet the required electric and thermal demands of the MG buildings during emergency conditions including the severe weather and disconnection of the utility electric and gas supplies.

The MG will be equipped with an advanced metering infrastructure (AMI) that will measure, collect and analyze energy usage, and interacts with advanced smart electricity meters, gas meters, BTU meters, and water meters, through various communication media. Due to the importance of load balancing on MGs, AMI is important for rapid sensing, communications and response capabilities.

Smart meters will be installed at each customer. The smart meters will provide a platform for a two-way communication network between the utility and MG controller and each participant's meter. Smart meters will communicate with building systems (demand generating devices) through a wireless communication system. The building's area network will link into a Local Area Network (LANs) to establish connectivity between network devices (e.g., smart meters) and the MG's central control system. The LAN will also use a communication system, such as wireless radio frequency (rf) mesh to establish connectivity between the electric meters and stand-alone cell relays that transmit signals to the central control system.

The DER's plants located at the Court House and the Train Station will be equipped with supervisory control and acquisition systems (SCADA).

3.MG Commercial and Financial Feasibility

The major benefits of the MG system to the electric utility and the NYISO will be as follows:

- Reduce peak demand on the system and help avoiding the need to invest in new utility assets to serve that area.
- Reduce capital expenditures necessary to meet the utility's required level of service reliability.
- Improve the electric supply to the neighboring customers located in the oldest part of the City downtown with aged utility electric and gas supply infrastructure.
- Energy benefits, including energy cost savings and reductions in the cost of expanding or maintaining energy generation capacity.
- Reliability benefits, which stem from reductions in exposure to power outages controlled by utility.
- Power quality benefits, including reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary power interruptions.
- Environmental benefits, such as reductions in the emissions of GHG and air pollutants.
- Public safety, health, and security benefits, which include reductions in fatalities, injuries, property losses, or other damages and costs that, may be incurred during prolonged power outages. Such outages are generally attributable to major storms or other events beyond the control of the utility.
- Improve the resilience of the electric distribution infrastructure and defer generation, transmission, and distribution investments (upgrades) and congestion in downtown of Utica, NY.
- Improve reliability for critical loads.
- Provide outage management.
- The MG will have the capacity to provide ancillary and price-driven demand response services to electric utility and NYISO.
- Reduce peak loads for the interconnected grid.

Customer Benefits from the Project will include:

- Increase in energy efficiency (lowering energy consumption) by demand and consumption reduction of electricity, natural gas and water use, implementing building energy management systems, lighting retrofits, HVAC upgrades, and building envelope improvements.
- Electric and thermal energy cost reduction in comparison with current conditions.
- Increase of reliability and safety of electric and thermal supply.
- Increase in quality of electric supply.
- Increase in security of energy supply during natural disasters and other risks.
- Increase in energy system sustainability.
- Improvement of the environment.

Community Benefits from the Project will include:

- The community will secure reliable and safe operation of the MG customers vital to the wellbeing to the City. This will increase community resilience to electric service disruption caused by severe weather and avoid associated substantial economic losses from disruption of customer operations.
- Economic development of the downtown area and job creation.
- Improvement of electric supply to neighboring customers.
- Improvement of the environmental conditions in downtown and avoidance of greenhouse gases (GHG).
- Reduction of other pollutants in the downtown area (NOx, CO, PM).
- Improvement of property values.
- Opportunity to start development of citywide district energy system.

The MG six customers are already solicited and registered. They actively participated in the feasibility study providing information about their systems and energy usage. Three (3) of the customers (City Court, Police Station and the Train Station) are owned and managed by the City of Utica and the Oneida County, NY, and the Memorial Auditorium is closely associated with the City. The Federal and the Newspaper buildings expressed interest in connecting to the MG system.

Proposed MG Ownership

A municipal City/County MG ownership model is recommended for the following reasons:

- The MG customers are critical to the reliable operation of the City and the County during the year, particularly during emergency situations (sever weather, snow storm or hurricane)
- The City owns the Court House and the Police Station facilities
- The County of Oneida owns the Train Station
- The Memorial Auditorium Authority is related to the City
- All MG customers are interested in improving the energy infrastructure and reducing energy cost for their buildings
- The City is planning to develop in the adjacent area a large hospital equipped with a CHP facility
- The City is interested in developing a citywide district energy system (DES) and the proposed MG system will be the first energy island of the DES in the downtown of Utica, NY
- The City is planning to start separation of the storm and sanitary sewer system and will be conducting extensive reconstruction of the City streets. The installation of MG electric

cables, hot water piping and communication cables could be combined in one trench with retrofit of the sewer system

- The City owns the right-of-ways to all streets and can install electric wires and hot water piping at the underground of the streets
- The existing electric, gas and water infrastructure in the proposed MG service area (Bagg's Square and Harbor Point) is the oldest in the City and is subject to limitations for expansion
- The City is actively conducting rehabilitation and economic development in the Bagg's Square and Harbor Point areas
- The City/County can retain a private development company which will construct and operate the MG system
- The City/County have excess to low cost municipal financing.

The technologies proposed for the MG system is widely used in the energy industry. The technologies include: on-site efficient, clean, small carbon footprint conventional CHP and renewable generation (solar PV); electric and thermal storage; advanced controls and automatic ability to operate independently from the main grid for an extended period of time (automatic connect and disconnect from main grid; demand response capability; balance system supply and demand; optimization of power system based on performance economics; reduced carbon footprint; improved reliability; advanced metering; distribution supervisory control and data acquisition (SCADA) systems; optimized and balanced in real time electric and thermal system supply and demand.

The project represents a typical neighborhood of a New York State City and can be easily replicated. The project can be expanded and replicated in other locations of the Utica and the New York State. The project will also demonstrate the island type development strategy and be integrated with the future central hospital CHP facility to be developed by the City in the adjacent area. The project will demonstrate the advantages of municipal ownership, which can be widely replicated in other NYS municipalities.

The proposed MG project directly promotes the objectives of the NY REV and Renewable Portfolio Standard (RPS). With assistance from the State, Utica community have been empowered to create and implement local strategies for rebuilding and strengthening the community against future extreme weather events. In July 2014, plans were completed in Oneida County impacted by severe flooding in 2013. The approach was focusing first on developing long-term resiliency strategies and actions. Locally driven resiliency plans considered damage, future threats, and economic opportunities.

The proposed MG system will positively contribute to the New York State Renewable Portfolio Standard Policy to increase renewable generation the NYS. The MG system includes a 150 kW solar PV unit and 250kW electric battery storage.

The development of the MG will benefit the economic development of the City of Utica and result in job creation. It is estimated that construction of the MG system in the City of Utica will result in creation of total 211 jobs (141 temporary construction and 70 permanent jobs).

The MG Project Team Members include:

- Project Manager -The Administration of City of Utica, NY, Utica Department of Urban and Economic Development, Urban Renewal Agency, Industrial Development Agency, Engineering Department - potential owner of the MG system.
- County of Oneida, NY- Engineering Department - active participant and potential co-owner of the MG system.

- Bagg's Square Association – active participant and developer of the area where the MG system is located.
- Utica Harbor Point Local Development Corporation – active participant and developer of the area where the MG system is located.
- National Grid - participant and cooperating partner.
- Mohawk Valley Economic Development Growth Enterprises Corporation (EDGE) - a vertically integrated economic development organization that assists businesses to locate sites and infrastructure development in Oneida and Herkimer Counties - project supporter.
- Cornell University Cooperative Extension of Oneida County – project supporter.
- MG customers – end users
- Joseph Technology Corporation – project consultant with extensive experience district energy, involved in development of 25 district energy/CHP systems in the US and overseas.
- Potential Developer/Operator –Cogeneration Power Technologies, Utica and Johnson Controls.

The City of Utica is the focus of regional economic revitalization efforts, most notably in the Bagg's Square and Harbor Point areas. The City Mayor and Common Council of the City direct the City activities. The common council has standing committees will be actively involved in the development of the MG system. Oneida County is a strong, vibrant, and resilient organization.

In the next two years the City is planning to separate the sanitary and storm sewer systems in the proposed MG area. Integrating the installation of the sewer mains with the MG underground infrastructure will result in substantial reduction of the excavation costs for the MG system.

Bagg's Square Association is an active development group dedicated to the revival of the oldest part of the City where the MG customers are located. The Bagg's Square Development is the oldest district in the City and has an old and outdated electric and gas infrastructure, which needs repair and reinforcement. Assessment of MG options is a timely and important undertaking for the City and above listed organizations.

All major MG equipment suppliers are identified and already provided budget estimates for the project. Based on these estimated the project preliminary cost was developed.

The City/County joint venture has substantial financial strength and bonding capacity. The legal advisor on the team is the Corporation Counsel Mr. William M. Borrill. The permits required for the MG system are typical for any construction project, will be issued by the City and will not cause any delays.

The proposed approach for developing, constructing and operating the MG system is as follows. The City economic development department in close cooperation with the Oneida County will be the general advocates and source of information about the MG system. They will educate the customers about the benefits of MG system, articulating and promulgating the vision to build support. The City/County will also engage other public agencies to provide supportive public policy.

The City/County or its agent will actively facilitate the development process. The City/County will create an MG Development Working Group staffed by representatives of the relevant departments, property owners who must connect in order to ensure the project's financial viability. The City/County will be the central point of contact for all of the internal and external stakeholders, and will be the entity to which they turn when they need answers.

The City/County will help to accelerate the MG system development process itself and also facilitate integration of the City's overall infrastructure plan to coordinate improvements to various underground utility services with the MG system. The City/County will continue to play an active role throughout the entire MG development process.

The project engineering consultant will build on the current feasibility study and prepare a comprehensive design that looks at site-specific energy data, specific sites for MG DER unit location options and piping and electric cable underground installation route. The project developer will deliver the physical assets, such as the MG energy system and the distribution system to the owner. The developer will also be the long-term MG system operator and be responsible for the ongoing technical operation and maintenance of the MG system.

The City will also establish and monitor standards of construction, operational performance, safety and pricing/consumer protection, and ensure compliance with standards and other applicable laws. In close cooperation with the MG owner the project developer will secure electric and thermal energy purchase agreements with the MG customers, secure financing, obtain construction permits, solicit construction bids from construction companies (in accordance with approved specifications), supervise the system construction, commissioning and operation of the MG system. The operator will be responsible for efficient operation of the MG system providing energy savings to the MG customers.

The proposed MG CHP system was widely used in cogeneration systems similar to Burrstone CHP system in Utica, NY. The electric and thermal rates will include peak demand, energy consumption, and operation and maintenance components. The rates will include widely accepted annual escalators for fuel, labor and materials. The MG owner will develop a road map for replication of the proposed system to similar communities.

Currently the MG customers own a substantial number of natural gas fired boilers, which will supply intermittent, peaking and back-up thermal loads and leverage the MG development.

The MG system operator will develop annual budget of the MG system including the revenues and expenses. The budget will be reviewed and approved by the owner of the system. The system owner, who will have the ultimate decision making responsibility, will also approve the electric and thermal energy rates. Smart meters integrated in the MG system control and communication system will continuously meter the customer electric and thermal energy peak and consumption. The operator will be responsible for MG system reliability and optimum load dispatch with maximum fuel and cost efficiency.

Legal Viability

The proposed ownership structure has to be approved by City Common Council and County Legislature. The City and the County own the sites where the MG DER's will be installed. The City also owns the streets where the MG hot water piping and electric cables will be installed. The MG system owner will protect the privacy rights of the MG customers. After the approvals, the City/County will select the system developer/operator through a competitive bidding process.

4. Benefit Cost Analysis and Financial Viability

The business model of the project is based on following energy, reliability, environmental and economic development benefits to the MG customers, the community and the utility.

Potential Revenue Streams to the MG Owner

- **Electricity Sales Revenue Stream.** The MG system will allow avoiding purchases of electricity and transmission and distribution services from the electric utility. MG system equipped with CHP units will generate electricity and thermal energy with higher efficiency and fewer emissions than the current system. The MG customers will also avoid electric utility reactive power charges, competitive transition charges or other surcharges. Moreover, addition of fuel-free solar PV unit will benefit the customers from reduced energy market price volatility. The preliminary analysis indicates that the MG system will reduce the total customers current cost of electricity from $738,000 to $590,400 providing about 20% savings. **So the electric revenue stream to the MG owner will be $590,400.**
- **Thermal Energy Sales Revenue Stream.** The extensive district energy experience indicates that the MG customers will benefit from reduction of the total thermal energy cost currently paid for self-generation of thermal energy. Typically the comparison of MG thermal energy cost to individual building cost takes into consideration the potential fuel savings from use of more efficient MG energy generation system. However, the current thermal self-generation cost of the customers contains a number of hidden components, which have to be taking into consideration. The major components of the current on-site self-production cost of useful thermal energy include: boiler plant initial and replacement capital, fuel purchases, boiler seasonal efficiency, operating labor, condensate return system, blow down and sewer, make-up water/water discharge sewer fees, chemical water treatment of make-up water and condensate, equipment repair and maintenance, insurance, inspections/annual recordkeeping, environmental and construction permits and lost building space. Preliminary estimates for the Utica MG customers indicate that the current self-generation cost of thermal energy amounts to $713,256/yr. Assuming that the MG system will provide 20% savings to the customers, **the potential revenue of thermal energy to the MG owner will amount to $570,600/yr.**
- **The power quality improvement to the MG customers is estimated by the Industrial Economics Incorporated (IEC) to be $296,000/yr.**
- **The value of deferred generation capacity is estimated by IEC to be $170,000/yr.**
- **Potential value of reduction of utility electric transmission and distribution losses is estimated by IEC to be $75,000/yr.**
- **The MG will reduce power interruptions and provide reliability cost savings estimated by the IEC to be $45,000/yr.**
- **The value of avoided emission damages is estimated at $100,000/yr.**
- **Additional Potential Revenues of the MG System not estimated at present time may include:** participation in demand response markets, sales of excess power to the utility system and ancillary services, enhanced electricity price elasticity, reduce the cost of meeting the state's renewable energy target, potential sales of thermal energy to neighboring buildings, and economic development and job creation for the City.

Capital Investment Cost of the MG Project

The capital cost of the project includes energy generation equipment, energy storage equipment, energy distribution infrastructure, upgrades to customer existing equipment. The initial investment also includes the following costs: project planning and administration costs, project design, building and environmental permits, efforts to secure financing, marketing the project and negotiating and administering customer contracts.

The total investment cost of the MG project is estimated at $13,040,000. The MG system capital cost will be reduced by the NYSERDA CHP system incentive of $972,000 and Solar PV NYSERDA incentive and Federal Income Tax Credit of $180,000. Total initial capital cost of the MG system will be $13,040,000- $972,000-$180,000=**$11,888,000**.

Annual Expenditures

- **Capital Carrying Charges.** The annual capital carrying charges of the capital cost of $ 11,888,000 (using municipal financing with interest rate of 4% for 20 years the capital recovery factor of 0.0736) are estimated to be **$874,957/yr.**
- **Fuel Cost.** Fuel cost for the DER electric generating units at fuel cost of $6.34/MMBtu (IEC recommended) is estimated to be **$488,453.**Our experience with district energy systems indicates that by coagulating the customers into one system it is possible to negotiate a lower price of natural gas.
- **Labor Cost.** Labor cost of four (4) operators at $80,000/yr is estimated to be **$320,000/yr.**
- **Operating and Maintenance Cost.** The vendors of the DERs offered service maintenance contracts at $0.015/kWh. At this unit cost the vendor's maintenance contracts will amount to $102,733. For our analysis this O&M cost was doubled to **$205,466.**

All the above outlined revenue streams and expenses are summarized in Table S-3.

The IEC and the Contractor benefit cost analysis results indicate that if there were no major power outages over the 20-year period, the MG project's costs would exceed its benefits. The IEC used the emission rate of 0.0808 tons/MWh for the MG CHP system erroneously provided by the Contractor. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 4.8 days per year.

Using the corrected input for the CO_2 marginal emission rate the Contractor revised the benefit cost analysis using the IEC computer program. The results indicate that if there were no major power outages over the 20-year period analyzed, the project's costs would exceed its benefits by smaller amount than estimated by IEC (see Section 5). In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 1.55 days per year (Contractor estimates).

Conclusions

- The MG system will supply continuously electricity and hot water to the community critical customers.
- It is technically feasible to construct an energy efficient and environmentally clean community MG system in the City of Utica.
- The IEC and the Contractor benefit cost analysis results indicate that if there were no major power outages over the 20-year period, the MG 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 4.8 days per year (IEC estimates) or 1.55 days per year (Contractor estimates).
- It is recommended to develop methodology for adding to the MG system cost benefits the monetized value of associated economic development and job creation for the community.
- It is recommended that the City of Utica and the Oneida County will be the combined owner of the MG system. After the approvals, the City/County will select the system developer/operator through a competitive bidding process.
- It is recommended to proceed to the detailed design - Stage 2 of the project.

The major barriers to implementation of the MG system that needs to be overcome are:

- Obtaining close cooperation of the electric utility and engage them as a partner. The utility has to provide points of common coupling of the MG system with the existing utility feeders, provide a permit for interconnection of the MG system to the utility feeders at points of common coupling, interconnect and interface the control and communication systems of the

Table S-3: Preliminary Benefit to Cost Ratio Estimates

Cost Component	Parameters and Cost
Key System Parameters	
system electric peak,kW	1,761
MG installed electric capacity,kW	2,490
CHP plant electric capacity,kW	670
non-CHP plant electric capacity,kW	1,408
total annual electric generation,kWh/yr	6,848,877
electric generation by CHP plant,kWh/yr	5,821,545
electric generation by non-CHP plant,kWh/yr	1,027,332
heat rate of CHP unit,MBtu/kWh	3,187
heat rate of non-CHP units,MBtu/kWh	3,869
heat recovery of CHP unit,MMBtu/hr	1,408
operating hours of CHP units,hr/yr	8,689
operating hours of non-CHP units	642
system peak heat load, mmbtu/hr	13
CHP plant thermal capacity,MBtu/hr	2.82
total existing boilers thermal capacity,MMBtu/hr	22.80
annual useful heat consumption,mmbtu/yr	17,831
annual useful heat production by CHP units,mmbtu/hr	5,632
annual useful heat production by boilers	12,199
maintenance cost for boiler plant , $/mmbtu/hr	700
maintenance cost for MG district piping and cable, $/foot-year	1.0
cost of electricity for boiler plant, $/mmbtu/hr	2,160
cost of water and sewer for boiler plant, $/mmbtu/hr	160
water treatment cost for boiler plant,$/mmbtu/hr	450
cost of natural gas for the MG plant, $/mmbtu	6.34
total natural gas consumption by the MG palnt,MMBtu/yr	77,043
capital cost of the MG system,$	13,040,000
NYSERDA and Federal incentives,$	1,152,000
final capital cost of MG system$	11,888,000
capital recovery factor at 4% for 20 years	0.0736
MG Energy Production Cost	
Fixed Costs:	
annual capital carrying cost of MG system,$	874,957
insurance @ 0.5 %,$	59,440
labor cost, $	320,000
maintenance cost for MG plants,$	205,466
maintenance cost for boiler plant,$	14,210
maintenance cost for district piping and cable,$	5,000
Variable Costs:	
fuel cost for the MG plant,$/yr	488,453
electric cost for boiler plant,$	28,080
water and sewer cost for boiler plant,$	2,080
water treatment cost for boiler plant, $	5,850
Total MG system annual production cost,$/yr	**2,003,536**
MG electric energy revenue,$/yr	590,400
MG thermal energy revenue,$/yr	570,600
power quality improvements,$/yr	296,000
MG avoided emission demages,$/yr	100,000
MG generation capacity cost savings,$/yr	170,000
MG distribution capacity cost savings,$/yr	75,000
MG reliability cost savings,$/yr	45,000
Total MG system benefits,$/yr	**1,847,000**
Benefit/Cost Ratio	**0.92**

utility and the MG, cooperate in utilizing the MG system demand response and ancillary capabilities.

- Limited experience of the City/County with development of community energy systems. This barrier will be overcome during the second stage of the project by demonstrating to the City, County and community at-large of the benefits of the MG system.
- Uncertainty of the potential regulation by the PSC of electric sales by the MG owner to its customers. It is assumed the PSC will clarify this issue by the time the MG system should be constructed. The MG hot water district heating system is not subject to regulation in the New York State.
- It is not clear how the estimated potential monetary benefits (except for energy efficiency benefits) will be recognized by the MG owner".
- In their comments on the feasibility study the National Grid (NG) has indicated that at this time no expenditures are planned in the area of the MG and that the estimated costs of building the MG electric and thermal system seems low. These costs will be refined in the Stage 2 project.
- In discussions with NG the project team clarified that the electric interconnections between MG customers will not be installed in the existing conduit.
- NG indicated that in order to operate the MG in parallel mode the existing electric distribution system will have to be converted to a radial feed system. This topic will be investigated in detail during Stage 2 project.
- National Grid indicated that sale/delivery of electricity by the MG is a problem because it violates franchise rights and will require special permission. This topic will be addressed during Stage 2 project.
- National Grid indicated that the 4.8 outages needed for a BCA of 1 - not likely to happen and they are not sure how cost recovery would work. It should be noted that the Contractor analysis indicated the outage rate of 1.55.

Section 1
Introduction

The goal of the project was to study the feasibility of building and operating a community Microgrid (MG) system for the purpose of maintaining electric and thermal services for the participating customers/facilities and the community at large at the City of Utica, NY at times when weather events or other emergencies severely disrupt the capacity of the local distribution and transmission system to serve essential customer needs.

The proposed project is located in the economically depressed areas of the City of Utica, Oneida County. Of the 62 New York counties, Oneida County per capita income is about 50% of the average NYS income. The 2010 U. S. Census lists Oneida County with a poverty rate of 14.9%, whereas NYS is 14.2%.The unemployment rate for Oneida County according to the NYS Department of labor in 2012 was 10.1%, whereas NYS was 8.8%. Currently about 10% end-users are using electric resistance systems for space heating and domestic hot water.

The project team includes the following organizations: the administration of City of Utica, NY (Project Manager), Utica Department of Urban and Economic Development, Urban Renewal Agency, Industrial Development Agency, the Oneida County, National Grid, Baggs Square Association, Harbor Point Local Development Corporation, Mohawk Valley Economic Development Growth Enterprises Corporation (EDGE), Cornell University Cooperative Extension Oneida County, end energy users and Joseph Technology Corporation(engineering consultant).

The major critical facilities comprising the MG include the City Court House, Police Station, Memorial Auditorium, Train Station, Federal Office Building, Observer-Dispatch Newspaper building.The development of the MG system is of prime importance to the wellbeing of the City. Historic quality and reliability of electric supply to the City is influenced by a major bottleneck in the New York transmission system between Utica and Hudson Valley areas. This congestion first appeared in the mid-1990s and has been increasing over the past 20 years as demand has grown.US DOE studies have repeatedly identified congestion in New York as a national concern. DOE designated this area as one of only two areas in the country that are Critical Congestion Areas – it's most severe designation.

With assistance from the State, Utica community have been empowered to create and implement local strategies for rebuilding and strengthening their communities against future extreme weather events. In July 2014, plans were completed in Oneida County impacted by severe flooding in 2013. The approach is focusing first on developing long-term resiliency strategies and actions. Locally-driven resiliency plans considered current damage, future threats, and economic opportunities.

The winters in Utica are very cold and snowy, as the area is susceptible to Lake Snow effect. For example, in 2011, a powerful ice storm struck Utica area. A dense layer of cold air coupled with heavy rain created ice accumulations in excess of three inches. The storm dumped freezing rain on the region for an unprecedented 5 days. Flooding from heavy rains and significant runoff from melting snow forced the evacuation of many homes and caused widespread damage across the region.

The feasibility study report presents the results of the following tasks:

- Development of MG capability
- Preliminary MG technical design and configuration
- MG commercial and financial feasibility
- Benefit-cost analysis.

Section 2
Development of Microgrid Capabilities

The project team identified 13 critical customers dispersed within the City within a maximum distance of two (2) miles. The critical customers are clustered within two (2) groups: one downtown group of commercial customers is located south of the major railroad truck system crossing the city, and the second group of industrial customers is located to the north of the railroad truck system (Figure 2-1). The project team visited and surveyed all critical customers, obtained information on their operation, existing equipment, electric and thermal consumption and loads and available back-up electric equipment.

The project team in close cooperation with the NYSERDA Project Manager decided to select for feasibility analysis the downtown group of critical customers forming a continuous MG (Figure 2-2). This MG includes customers providing essential services to the community and must be in operation during any emergency situation (Table 2-1). Table 2-2 presents the MG customers current energy use and back-up capacity.

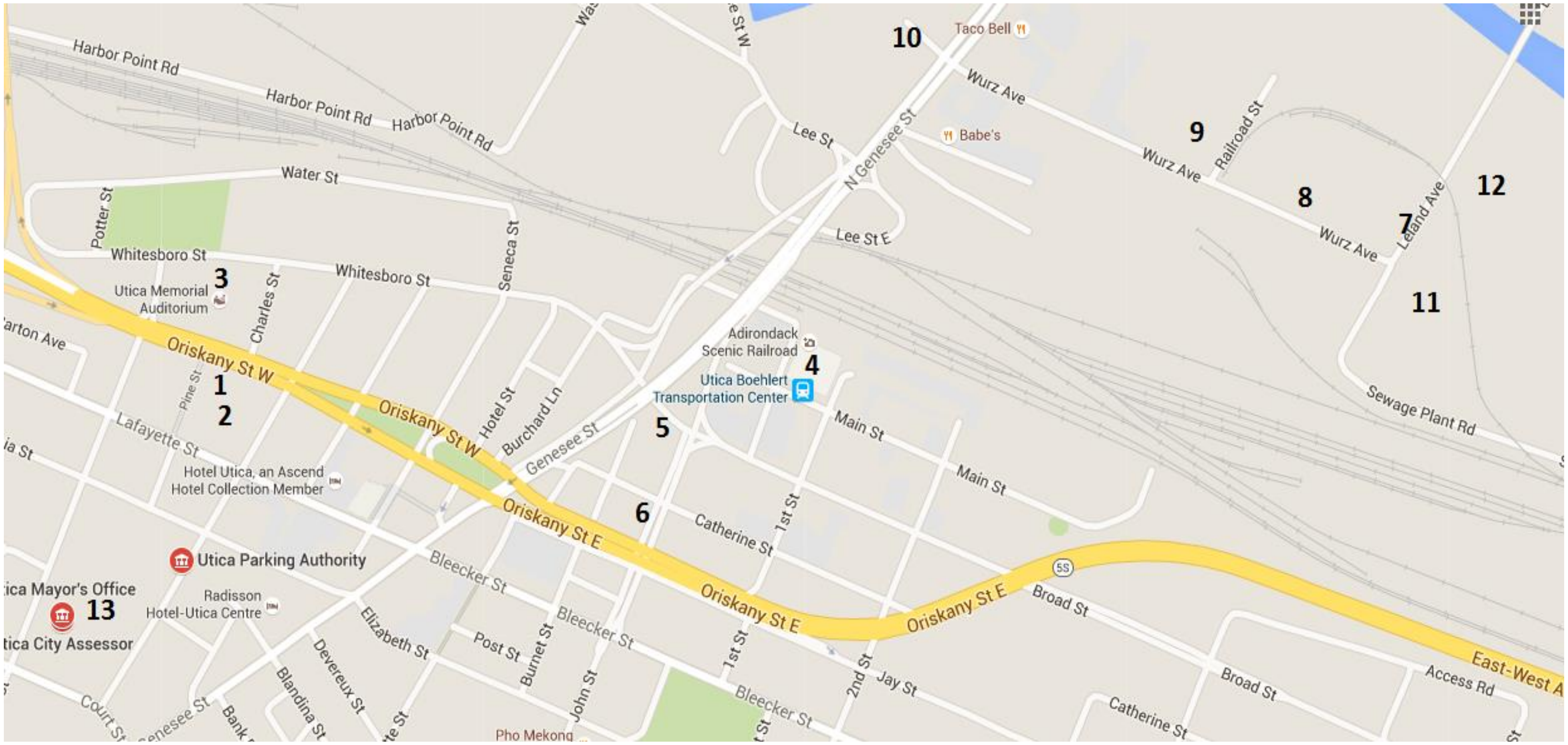
Table 2-1: Impact of MG Critical Facilities on the City of Utica Operation

No.	Name of Critical Facility	Shut-down of Electric and Heat Service in Emergency Situations
1	City Court House	Reduce the capabilities of maintaining public order and crime fighting
2	City Police Station	
3	Memorial Auditorium	Shut down the potential public shelter
4	Boehlert Train Station	Disrupt the regional train operation
5	Federal Building	Disrupt the operation of local federal authority
6	Observer-Dispatch Newspaper	Disrupt the regional newspaper operation

Table 2-2: Microgrid Customers Current Energy Use and Back-up Capacity

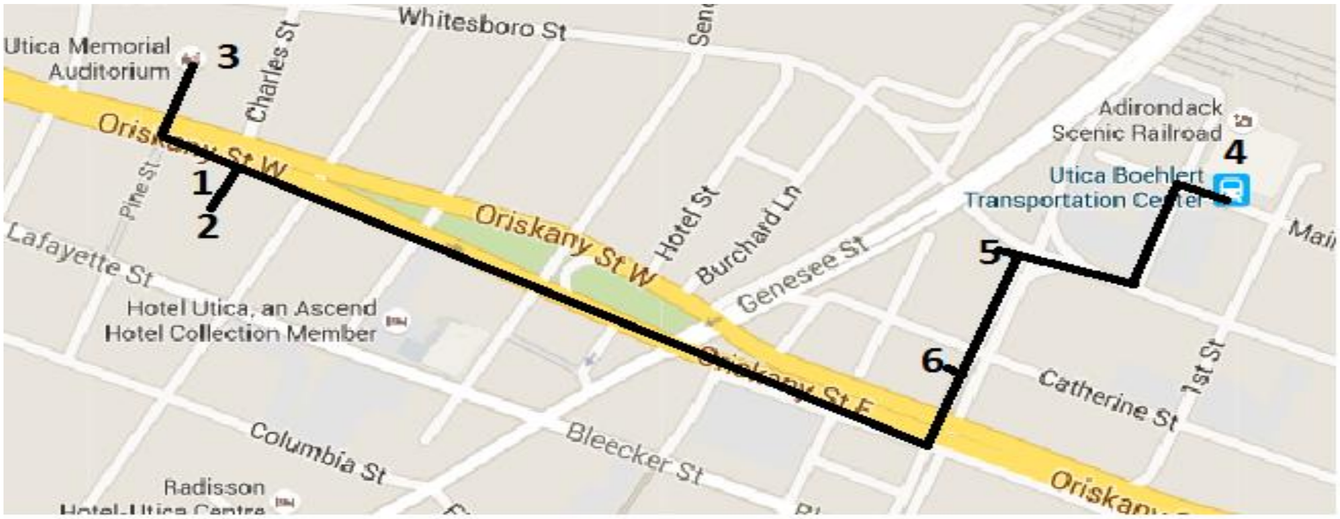
No.	Name of Customers	Address	Area,sq.ft	Electric Peak,kW	Electric Consumption, kWh	Gas Consumption, MMBtu	Existing Back-up Generation
1	City Court House	200 Elizabeth Street	36,634	404	1,324,914	9,804	100kW Gas Fired
							by Kohler
2	City Police Station	413 Oriskany Street	30,000	Comb.w/Court	Comb.w/Court	Comb.w/Court	
3	Memorial Auditorium	400 Oriskany Street	62,340	687	3,017,882	6,234	250kW Gas Fired
							by Cummins
4	Boehlert Train Station	321 Main Street	115,704	255	1,293,900	6,891	57kW+15kW gas
							Fired, Onon
5	Federal Building	10 Broad Street	77,637	267	562,500	3,631	
6	Observer-Dispatch Newspaper	221 Oriskany Plaza	47,318	148	649,681	3,159	
		Total	**369,633**	**1,761**	**6,848,877**	**29,719**	

Figure 2-1: Location of all Critical Facilities in the City of Utica, NY



1-City Court House. 2-City Police Station. 3-Memorial Auditorium. 4-Bohlert Train Station. 5-Federal Building. 6-Observer-Dispatch Newspaper. 7-CENTRO. 8-Fuel Tank Farm. 9-DPW Garage. 10-NYS Canal Corporation. 11-Sewage Waste Treatment Plant. 12-Oneida-Herkimer Solid Waste Authority. 13-City Hall.

Figure 2-2: Location of Microgrid Customers in the City of Utica, NY



1-City Court House; 2-City Police Station; 3-Memorial Auditorium; 4-Boehlet Train Station; 5-Federal Building; 6-Observer-Dispatch Newspaper

The selected MG will:

- Serve multiple physically separated critical facilities located in relatively close proximity and forming a separate island.
- The MG primary generation source will be CHP and DG facilities.
- The combination of generation resources will provide MG on-site power in both grid-connected and islanded mode.
- Will be able to automatically separate from grid on loss of NG utility service and restore to grid after normal power is restored.
- Comply with manufacturer's requirements for scheduled maintenance intervals for all generation.
- Provide power to a diverse group of critical facilities connected directly to the microgrid.
- Include an uninterruptible fuel supply or minimum of one (1) week of fuel supply on-site.
- Have black-start capability.

The MG should include the following preferred capabilities:

- Integrate and demonstrate operation of advanced, innovative technologies that enable customer interaction with the grid such as, MG Logic Controllers, Smart Grid Technologies, Smart Meters, Distribution Automation, Phasor Measurement Units (PMU), providing distributed measurements throughout the MG and its functionality in smart protective relays, voltage regulators, reclosers, and meters, Energy Storage and Communication Devices with the Utility Grid and within the MG system.

- An active network control system that optimizes demand, supply and other network operation functions within the MG. The network control system should have the ability to optimize and balance electrical demand with sources, schedule the dispatch the resources, provide synchronization and Volt/VAR/frequency controls, preserve grid reliability and cybersecurity, interact with, connect to, and disconnect from the utility grid, provide ancillary services (grid-connected, real-power-related, and reactive-power-related),black start, user interface and data management, two-way communication, supervisory control and data acquisition (SCADA), and have interoperability in order to improve the grid’s power quality and resilience, while reducing overall cost.

- Include energy efficiency and demand response options to minimize MG generation requirements. Meeting end-user needs by ensuring uninterruptable power supply (UPS) for critical loads, controlling power quality, reliability, and promoting customer participation through demand-side management and community involvement in electricity supply.

- Address operation, maintenance and communications for the NG electric system to which the MG will be interconnected (e.g., underground networks, overhead loops, and radial overhead systems).

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

- Take account of a comprehensive cost/benefit analysis that includes the community, utility and potential developer’s perspective.

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

- 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. Enhancing the integration of distributed energy resources that help to reduce carbon emissions, peak load congestion, and line losses by locating generation near demand.

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

- 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. The MG will improve the resilience of the electric distribution infrastructure, defer generation, transmission, and distribution investments.

- Support power quality enhancements for connected loads, improve reliability for critical loads.

- Provide outage management, balances distributed and central control, enable price-driven demand response, and reduce peak loads for the interconnected grid,

Description of Energy Systems of the MG Customers

1. City Court

The City Court has an emergency 100 kW generator operating on gas. Maintenance is provided by Kohler Power Systems. The generator is tested every week. The generator also serves the adjacent police station.

Heating is provided by 2 (two) hot water boilers manufactured by Teledyne Lars (Canada).The boilers fire natural gas and each boiler input is 850,000 Btu/hr. No oil back-up is available. There is one gas fired DHW tank 90 gal. Service is provided by Kinsley Power Systems.

Cooling is provided by 3(three) McQuay (same size) units installed in 2002 with R-22 in the basement. The units serve each court room. EVAPCO cooling tower is located outside the building on the ground.

The Court has a common electric service with the collocated Police Station. Hot water from the Court plant is also supplied to the Police Station. In the building there are about 50 people. The electric and gas consumption and cost are provided in Tables 2-3 and 2-4.

Table 2-3: City Court Electric Consumption and Cost

Month	Consumpt. kWh	Peak, kW	Total Cost,$
Jan.	98,445	251	13,651
Feb	100,455	251	9,947
Mar	89,400	214	9,206
Apr	98,102	351	9,714
May	115,622	307	11,906
Jun	137,989	383	14,397
Jul	137,769	404	19,617
Aug	137,713	349	14,181
Sep	105,679	367	13,032
Oct	101,898	336	8,701
Nov	105,513	251	10,448
Dec	96,329	251	13,357
Total	1,324,914		148,156

Table 2-4: City Court Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan.	1,311	4,983
Feb	1,821	6,919
Mar	1,579	6,000
Apr	1,164	4,423
May	163	619
Jun	23	87
Jul	29	110
Aug	17	65
Sep	63	239
Oct	541	2,056
Nov	1,265	4,807
Dec	1,828	6,946
Total	9,804	37,256

2. Police Station

Constructed in 1924.The building has a common electric service with the Court building. The building is provided with a Schlamberger electric meter and transfer switch. The facility has McQuay heat/cooling units and more than 50 pumps. The domestic hot water is supplied from a gas fired a 500 gal tank.

The Police also has a separate car garage supplied with electric service from Police Station. The Garage has its own small gas fired heating unit.

3. Utica Memorial Auditorium (UMA)

The Utica Memorial Auditorium (UMA) was built by the City of Utica in 1959 on the site of the old Erie Canal on land donated by the State of New York. The building occupies 62,340 sq.ft. The City operated the Auditorium from 1960 until 1996. In 1996, the UMA, was sold to the Upper Mohawk Valley Memorial Auditorium Authority (UMVMAA), which operates the facility. The UMVMAA was created by the New York State Legislature in 1996 to own and operate the Utica Memorial Auditorium. The Authority is comprised of seven local residents, three of whom are appointed by the Oneida County Executive and four by the county legislature. The UMA continues to be a premiere entertainment facility of the City.

The building has a complex energy and utility system including heating, cooling, humidification control, lights, environmental control, fire/life safety, water, telephone systems and communication lines to the main arena area and to individual ancillary spaces. All systems are flexible, since the building income is dependent on the time it takes to change from one function to the next. The building also has a restaurant, food courts, concession stands, sport stores, visiting team lockers, training rooms, TV and radio broadcasting studios.

The building uses multiple air-handling units supplied from a central hot/chilled water plant to serve the wide HVAC load variations. The variable air volume (VAV) system is equipped with multiple speed fans, with provision for operating with 100% outdoor air. The office and restaurant spaces operate at higher and differing hours from the main arena and are supplied by separate individual air-handlers. The building has two (2) x100 HP hot water boilers manufactured by Clever Brook and two (2) x 150 ton Carrier chillers.

To reduce the use of outdoor air, excess air from the main arena is introduced, with some reheat or precooling to maintain locker room temperature from being too hot or cold. To maintain air balance, locker rooms have separate supply and exhaust systems. The building has radiant heating coils in the seating area floor slabs and infrared radiant heating panels above the seating areas. The building has hot water perimeter heating, and dehumidified air movement across the glass area to avoid fogging.

Hot water is used for food preparation, cleanup, locker room showers, and rest rooms. The peak usage occurs during the cleanup period, typically soon after opening and immediately prior to closing. Hot water consumption varies significantly among individual facilities. Most water heating is done separately from the building heating system.

The building sport arena includes ice hockey rink. The ice surface for hockey events sizably reduces the sensible and latent load, and poses difficult problems of fog and condensation on interior surfaces. The refrigeration system is a major energy consumer, when the rink ice is being made or maintained. The ice temperature needed for hockey is 22°F and for curling 24°F. A separate rink defogging system is used to dehumidify the air, as increased ventilation tends to worsen the conditions when outdoor conditions are humid.

The lighting design over the rink is flexible for rink use and non-use. Since the arena is also used for concerts the facility has dimming light capabilities. His is accomplished by multiple lighting circuits to allow selective on/off switching of the above lighting.

The facility has a back-up 250kW Cummins generator fired by natural gas. The current electric and gas consumption and cost are provided in Tables 2-5 and 2-6.

Table 2-5: UMA Electric Consumption and Cost

Month	Consumpt. kWh	Peak, kW	Total Cost,$
Jan	259,507	437	27,807
Feb	246,820	429	24,726
Mar	238,740	424	25,626
Apr	230,510	437	25,991
May	223,476	512	24,330
Jun	269,513	635	29,318
Jul	310,874	637	36,653
Aug	297,838	687	32,982
Sep	234,867	615	27,225
Oct	186,962	513	23,415
Nov	254,991	449	25,641
Dec	263,784	420	28,253
Total	**3,017,882**		**331,967**

Table 2-6: UMA Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan	1,114	4,069
Feb	1,132	4,556
Mar	1,266	5,013
Apr	1,161	4,817
May	467	2,136
June	42	262
July	12	34
Aug	8	33
Sept	10	43
Oct	15	78
Nov	165	156
Dec	842	2,492
Total	**6,234**	**23,689**

4. Utica Boehlert Transportation Center

Building is under jurisdiction of Mark Laramie- Deputy Commissioner of Oneida County DPW Division of Engineering. The building occupies 115,704 sq.ft and is on historic register and is a REA building. The building has a gas fired 57 kW back-up generator manufactured by Cummins NorthEast ONON 2005, 208 V.

The building heating is by 2x3,100,000 Btu/hr (input) /2,400,000 (output) Btu/hr Smith Cast Iron steam boilers,1982 vintage. There are four (4) system loops: 2 hot water loops and 2 chilled water loops, and 2 HW and 2 CW pumps. There is a side walk ice melting loop in front of the building. In the boiler room they have a small additional 15 kW generator; it is the lowest elevation in the building. They have four (4) Air Handlers and 2x10 HP pumps.

In the main hall there are multiple heating units installed under the benches, and perimeter convectors and old radiators. There is one (1) chiller and a variable air volume (VAV) system.

Electric supply is very poor; they lose power for about four (4) hours at the time almost every month.

Basement is flooded with water after major rains; the water is 80 cm deep. Have about 15 sump pumps ½ HP each.

Have some space available on the roof for solar panels but they are part of the County solar farm installation and do not want to lose the credit for after the meter solar panels.

The current electric and gas consumption and cost are provided in Tables 2-7 and 2-8.

Figure 2-7: Train Station Electric Consumption and Cost

Month	**Consumpt. kWh**	**Peak,kW**	**Total Cost,$**
Jan	132,300	234	12,566
Feb	121,800	222	10,164
Mar	119,400	225	11,341
Apr	106,800	225	10,330
May	86,700	204	8,144
Jun	86,700	**255**	9,046
Jul	105,000	222	13,161
Aug	108,900	222	10,533
Sep	82,200	237	8,888
Oct	86,700	222	8,144
Nov	123,000	210	10,264
Dec	134,400	213	12,766
Total	**1,293,900**		**125,348**

Table 2-8: Train Station Gas Consumption and Cost

Month	Consump. MMBtu	Cost Delivery,$
Jan.	1,396	1,595
Feb	1,187	1,698
Mar	983	1,323
Apr	538	986
May	516	385
Jun	0	365
Jul	1	365
Aug	0	365
Sep	1	370
Oct	121	374
Nov	919	1,334
Dec	1,228	1,815
Total	**6,891**	**10,975**

5. Federal Building

The building has 3x1,200,000 Btu/hr Smith Cast Iron steam boilers supplying 3 heat exchangers on the top of the boilers. The heat exchangers supply hot water through the building. On the coldest day need only one boiler. Blowdown goes in the drain. The boilers fire natural gas and have no back-up. They have 1(one) DHW heater Bradford White Ultra High Eff 60-90 gal and 1 (one) 135 gal water tank.

They have no emergency generator but considering a 200kW generator. The current electric and gas consumption and cost are provided in Tables 2-9 and 2-10.

Table 2-9: Federal Building Electric Consumption and Cost

Month	Consumpt. kWh	Peak, kW	Total Cost,$
Jan.	36,600	123	4,026
Feb	36,600	123	4,026
Mar	36,300	123	3,993
Apr	39,900	132	4,389
May	43,800	168	4,818
Jun	60,000	240	6,600
Jul	74,700	267	8,217
Aug	66,600	225	7,326
Sep	47,400	234	5,214
Oct	41,100	147	4,521
Nov	41,100	147	4,521
Dec	38,400	123	4,224
Total	**562,500**		**61,875**

Table 2-10: Federal Building Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan.	684	3,387
Feb	801	3,844
Mar	535	2,962
Apr	209	1,743
May	26	264
Jun	16	108
Jul	10	90
Aug	11	85
Sep	42	233
Oct	127	627
Nov	470	2,230
Dec	701	4,569
Total	**3,631**	**20,141**

6. OBSERVER-DISPATCH NEWSPAPER

The building occupies 47,318 sq.ft and has 3 stories plus penthouse and basement. In this building they do only the newspaper editing, the printing is done in Syracuse. The building has one (1) HW boiler on the second floor, McLain 3,780,000 Btu/hr gas no oil, and one on the third floor (PENCO 800 lb/hr).Gas supply is by National Grid and Integrys, used to be Hess. The building has a variable air volume (VAV) system. The computer room has an APC battery that serves only the room. The comfort heat and cooling by a LIEBER Unit. The building has one chiller 143 ton, 208V 3 phase, located on the third floor. The building has no back-up generator, have a disaster plan. The current electric and gas consumption and cost are provided in Tables 2-11 and 2-12.

Table 2-11: Newspaper Building Electric Consumption and Cost

Month	Consumpt. kWh	Peak,kW	Total Cost,$
Jan.	46,653	80	5,132
Feb	46,615	84	5,128
Mar	42,604	76	4,686
Apr	44,768	80	4,924
May	54,959	140	6,045
Jun	65,990	140	7,259
Jul	65,971	148	7,257
Aug	71,892	140	7,908
Sep	65,154	144	7,167
Oct	51,162	144	5,628
Nov	47,702	92	5,247
Dec	46,211	84	5,083
Total	649,681		71,465

Table 2-12: Newspaper Building Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan.	548	3,173
Feb	585	3,331
Mar	431	2,626
Apr	279	1,514
May	33	244
Jun	76	663
Jul	34	272
Aug	31	220
Sep	60	349
Oct	187	1,005
Nov	410	2,190
Dec	484	2,925
Total	3,159	18,512

Section 3
Preliminary Technical Design Costs and Configuration

Load Characterization

The proposed MG system includes six customers: the City Court House, the City Police Station, the Memorial Auditorium, the Boehlert Transportation Center, the Federal Building and Observer-Dispatch Newspaper (Figure 2-2). The City Court and the Police Station are adjacent buildings and have a common electric service. The hot water boilers located in the basement of the Court House also supply with hot water the Police Station. The customers are located in two clusters to be connected with electric cables and hot water piping. The MG will supply with electricity and thermal energy all six customers.

Tables 3-1 and 3-2 present the combined monthly electric and thermal loads for two clusters of customers comprising the entire MG. Table 3-3 presents the combined monthly electric and thermal loads for the entire MG.

Table 3-1: Current Electric and Gas Consumption and Cost for City Court House, City Police Station, and Memorial Auditorium

Month	Consumpt. kWh	Peak,kW	Total Cost,$
Jan.	322,682	677	44,237
Feb	329,271	677	32,235
Mar	293,035	579	29,833
Apr	321,558	949	31,480
May	378,985	828	38,583
Jun	452,300	1,033	46,655
Jul	451,578	1,091	63,571
Aug	451,395	943	45,955
Sep	346,394	990	42,231
Oct	334,001	907	28,197
Nov	345,850	677	33,858
Dec	315,747	677	43,286
Total	**4,342,796**		**480,123**

Month	Consumpt. MMBtu	Total Cost,$
Jan.	2,145	9,923
Feb	2,979	12,224
Mar	2,583	9,467
Apr	1,904	8,949
May	267	1,107
Jun	38	138
Jul	47	214
Aug	28	124
Sep	103	378
Oct	885	3,346
Nov	2,069	7,854
Dec	2,990	10,960
Total	**16,038**	**64,684**

Table 3-2: Combined Electric and Gas Information for the Train Station, Federal Building and Observer-Dispatch Newspaper Building

Month	Consumpt. kWh	Peak,kW	Total Cost,$
Jan	215,553	437	21,724
Feb	205,015	429	19,317
Mar	198,304	424	20,021
Apr	191,468	437	19,644
May	185,459	512	19,008
Jun	212,690	635	22,905
Jul	245,671	637	28,635
Aug	247,392	587	25,767
Sep	194,754	615	21,269
Oct	178,962	513	18,293
Nov	211,802	449	20,032
Dec	219,011	420	22,073
Total	**2,506,081**		**258,688**

Month	Consumpt. MMBtu	Cost,$
Jan	2,628	8,155
Feb	2,574	8,874
Mar	1,948	6,911
Apr	1,025	4,243
May	576	892
Jun	93	1,136
Jul	46	727
Aug	42	670
Sep	103	952
Oct	435	2,006
Nov	1,799	5,755
Dec	2,414	9,308
Total	**13,681**	**49,628**

Table 3-3: Current Combined Electric and Gas Consumption and Cost for all MG Customers

Month	Consumpt. kWh	Peak,kW	Total Cost,$
Jan	538,235	1,114	65,961
Feb	534,286	1,106	51,553
Mar	491,339	1,003	49,853
Apr	513,026	1,386	51,124
May	564,444	1,340	57,591
Jun	664,990	1,668	69,561
Jul	697,249	1,728	92,206
Aug	698,787	1,530	71,722
Sep	541,148	1,605	63,500
Oct	512,963	1,420	46,490
Nov	557,652	1,126	53,890
Dec	534,758	1,097	65,359
Total	**6,848,877**		**738,811**

Month	Consumpt. MMBtu	Total Cost,$
Jan.	4,773	18,078
Feb	5,552	21,098
Mar	4,531	16,378
Apr	2,930	13,191
May	842	1,999
Jun	130	1,274
Jul	93	941
Aug	70	794
Sep	206	1,329
Oct	1,320	5,352
Nov	3,868	13,608
Dec	5,404	20,269
Total	**29,720**	**114,312**

Figures 3-1 and 3-2 present the annual electric load duration curves for two clusters of customers. Figure 3-3 presents the combined MG annual electric load duration curve for six customers comprising the entire MG. The load duration curves were constructed based on interval and monthly electric meter readings obtained from the National Grid for the six customers.

Figure 3-1: Combined Electric Load Duration Curve for City Court House, City Police Station, and Memorial Auditorium

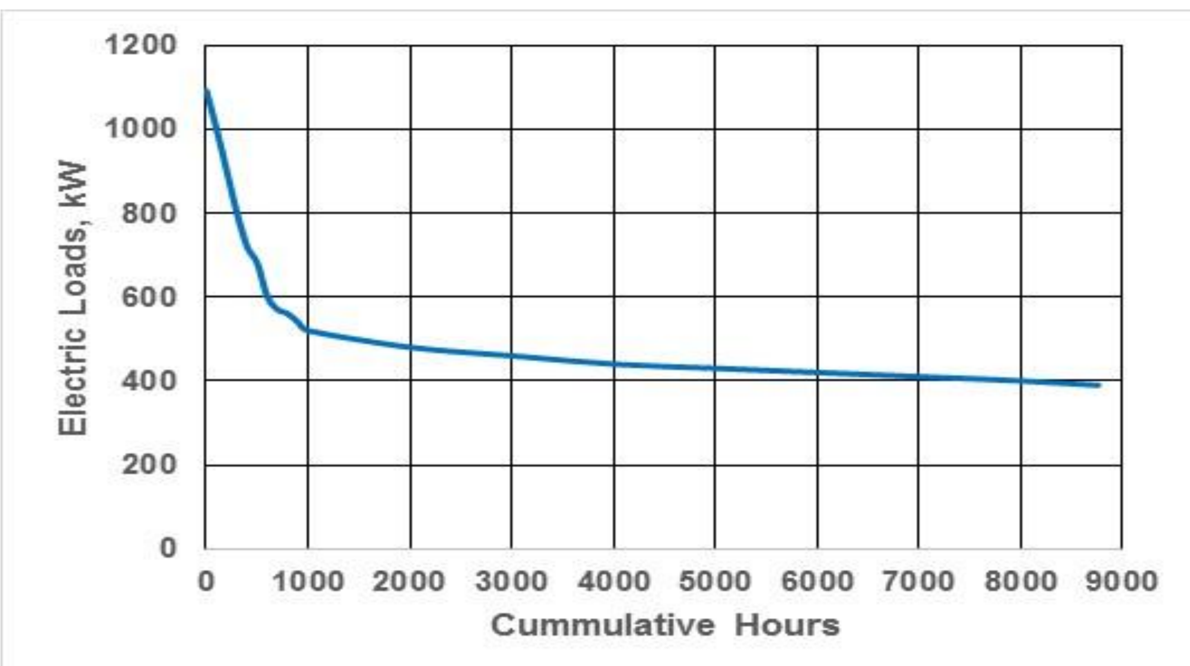


Figure 3-2: Combined Electric Load Duration Curve for the Train Station, Federal Building and Observer-Dispatch Newspaper Building

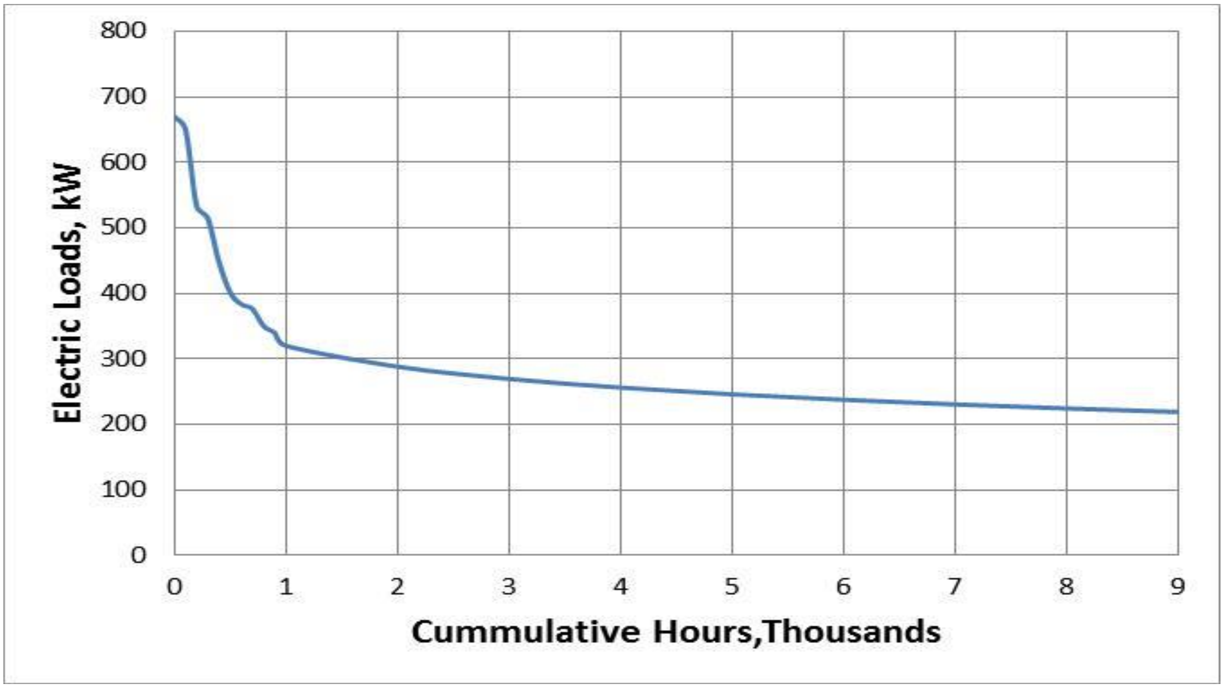
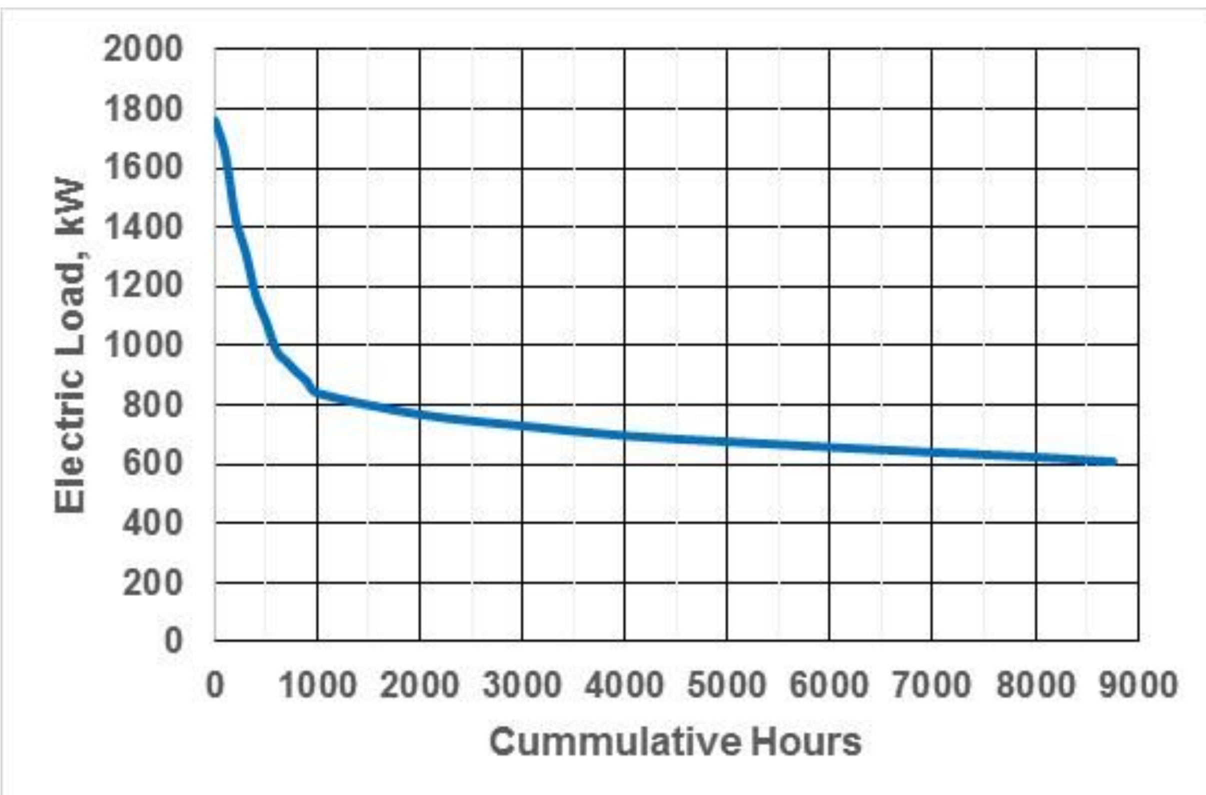


Figure 3-3: Combined Annual Electric Load Duration Curve for the MG six customers



The combined MG thermal load duration curves for the two clusters of customers and the entire MG are presented in Figures 3-4, 3-5 and 3-6. The thermal load duration curves were constructed based on the monthly gas bills obtained from the MG customers and the annual outdoor temperatures recorded for Utica.

Figure 3-4: Combined Thermal Load Duration Curve for City Court House, City Police Station, and Memorial auditorium,

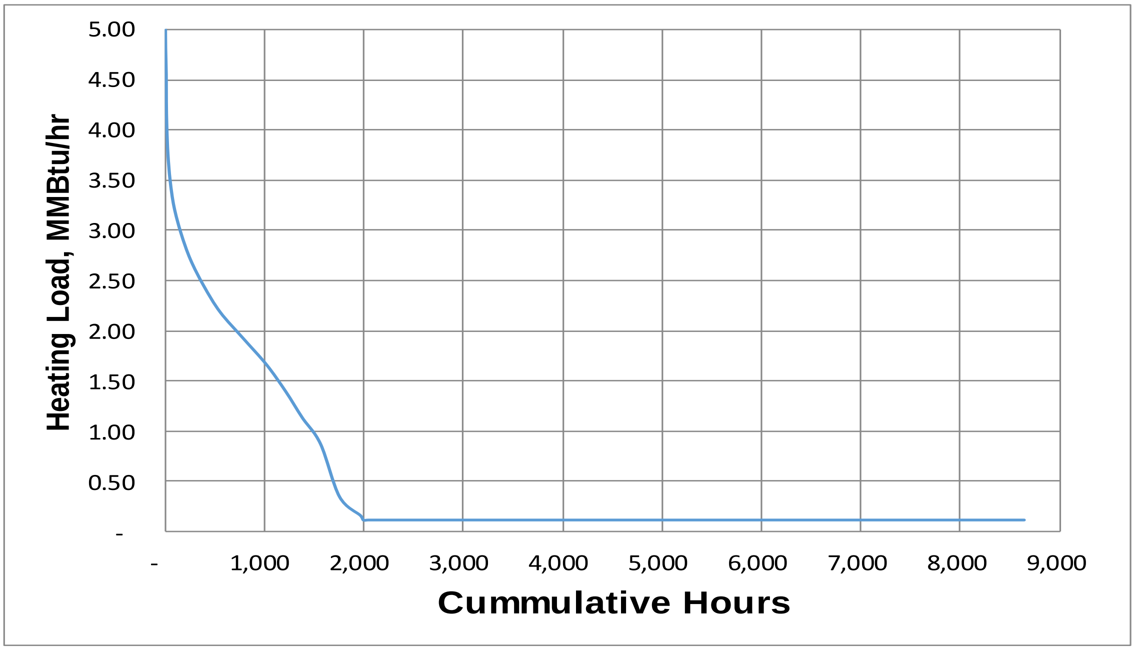


Table 3-5: Combined Thermal Load Duration Curve for the Train Station, Federal Building and Observer-Dispatch Newspaper Building

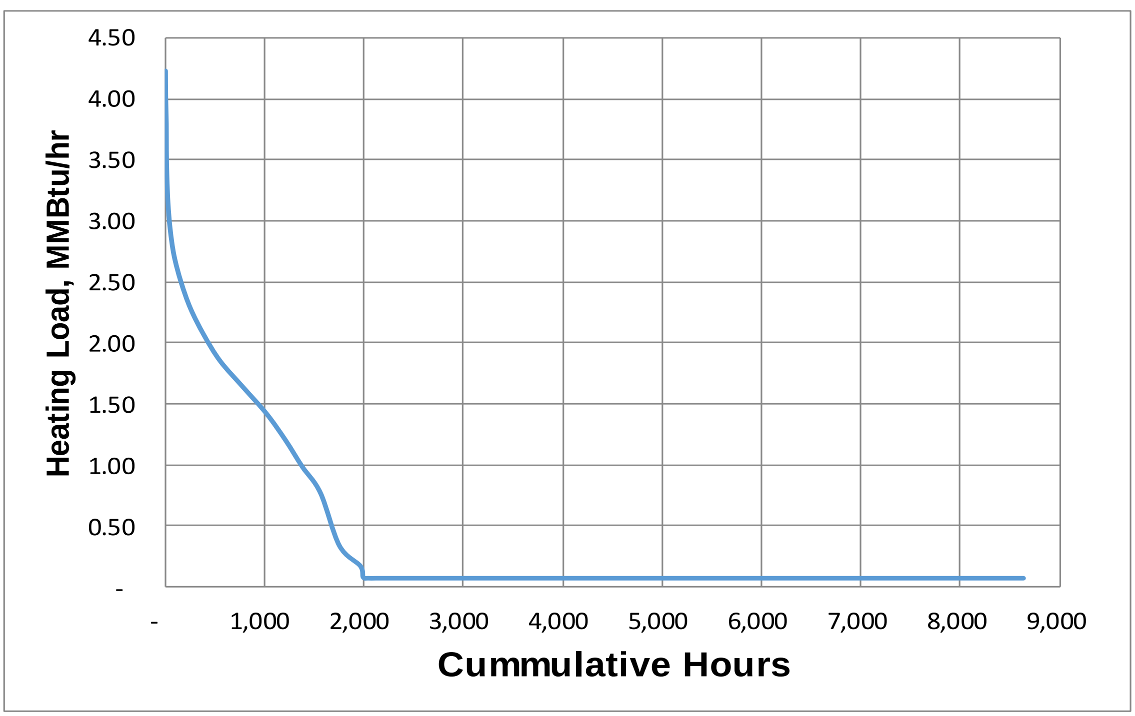
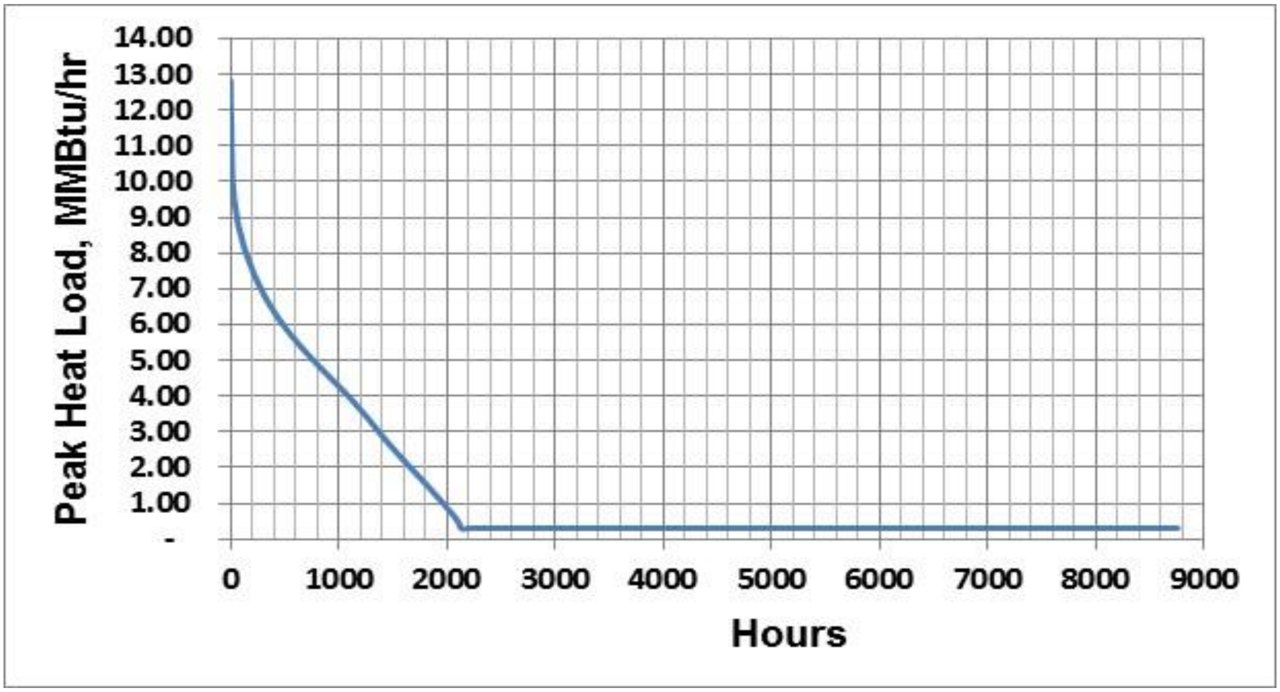


Figure 3-6: Combined Annual Thermal Load Duration Curve for the MG six customers



The analysis demonstrate that the combined peak electric load of the MG is 1,728kW and the peak occurs in the summer (caused by air conditioning load).The combined peak heating load of 13 MMBtu/hr takes place in the winter.

To maximize the potential savings from cogeneration it is proposed to install two (2) x 335 kW reciprocating CHP units at the basement of the Court House and supply from this plant the MG base electric and thermal loads of all six (6) buildings. It is also proposed to install four (4) x 400kW reciprocating electric generating units at the basement of the Boehlert Train Center and supply from this plant the intermediate and peak electric load of all MG customers. The estimates demonstrates that the roof of the Train Station will accommodate a 150kW PV solar installation. It is also proposed to install a 250kW electric storage at the basement of the Train Station. The intermediate and peak thermal loads will be supplied by the existing thermal sources. The generating capacities of the proposed distributed energy resources are summarized in Table 3-4.

The current peak electric demand of the MG system is close to 1800 kW. The total proposed DER's electric capacity is 2400 kW. The system will operate with n+1 strategy. The proposed capacity will provide the reliability of electric supply in case of forced shut-down of the largest 400 kW unit. The proposed DER units are fired with natural gas. In order to provide the electric supply in case of interrupted natural gas supply an installation of propane storages are proposed at the Court House and Train Station.

The manufacturers of the reciprocating units indicated that when firing propane gas instead of natural gas the unit capacity will be reduced by about 40%.The propane storage capacity at both locations will provide a one (1) week propane supply. The interruption of natural gas supply may take place during the winter months (sever weather or snow storm) when the peak electric load is about 1200kW.The one (1) week propane storage capacity to generate 1200kW of electricity is estimated at three (3) storage tanks each with capacity of 7,500 Gallons.

Table 3-4: Generating Capacities of the Proposed Distributed Energy Resources

No.	Name of Customers	Address	Area,sq.ft	Electric Peak,kW	Annual Aver. Electric Load,kW	Annual Electric Consump.,kW	Montly Aver. Electric Consump.,kWh	Weekly Aver. Electric Consump.,kWh	Annual Gas Consump., MMBtu	Existing Thermal Capacity,MBtu/hr	Existing Back-up Generation	MG Electric Gener.,kW	MG Thermal Gen.,MBtu/hr
1	City Court House	200 Elizabeth Street	36,634	404		1,324,914	110,410	25,479	9,804	2x850	100kW Gas Fired	2x335kW CHP	2,816
											by Kohler	Gas Fired Recip.	
2	City Police Station	413 Oriskany Street	30,000	Comb.w/Court		Comb.w/Court			Comb.w/Co	Comb.w/Court		Units	
3	Memorial Auditorium	400 Oriskany Street	62,340	687		3,017,882	251,490	58,036	6,234	2x3,350	250kW Gas Fired		
											by Cummins		
4	Boehlert Train Station	321 Main Street	115,704	255		1,293,900	107,825	24,883	6,891	2x3,100	57kW+15kW gas	4x400kW Gas	
											Fired, Onon	Fired Recip.Units	
5	Federal Building	10 Broad Street	77,637	267		562,500	46,875	10,817	3,631	3x1,200		1x150kW PV Solar	
6	Observer-Dispatch Newspaper	221 Oriskany Plaza	47,318	148		649,681	54,140	12,494	3,159	1x3,780		1x250kW Electric	
										1x800		Battery	
		Total	369,633	1,761	1,344	6,848,877	570,740	131,709	29,719	22,800		2,493	2,816

Proposed MG Infrastructure and Operations

This section presents the results of electric and thermal load assessment for the proposed MG and development of preliminary electrical and thermal infrastructure configuration and costs.
Currently the MG customers are supplied with electricity by National Grid Company and with natural gas by different independent gas providers. Four of the proposed MG customers have limited back-up electric capacity and have no on-site electric generation. The summary of current electric and gas loads and consumption of the MG customers is presented in Table 2-2.

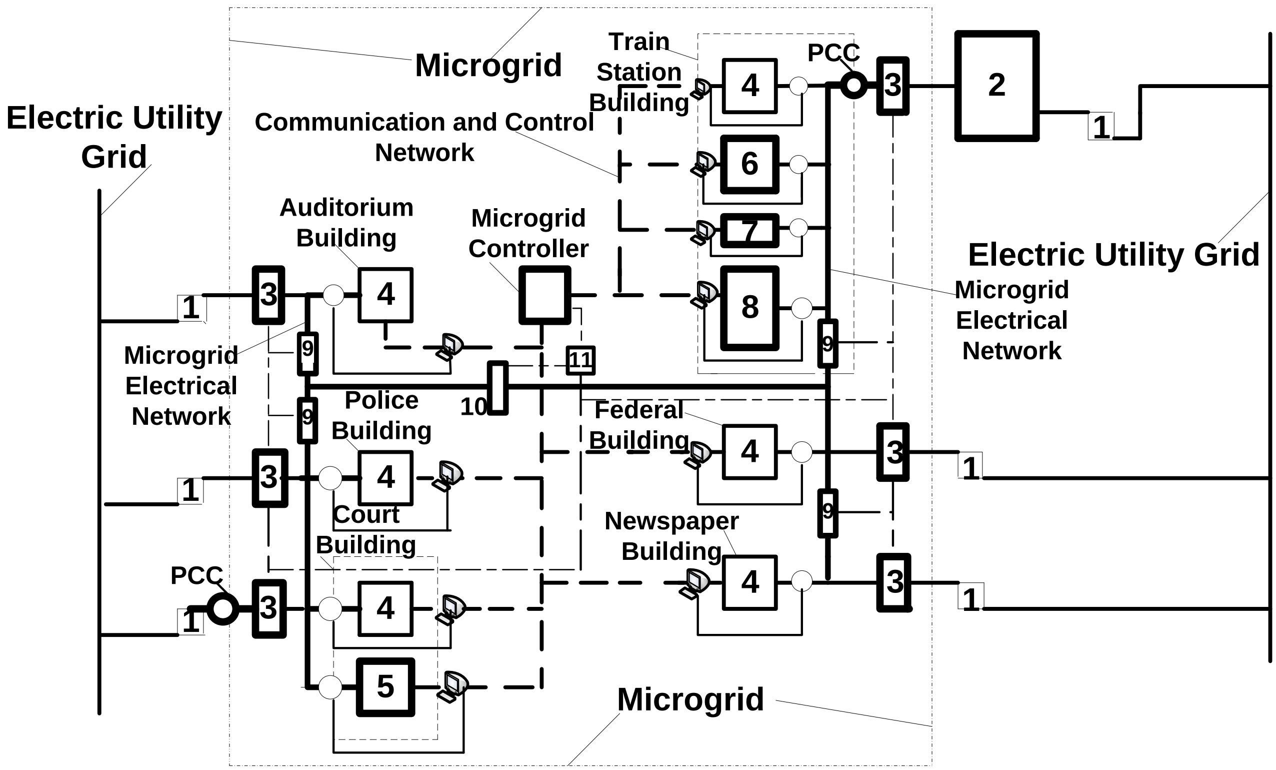
The National Grid indicated that the City Court House, the City Police Station and Memorial Auditorium are currently supplied with underground low voltage AC primary feeders with 120/208 Volts. The Boehlert Train station is supplied with an underground AC primary 4.16 kV feeder. At the Train Station the feeder is connected to three (3) transformers owned by the utility. The transformers are connected to the Train Station switchgear equipped with 120/208V breakers. The Federal Building and the Newspaper Building are supplied with underground low voltage AC primary feeders with 120/208 Volts.

The MG one-line electric diagram is presented in Figure 3-8.It is proposed to supply the MG customers with two (2) new distributed energy resources (DER) each installed at the City Court House and the Boehlert Train Station. The DER's will be connected with new electric cables and hot water supply and return piping installed underground in a common trench (the installation route see Figure 2-2) and will supply all MG customers with electricity and hot water. The City advised the project team that the City owns the rights to the public ways to lay distribution electric cables and district heating piping. The MG system will be connected to the National Grid system at two points of common coupling: one-at the Court House and the second-at the Train Station.

Based on detail electric and heat load analysis it was decided to select the following DER's equipment: 2x335 kW CHP high efficiency reciprocating units installed at the basement of the Court House and 4x400 kW electric generating reciprocating units installed at the basement of the Train

Station. In addition it is also proposed to install a 150 kW solar PV system at the roof of the Train Station and a 250 kW electric storage facility at the basement of the Station. Both DER's will be integrated with the existing hot water boilers and chillers which will supplement the heat and cooling supply from the CHP units. The MG one-line equipment diagram is presented in Figure 3-9.

Figure 3-7: One-line Electric Diagram of the MG



1- Utility Meter. 2-Utility Transformer. 3-Islanding Breaker. 4-Building Swichgear. 5-CHP Recip.Units. 6- Electric Recip.Units. 7-Solar PV Unit. 8- Electric Storage. 9-Isolation Breaker. 10-Synchronizing Isolation Breaker. 11-Breaker Control Network.PCC-Point of Common Coupling.

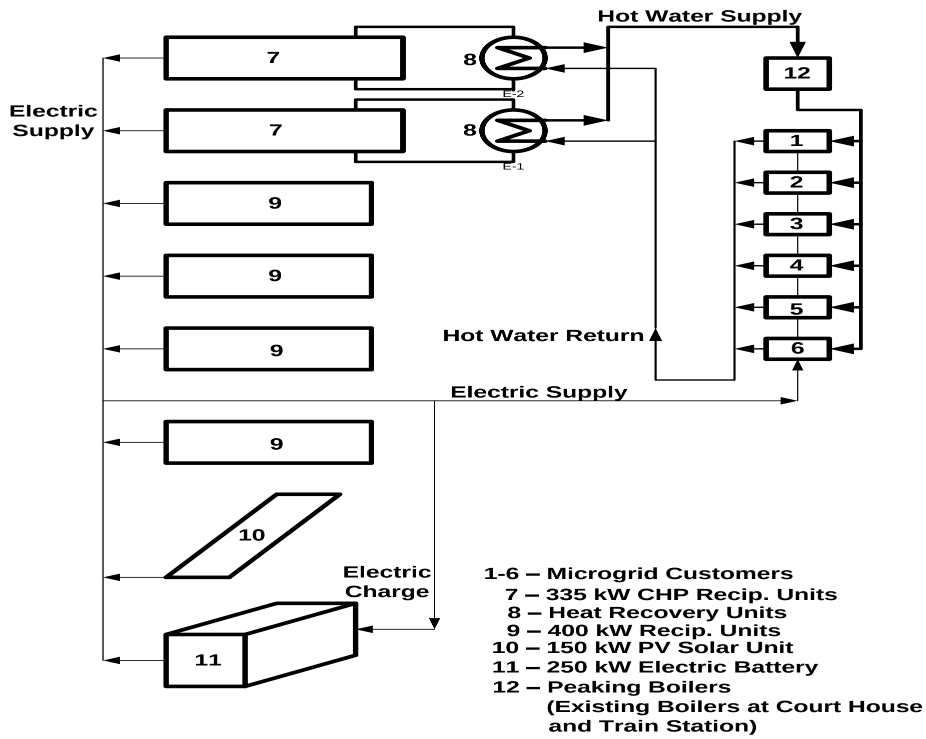
Local Control Agent. Local Protection Element

The MG system will operate in parallel with the National Grid at normal conditions. However in case of emergency and failure of the National Grid electric supply, the MG plant will disconnect from the grid and operate in the islanded mode.

Integration of the MG plant with utility electric distribution system will require conformance with utility requirements, which are described in National Grid / *DG Installation Process Guide per NY SIR* / July 2011 ver. 1.0: Distributed Generation Installation Process Guide for Connections to National Grid Distribution Facilities per the New York Standardized Interconnection Requirements (the NY SIR).

The interconnection of the MG to the National Grid will offer the opportunity, when economically feasible, to participate in regional energy markets (i.e., sell excess power, purchase supplemental power or participate in demand response programs).

Figure 3-8: MG One-line Equipment Diagram



Parallel Interconnection

Parallel connection of MG (MG) plants with the National Grid requires to address the following issues:

- Frequency and Voltage regulation.
- Disconnection and reconnection in the event of grid disturbances.
- Safe intentional islanding operation.
- Control of faults when in grid-connected mode.
- Protection coordination.

To operate in a parallel grid-connected mode, the MG should:

- Connect safely to the grid at the correct frequency and phase.
- Inject electricity of sufficient quality (appropriate power factor and voltage, low total harmonic distortion).
- Disconnect quickly and safely from the grid when a disturbance is detected on the grid and reconnect when it is safe to do so.

In the parallel mode the MG plant will rely on the electric grid to maintain frequency regulation. However, if frequency or voltage on the grid at the point of interconnection deviates sufficiently from accepted standards, the MG plant will be programmed to disconnect from the grid.

Regulation of voltage by a grid-connected MG generator depends on the preference of the utility. A key difference is that whereas frequency is a variable that is constant across the whole utility electric power system (and thus subject to control throughout the system by a few large electric utility generators), voltage varies from node to node throughout the system depending on the distribution of loads, generation, and power factor correcting capacitor banks.

Islanded MG Operation
Islanding refers to the condition when the MG becomes isolated from the main grid but remains energized by its own generation resources. In an islanded MG the DER's will control frequency and voltage. The voltage at the terminals of a rotating generator depends on the changing magnetic flux through the generator's stator windings as the generator's rotor spins. This is controlled by a synchronous automatic voltage regulator (AVR). As voltage starts to sag, the AVR responds by sending more current to the rotor, increasing voltage. Typically the AVR is set in a mode that attempts to keep voltage constant. As the load changes, it increases or decreases field strength in response**.** Islanding may be unintentional or intentional.

Unintentional islanding can:(1) present a hazard to line workers who might assume the lines are not energized during a failure of the central grid,(2) deny central control over power quality, (3) damage utility or customer equipment at time of reconnect if not properly coordinated. These concerns are addressed through anti-islanding features (such as transfer trip schemes and phasor measurement units) included in standards such as Underwriters Laboratories (UL) 1741 and IEEE 1547.

Intentional islanding of the MG will be used in emergency situations. The MG interconnection with National Grid will be designed in a way that permits the MG to continue operating autonomously and provide uninterrupted service to MG customers during outages on the main grid. The IEEE standard 1547.4-2011 specifically addresses power systems that include intentional islanding. Implementing intentional islanding requires that the system perform several steps, reliably, in correct sequence and timing:(1) the MG generator must recognize an abnormal condition on the utility grid and disconnect a circuit breaker located at an appropriate location to separate the generator and islanded MG load from the main grid, (2) upon disconnecting, the MG generator must immediately switch from "synchronized mode" to "autonomous mode" engaging controls to regulate frequency. The generator's AVR controls will need to switch over immediately to operate in a different mode. If the AVR was operated in a power factor control (pfc) mode when connected to the main grid, it will need to switch to voltage control mode, and (3) the MG system must continue to sense line voltage on the main grid, and when main grid power returns to stable conditions, initiate reconnection, and return to control regimes (e.g. letting the grid control frequency) appropriate for grid-connection. Before reconnection, the MG's generation must be synchronized with the main grid.

The protective relay settings governing intentional islanding for reconnection will take into account the timing and effects of reclosers on the grid's feeder to which the MG generator reconnects. When a line is disconnected after a fault, a recloser will automatically re-energize the line after a short delay. The MG generator controls must: (a) disconnect the generator fast enough to avoid being online when a recloser energizes the circuit; and (b) wait to resynchronize until grid voltage and frequency are stable (typically a few cycles).

For the synchronous generators selected for the MG, the frequency of the output is directly related to the rotational speed of the rotor—at a given speed, the generator will always produce the same frequency. Before connecting to the grid, the voltage output from a synchronous generator must be synchronized with the grid voltage. In order to ensure safe operation of a MG protective relays must detect abnormal conditions, including short circuits and overloads, and operate circuit breakers to isolate the malfunctioning system components, preventing damage to the generator and to the distribution system components. The selected relays can measure voltages of 480V and lower directly without voltage transformers. Once a fault condition that caused a relay to interrupt a circuit has been resolved, the relay will automatically re-close the circuit.

Typically the microprocessor is a single relay that incorporates the functions of many discrete relays, potentially allowing a single device to provide all necessary protection functions. There are a number of vendors who offer multifunction relays. For this project the Schweitzer Engineering Laboratories (SEL) electric relays were selected.

Distributed Energy Resources Characterization

As indicated above it was decided to select the following equipment: 2x335 kW CHP reciprocating units installed at the basement of the Court House and 4x400 kW reciprocating units installed at the basement of the Train Station. In addition it is also proposed to install a 150 kW solar PV system at the roof of the Train Station and a 250 kW electric storage facility at the basement of the Station. Both DER's plants will be integrated with the existing hot water boilers and chillers which will supplement the heat and cooling supply from the CHP units. The detail description of the DER's is provided below.

Two (2) CHP GE JMS 208 natural gas fired engine generator packages

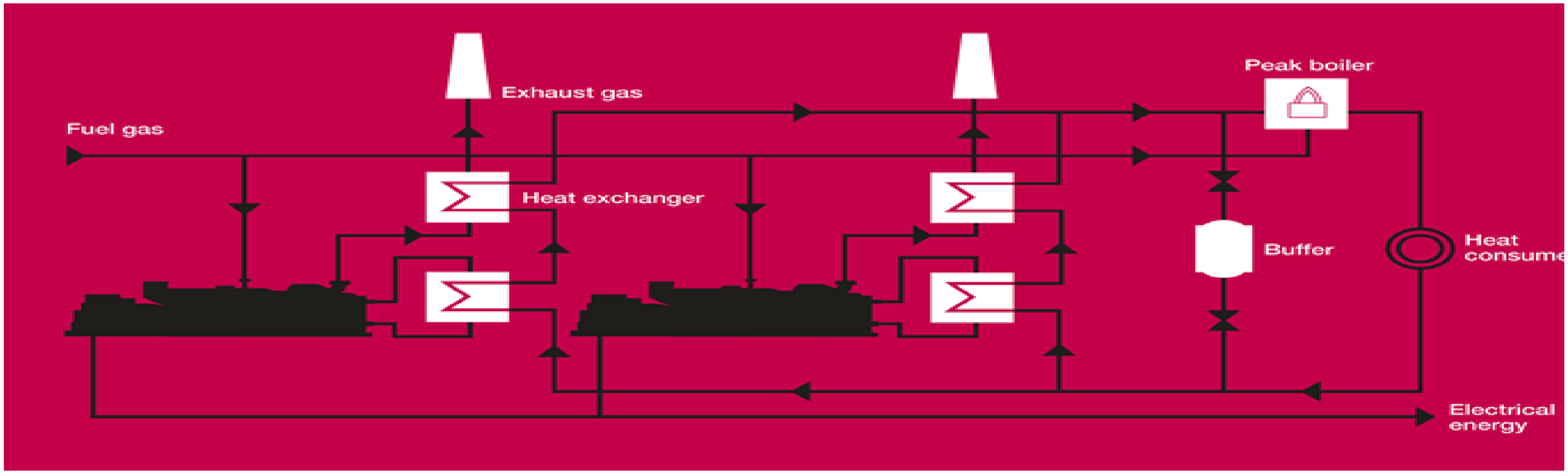
Each CHP engine generator package is rated at 335kW, 480V, 3 phase, 60HZ, 1.0 PF. The engine generator is built to the same standards as the larger GE power generation units and will be used for prime power operation and will not require a major overhaul for 8 years. Heat recovery includes both the jacket water and engine exhaust producing hot water (Figure 3-10). To comply with NYSERDA grant requirements the engine NOx emission will be .54g/BHP-hr and an oxidation catalyst is included for CO reduction. The package includes a horizontal radiator and silencer.

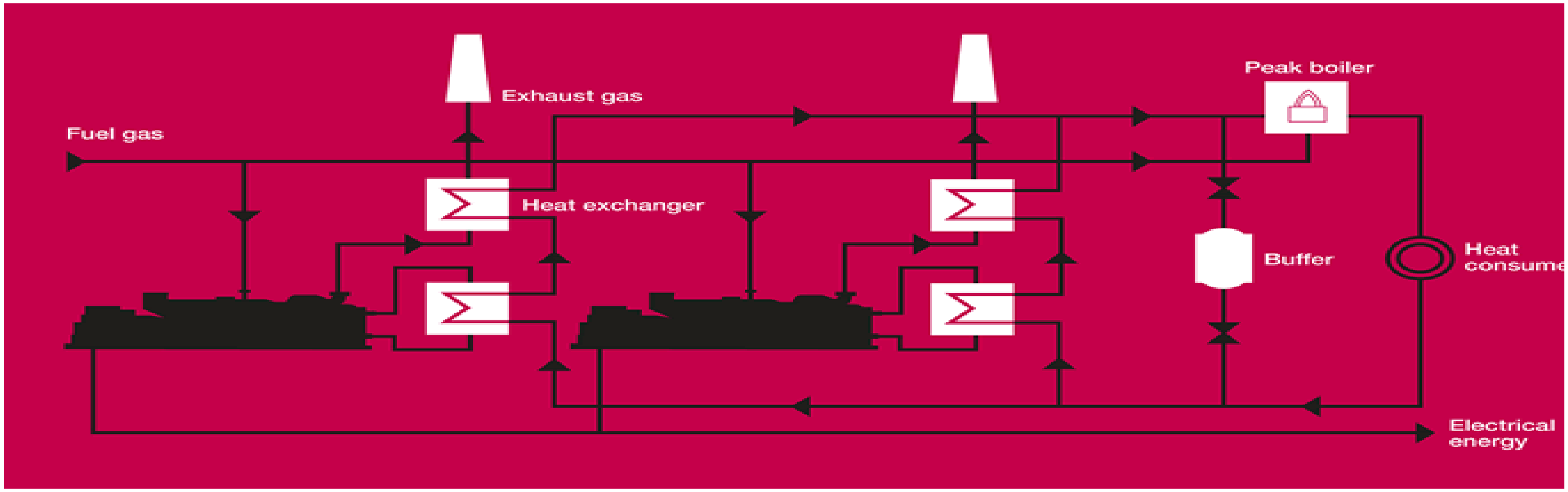
The engines have the ability for black start and island operation. It can provide an additional layer of backup power for the facility. Over the last couple years the region has experienced several major weather events that have caused lasting power outages. It should be noted that the gas engines react differently than diesel engines. Engines need to be step-loaded in prescribed increments according to the class of power.

Each unit will include the following equipment:

- One (1) GE JMS 208 engine generator package rated at 335 kW
- One (1) GE DIA.NE generator set control systems with generator protection
- One (1) GE DIA.NE WIN communication package (remote monitoring)
- One (1) Modbus RTU
- One (1) Island and black start package
- One (1) Thermal exhaust blanket package
- One (1) Vibration sensor
- One (1) Generator condensate anti-corrosion heater

Figure 3-9: Two (2) CHP GE JMS 208 Natural Gas Fired Engine Generator Packages





- One (1) Input/export control signal
- One (1) CT measurement package
- One (1) DVR
- One (1) M1 panel air conditioner
- One (1) Radiator package
- One (1) Oxidation catalyst
- One (1) Exhaust heat recovery heat exchanger
- One (1) Decoupling heat exchanger
- Initial oil fill.

Performance

Ratings are per ISO-ICFN continuous power with the following standard reference conditions: Barometric pressure 14.5 PSI, or 328 feet above sea level, air temperature 84°F, relative humidity 30 %.

System Performance		
Electric Output	335 kW @ 480V	
Fuel Input	3.187 MMBTU/HR LHV of 868 BTU/CF	
Electric Efficiency	35.90%	
Heat Recovery	1.408 MMBTU/HR 190ºF hot water	
Thermal efficiency	44.10%	
Overall efficiency	80.10%	
Guaranteed Emissions		
	Pre-Catalyst	Post Catalyst
NOx	.53 grams/bhp-hr	.53 grams/bhp-hr
CO	3.0 grams/bhp-hr	.5 grams/bhp-hr
VOC	.43 grams/bhp-hr	.15 grams/bhp-hr
Formaldehyde	0.3 grams/bhp-hr	.015 grams/bhp-hr
Acrolein	.02 grams/bhp-hr	.006 grams/bhp-hr

The DIA.NE engine generator control module is a state of the art engine generator management system which GE has introduced for all it's engine types. The system is based on a central industrial control system which takes on the tasks of the closed loop module control system, the open loop module system and module visualization. The coupling to the central control system takes place via standardized industrial bus connections or direct signal lines via a PC station as well as remote monitoring via I/P address. Remote monitoring is standard with all long term maintenance agreements. The system allows NES support personal to monitor engine operation, diagnose engine generator problems and make changes remotely. Capable to respond quickly upon notification of an engine issue and run a diagnostic program to identify the problem and either correct over the internet, direct the site operator to correct or dispatch a NES service technician.

The DIA.NE system enables:

- Remote monitoring of operating parameter and alarm displays, trend data.
- Management, starting and stopping of generator set and auxiliaries along with remote acknowledgement of error/alarm messages.
- Connection options include modem, Internet, and LAN.
- Remote host computers and monitors are optional.

The visualization unit color VDU produces a clear and understandable overview of all information and measured values and is user-friendly. The DIA.NE is composed of the following units:

- A central industrial control system for closed-loop and open loop control and visualization
- Decentralized input/output modules in the module control cabinet
- Connections to intelligent sensors and actuators on a Can-bus basis
- Decentralized input/output modules on the engine.

Engine Generator Management Functions

- Speed control
- Idling controller
- Isolated-operation controller
- Output regulator
- LEANOX controller
- Knock control system
- Ignition voltage measurement.

The DIA.NE (Dialog-Network) free standing control panel provides an engine-generator management system featuring a membrane touch pad display for interface and operation of the generator set equipment. The DIA.NE system includes:

- Central engine and control module.
- An industrial grade computer with 10” VGA TFT color graphics display, 10 function keys, display selection keys, 10-key numeric keyboard for input of operating parameters, auxiliary keys for START, STOP, lamp test, and special functions. A RS485 serial port interfaces to the central computer and multi-transducer.

Main displays available from the DIA.NE panel include:

- Generator set interconnection electrical values: Phase current, Neutral current, Voltage (Phase-to-Phase and Phase-to-Neutral), Active power, Reactive power, Apparent power, Power factor, Frequency.
- Engine oil pressure and temperature, Jacket water circuit pressure and temperature, Exhaust gas temperatures, Engine controller, Auxiliary PID controller, Auxiliary status, Operational data such as operating hours, service hours, number of starts, active power demand (kWh), reactive power demand (kVArh), and measured values required for the operational logbook. System set-up Graphical data logging and trending for up to sixteen (16) measured values, Long term trending of data for 30 second intervals up to one (1) month duration, Short term trending provides data for troubleshooting.
- PLC base central engine management which controls the following: Speed control in no load and isolated operation, Power output control in a parallel operation.

- LEANOX control system for control of boost pressure relative to generator terminal output and fuel mixture temperature via the GE Jenbacher engine driven air-gas mixer, Knocking controls enable adjustment of the ignition point, power output, and potentially the mixture temperature in the event of a knocking condition, Load sharing between generator sets is isolated operations, Proportional power reduction as a result of a fault, Generator set logic control, Generator monitoring of up to eight (8) functions simultaneously: Overload/short-circuit [51], [50], Over voltage [27], Undervoltage [59] ,Asymmetric voltage [64], [59N], Unbalance current [46], Failure Excitation [40], Overfrequency [81].

DIA.NE WINN Communication Package (remote monitoring)
The system provides for remote operation and monitoring of the generator set and related auxiliaries.

Four (4) x 400 kW Reciprocating Electric Generation Units
Nominal Rating of each unit 400kW
Net kW 383kW
Natural Gas Input 3,869 MBtu/hr
Synchronous 480 V, 60 Hz

Each unit (Figure 11) includes all basic Components & Accessories, Oscillation Decoupling & Vibration Protection, Auto Lube-Oil System including Day Tank and Oil Extension Tank, Electrical Pre Heating, Gas Connection pre-flanged, Gas Regulation, Gas Train, Gas Mixer, Air/Fuel Ratio Control, Heat Value Recognition, Auxiliary Controls, Multi-Level Heat Extraction & Thermal Circulation, Pumps, JWHE incl. Insulation, 3-Way Mixers, Expansion Vessels, Controls & Safety Devices, Double Bearing Generator, CB, Switchgear Cabinet, General Electronic Management (GEM) combining all System Controls (Engine, and all Aux. Control Functions), Profibus or Modbus Interface capable, Island Mode capable, Stainless Steel Exhaust Silencer <65dBA.

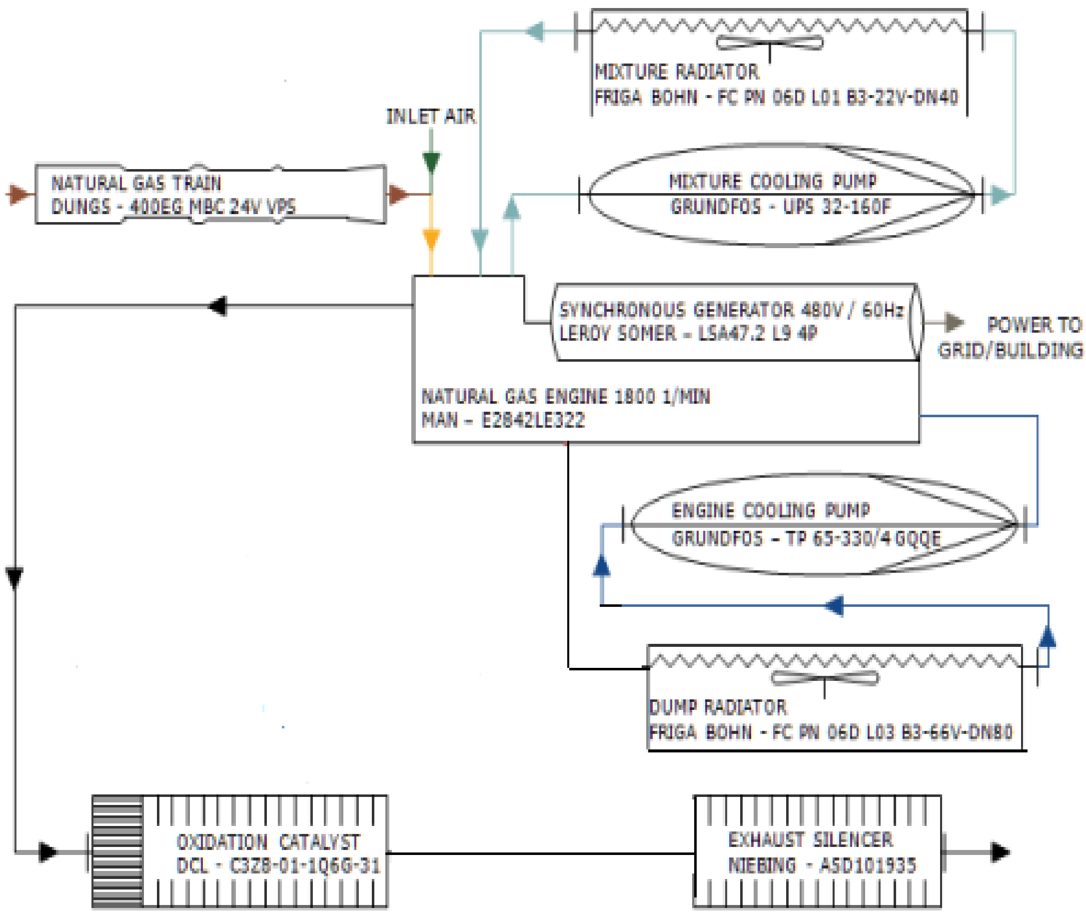
SCR Selective Catalytic Converter including Oxi-Cat
- Reduces NOx Emission's to < 0.1 g/bhp-hr @ 15% O_2
- Reduces CO Emission's to < 0.68 g/bhp-hr @ 15% O_2
- Reduces HCHO Emission's to < 0.1 g/bhp-hr @ 15% O_2
- Reduces NMHC Emission's to < 0.4 g/bhp-hr @ 15% O_2

Solar Photovoltaic System
System Size: 150.8 kW
Solar Module: Trina TSM-260
Module Output: 260 Watts
Module Quantity: 580
Inverter Type: Solar Edge, 3 Phase, 480V
Mounting Type: Ballasted Roof

ZAC Electric Battery
Life-time 10,000 cycles @ 100% DOD - 20 Years
Maximum power: 288 kW
Energy: 960 kWh
Nominal power: 128 kW
Duration at nominal power: 7 hours
Charge/Discharge switching time: <25 ms
Automatic rejuvenation: Included

Remote monitoring: Included
Output voltage: 480V 3 phase
ESU efficiency - AC/AC 74% at nominal power
ESU efficiency - DC/DC
90% at nominal power ZAC Mechanical & Operating Parameters
Communication
USB, 485, Modbus Ethernet.

Figure 3-10: 400 kW Natural Gas Fired Recip. Electric Generating Unit



The described DER's have the capability to continuously meet electrical and thermal demand of the MG customers and are resilient to the forces of nature (sever weather) for the following reasons:

- The MG system is capable to supply the electric peak with the largest 400kW unit and the solar PV unit out of service.
- The DER's consist of multiple units and have the following capabilities: black start, load-following, part-load operation, maintain voltage and frequency, ride-through voltage and frequency events in islanded mode, capability to meet interconnection standards in grid-connected mode.

- The peak thermal capacity of the MG is 13 MMBtu/hr. The new installed thermal capacity is 2.8 MMBtu/hr. This capacity will supply the annual base thermal load. This capacity is supplemented with the 22.8 MMBtu/hr capacity of existing boilers (see Table 3-4).
- The MG electric and hot water distribution lines are located underground.
- In case of the interrupted natural gas supply, the peak electric load of 1200 kW during the winter months can be supplied by a back-up propane storage with one (1) week capacity.
- The DER's are located at the basements of two separate buildings and are reliably protected from forces of nature in case of severe weather, a snow storm or hurricane.
- To ensure uninterrupted electric supply to priority loads, manage intermittent resources by providing fast-acting load following, provide reactive power support and allow optimal sizing and operation of DER units, an electric battery storage is incorporated in the MG.

Electrical, Thermal and Information Technology (IT)/Telecommunications Infrastructure Characterization

Currently the City Court House, the City Police Station and Memorial Auditorium are supplied with underground low voltage AC primary feeders with 120/208 Volts. The Boehlert Train station is supplied with an underground AC primary 4.16 kV feeder. At the Train Station the feeder is connected to three (3) transformers owned by the utility. The transformers are connected to the Train Station switchgear equipped with 120/208V breakers. The Federal Building and the Newspaper Building are supplied with underground low voltage AC primary feeders with 120/208 Volts.

The proposed MG DER's will generate 480V electricity. The electricity will be distributed throughout the MG underground electric distribution system (Figure 2). At each of the MG customers a smart meter, a new advanced circuit breaker (fast switch capable to sense conditions on the National Grid and rapidly connect and disconnect the MG breakers) and a 480V: 120/208 V step-down transformer and switchgear will be installed. The switch gear will be connected to a local MG controller and the existing switchgear which currently provides the electric supply of the customer. No utility electric distribution system will be used for the MG.

The operation and management of the MG will be controlled and coordinated via both local MG controllers, and a central controller, which executes the overall control of the MG and coordinates the operation and protection requirements of the micro-source controllers. The central controller will provide executive control functions over aggregate system operation, including the individual micro-source controllers, DERs and power conditioning equipment. The central controller will ensure that power quality and reliability on the MG are maintained through power-frequency control, voltage control, and protection coordination. The central controller will also manage economic dispatch of MG resources, including use of macro-grid power, which it will determine through an optimization process. The optimization will take into consideration variables including the cost of electricity, cost of gas or fuel inputs, weather, interconnected load forecasts, and MG DER characteristics and availability, among others. The central controller is designed to operate in an automated fashion under several different operating modes (i.e., normal grid-connected mode or island mode), but has the capability of manual override if necessary.

The MG will use the SEL's MG Controller which is equipped with the SEL-3530 Real-Time Automation Controller (RTAC). The RTAC has the ability to optimize and balance electrical demand with DER's, schedule the dispatch the resources, provide synchronization and Volt/VAR/frequency controls, preserve grid reliability and cybersecurity, interact with, connect to, and disconnect from the utility grid (using fast switches), provide ancillary services (grid-connected, real-power-related, and reactive-power-related),black start, self-healing of the MG distribution system, user interface and data management, two-way communication, supervisory control and data acquisition (SCADA), and have interoperability in order to improve the grid's power quality and resilience, while reducing overall cost. The RTAC will also communicate with fast switches to enable quick intentional islanding and automatic re-synchronization of MG systems with the macro-grid. The MG fast switches will detect conditions both on the utility and MG sides and make rapid decisions about whether to maintain connected to the macro-grid or to seamlessly separate and institute islanded operations. With a fast switch, MGs could electrically isolate themselves within milliseconds, preventing the need to trip connected generation. A similar process will occur when the macro-grid comes back on-line and the MG reconnects – generation is tripped for a time period before re-synchronization can occur with the utility system.

This device also has all necessary control logic embedded for the control of all protection devices within the MG. Additional controls will be supported by the RTAC and will be identified during the design phase of the MG system. The RTAC will be the catalyst for supplying necessary information to the SEL-3355 Industrial Computer platform which will operate the required Human Machine Interface (HMI). The HMI will provide operator control interaction, system status, real time information, and historical log review. The following two protection options are evaluated. The final option will be selected during the design phase.

Figure 3-12 presents Option 1 for a wired communications system. This system will use fiber optic communications cables between each of the buildings. All remote points (Customers) will be terminated at the originating location into the MG Controller through an SEL fiber optic Ethernet switch, identified as “Ethernet Network”. The exact communications hardware requirements will be defined during the design stage. A brief description of selected equipment is presented below.

- The SEL-700G Generator Protection Relay (Figure 3-13). SEL-700G units will be connected to each power generation point: CHP, Electric Generating Units, Solar PV and Battery Unit. The SEL-700G will perform the following functions on these generation points, including but not limited to, Overcurrent, Overvoltage/Undervoltage, Frequency, Voltage and Frequency synchronization and more to be identified. The SEL-700G Generator Protection Relay provides primary and backup protection. Adding the neutral voltage connection provides stator ground protection, based on fundamental-frequency and third-harmonic neutral-voltage measurements. Connecting the neutral current input provides protection for solidly grounded or resistance-grounded machines. Includes an auto synchronizer which replaces external generator control and synchronizer relays with the built-in automatic synchronizer function. Frequency, voltage, and phase control of the generator are automatically synchronized and connected to the power system. The generator synchronization process will be monitored using generator start reports and the PC-based synchroscope.

The SEL-700G also provides Current Differential Protection by applying sensitive percentage-restrained current differential elements and an unrestrained element, along with synchronism check and volts-per-hertz elements, across the entire unit to protect both the generator and the step-up transformer. Optional current differential elements detect stator faults using a secure, sensitive current differential function. Power transformer and CT connection compensation allows the unit step-up transformer to be included in the generator differential zone.

The system Includes Breaker Wear Monitoring device which records accumulated breaker contact wear with the breaker monitor function, which uses the manufacturer’s specifications for defining breaker operation limits. The internal monitor tracks the total number of close/open operations and integrates the interrupted current per phase. Sets an alarm to alert operators when measured and accumulated quantities approach maintenance thresholds. This information facilitates proactive breaker maintenance and replacement without underutilizing resources. Includes fiber-optic Ethernet ports, or serial communications, and several protocols, including Mirrored Bits communications and IEC 61850. Multiple Modbus TCP or Modbus serial sessions for custom configuration are available. The DNP3 Serial or DNP3 LAN/WAN protocols could be used.

- The SEL-751 Intertie Protection Relay (Figure 3-14). Each primary utility disconnection point will have an SEL-751 installed for protection. These relays will open and close the breakers to connect and disconnect each building from the utility service connection. The relay will provide feeder protection, with overcurrent, overvoltage, undervoltage, directional power, load encroachment, and frequency elements; fault location, arc-flash detection, and high-impedance fault detection applications.
- Tie-Breakers internal to the MG system as well as potential interconnection with the utility for possible power export options. The actual number of Tie Breakers and associated SEL-751's will depend on final design requirements. Will be integrated into serial- or Ethernet-based communications with IEC 61850, MIRRORED BITS communications, DeviceNet, Modbus, DNP3, and other protocols.
- SEL-2440: presently each facility includes a SEL-2440 Discreet Programmable Automation Controller. These devices may be used to incorporate control functions at each location within the MG system, as well as provide status indication of various physical assets.

Figure 3-15 presents Option 2 for a wireless communications system. Because the physical locations of all properties are within the range of SEL's radio devices (less than 20 miles), SEL proposed this solution. Some aspects will still need to be taken into consideration which have yet to be defined: unobstructed line of sight, property restrictions, or other required aspects yet defined. The Option 2 includes the following equipment:

- SEL-3031. The SEL-3031 is a serial radio transceiver which supports Point-to-Point or Point-to-Multipoint operations at 915MHz frequency. This device has a clear line of site range of approximately 20 miles depending on actual configuration.

- SEL-700G.Multiple SEL-700G units will be connected to each power generation point; CHP, Solar, Battery, etc. The SEL-700G will perform protection functions on these generation points, including but not limited to, Overcurrent, Overvoltage/Undervoltage, Frequency, Voltage and Frequency synchronization and more to be identified. The exact protection requirements needed will be identified during design and future feasibility studies.

- SEL-849. Each primary utility disconnection point will have an SEL-849 installed for protection. These relays will open and close the breakers to connect and disconnect each building from the utility service connection. Additionally, the SEL-849 provides protection for Overcurrent, Frequency, ArcFlash, and other features. The exact protection requirements needed will be identified during design phase.

- SEL-751.The SEL-751 will control the Tie-Breakers internal to the MG system as well as potential interconnection with the utility for possible power export options. The actual number of Tie Breakers and associated SEL-751's will depend on final design requirements.

The overall views of the panels for both options are provided in Figure 3-16.

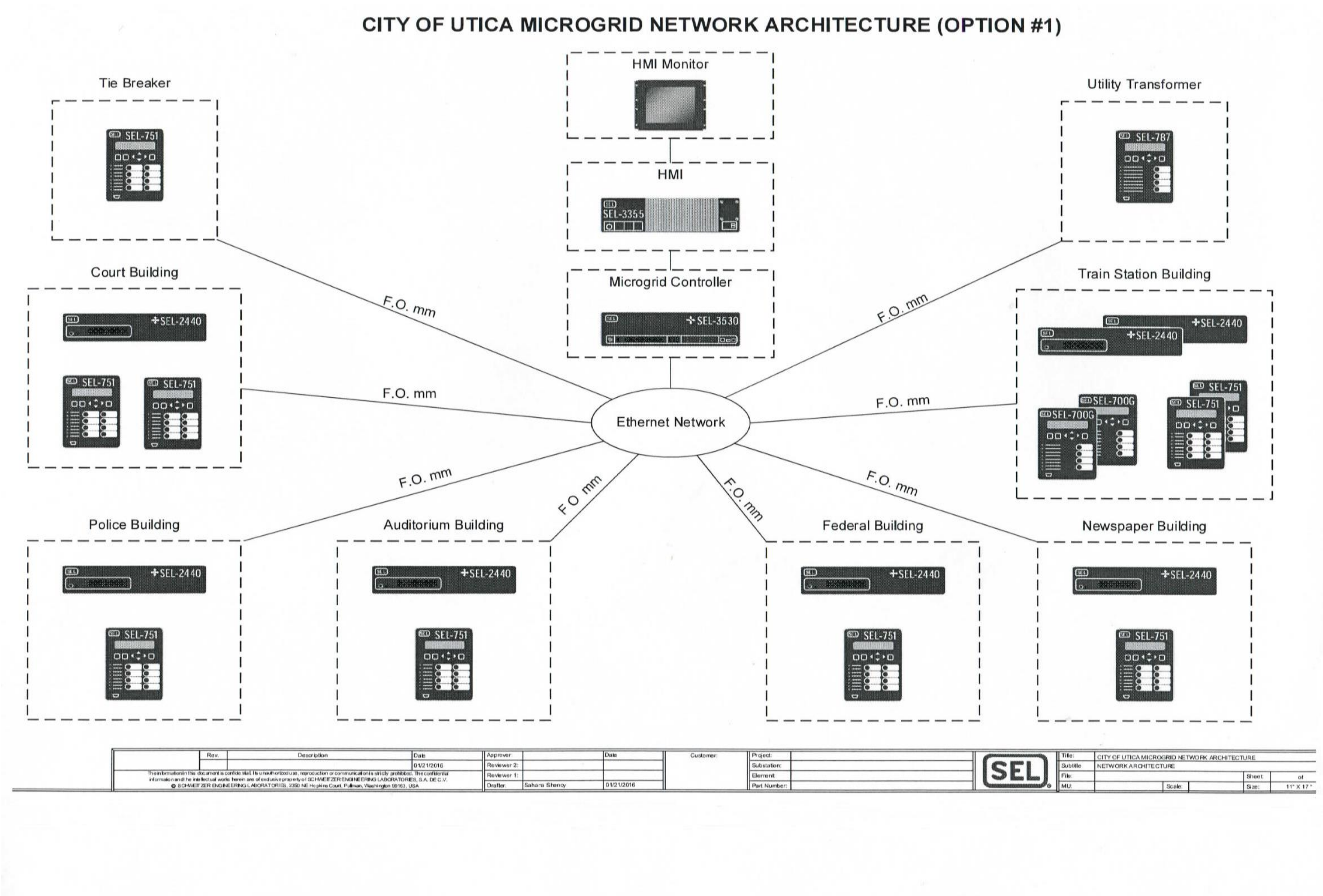
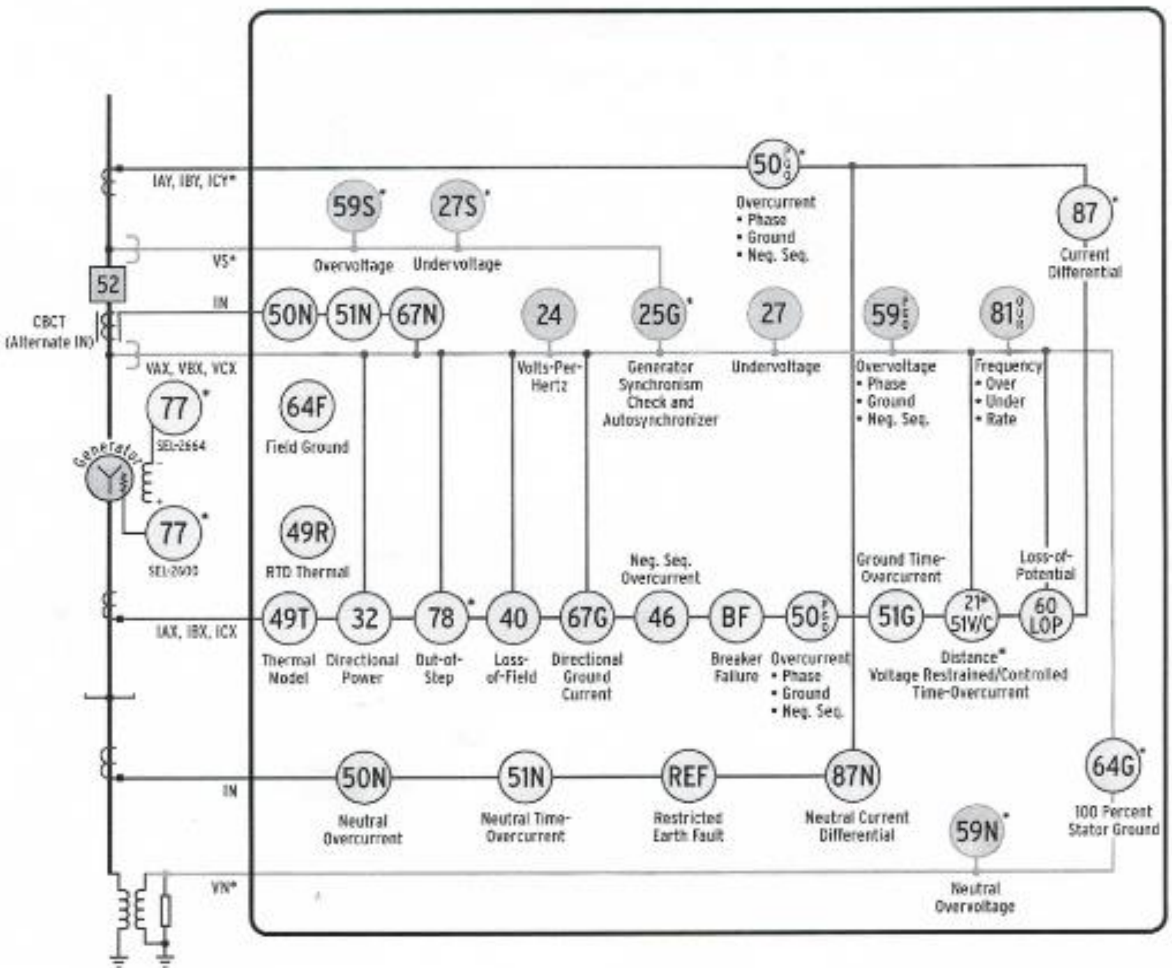


Figure 3-11: Fiber Optic MG Architecture Diagram

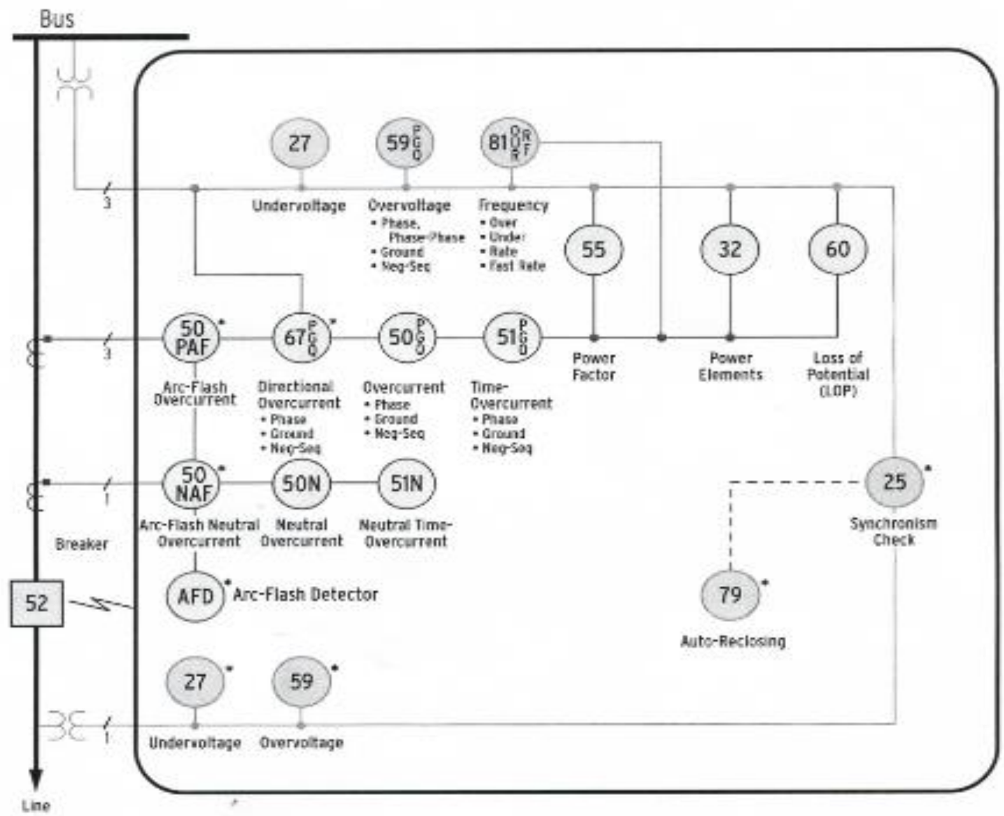
Figure 3-12: SEL-700G Generator Protection Relay



- Sequential Events Recorder
- Event Reports
- SEL ASCII, Ethernet*, Modbus TCP*, SNTP*, IEC 61850*, DNP3 LAN/WAN*, DNP3 Serial*, Modbus RTU, Telnet, FTP, and DeviceNet™ Communications*
- Front-Panel LED Programmable Targets
- Two Inputs and Three Outputs Standard
- I/O Expansion*—Additional Contact Inputs, Contact Outputs, Analog Inputs, Analog Outputs, and RTD Inputs
- Single or Dual Ethernet Copper or Fiber-Optic Communications Port*
- Battery-Backed Clock, IRIG-B Time Synchronization
- Instantaneous Metering, Demand Metering
- Programmable Pushbuttons and LED Indicators
- Off-Frequency Operation Time Accumulators
- Advanced SELogic Control Equations
- 32 Programmable Display Messages
- Mirrored Bits Communications
- Synchrophasor (IEEE C37.118)
- Breaker Wear Monitor
- Event Messenger Compatible

*Optional

Figure 3-13: SEL-751 Intertie Protection Relay



- Sequential Events Recorder
- Event Reports and Load Profile
- SEL ASCII, Modbus® RTU, Ethernet*, Modbus TCP*, IEC 61850*, DNP3 LAN/WAN*, DNP3 Serial*, SNTP*, Telnet*, FTP*, and DeviceNet Communications*
- Event Messenger Compatible
- Front-Panel Tricolor LED Programmable Targets
- Two Inputs and Three Outputs Standard
- I/O Expansion*—Additional Contact Inputs, Contact Outputs, Analog Inputs, Analog Outputs, and RTD Inputs
- ST® Fiber-Optic Communications Port
- Single or Dual Ethernet, Copper or Fiber-Optic Communications Port*
- Battery-Backed Clock, IRIG-B Time-Synchronization
- Instantaneous Metering
- Eight Programmable Front Pushbuttons and Tricolor LED Indicators
- Advanced SELogic® Control Equations
- 32 Programmable Display Messages
- Station Battery Monitor*
- Breaker Wear Monitoring
- Synchrophasor Protocol (IEEE C37.118)
- Arc-Flash Protection*
- Peak Demand, Demand Metering
- Aurora Mitigation Islanding Detection (81RF Element)
- Load Encroachment
- High-Impedance Fault Detection*
- Fault Locator
- Directional Protection*

*Optional

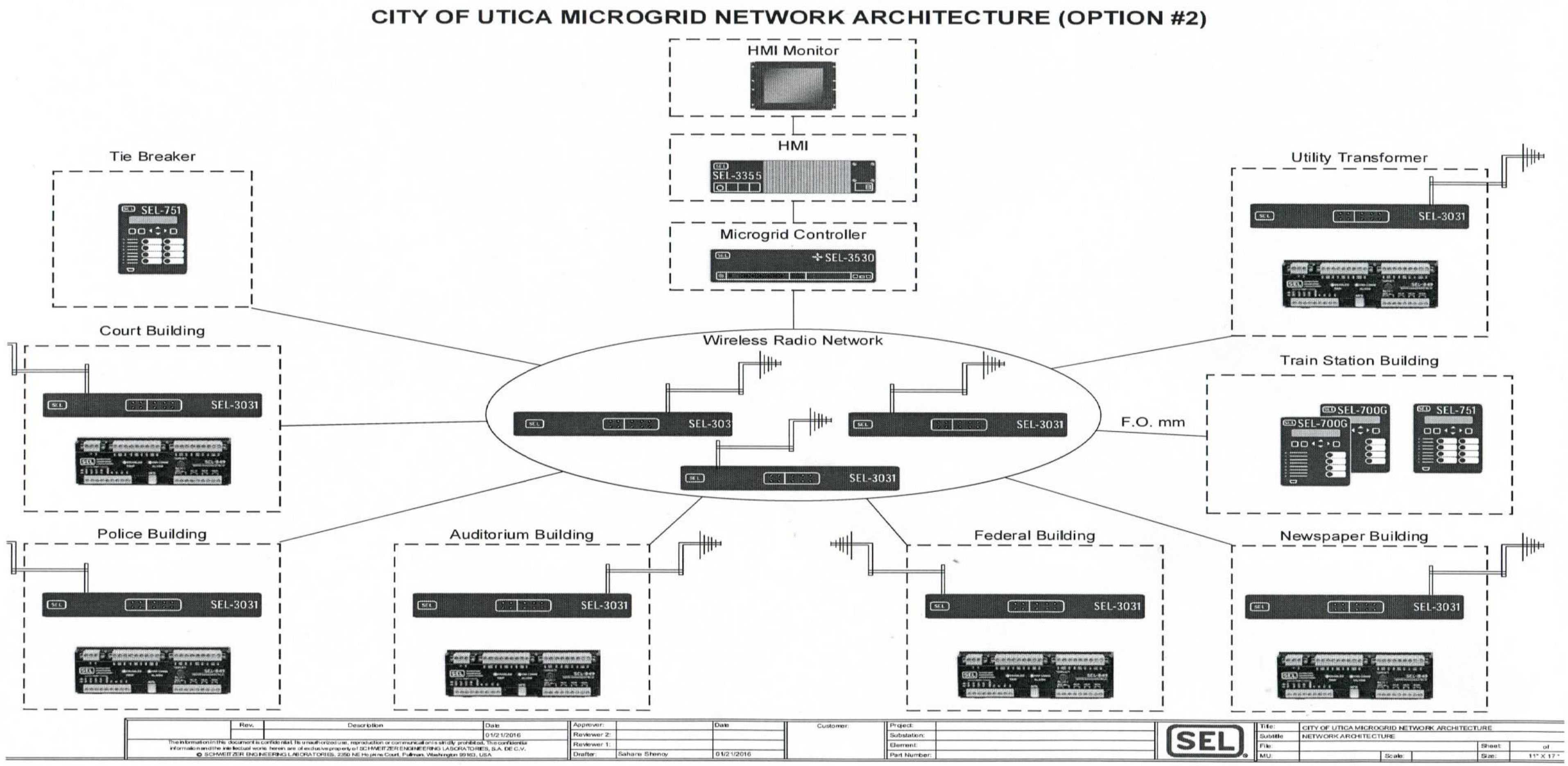
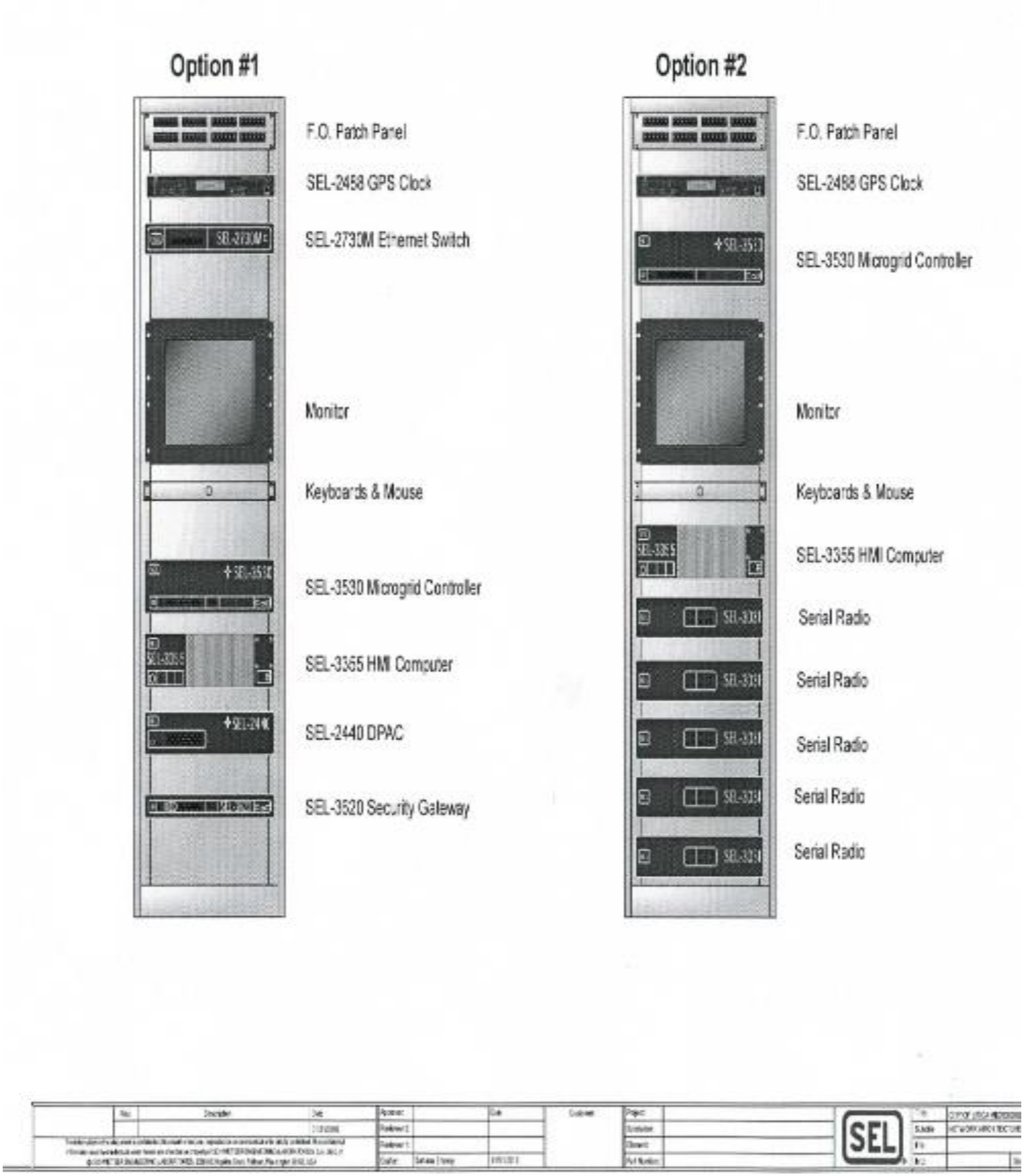


Figure 3-14: Wireless MG Architecture Diagram

Figure 3-15: Control Panels for Fiber Optic and Wireless Architecture



MG and Building Controls Characterization

Two of the six MG customers (the Train Station and the Memorial Auditorium) currently have Building Energy Management Systems (BEMS).The primary functions of those BEMS is to optimize the operation of the HVAC systems. It is proposed to install the MG control system at the Train Station. The existing BEMS systems will be integrated with the MG controller responsible for providing optimum supply and return temperatures of the MG central hot water system. The hot water supply temperature will be modulated in accordance with outdoor temperature sensors by specially developed algorithm. The existing individual cooling systems will be also controlled by the central MG controller.

As described in the previous Subtasks the MG controller has the capability to perform the following functions:

- Automatically connecting to and disconnecting from the grid
- Load shedding
- Black start and load addition
- Performing economic dispatch and load following
- Demand response
- Storage optimization
- Maintaining frequency and voltage
- PV observability and controllability; forecasting
- Coordination of protection settings
- Selling energy and ancillary services
- Data logging features.

As described above the MG DER's have redundant electric and thermal capacity to meet the required electric and thermal demands of the MG buildings during emergency conditions including the severe weather and disconnection of the utility electric and gas supplies.

It is also proposed to install BEMS at the City Court, Police Station, the Federal Building and the Newspaper building. All BEMS systems will be integrated with the MG controller. The BEMS will allow to implement a number of energy efficiency measures which will result in reduction in the electric and thermal demand and substantial savings in electric and thermal energy consumptions. Some of these measures are described below.

The MG will be equipped with an advanced metering infrastructure (AMI) that will measure, collect and analyze energy usage, and interacts with advanced smart electricity meters, gas meters, BTU meters, and water meters, through various communication media. Due to the importance of load balancing on MGs, AMI is important for rapid sensing, communications and response capabilities.

Smart meters will be installed at each customer. The smart meters will provide a platform for a two-way communication network between the utility and MG controller and each participant's meter. Smart meters will communicate with building systems (demand generating devices) through a wireless communication system. The building's area network will link into a Local Area Network (LANs) to establish connectivity between network devices (e.g., smart meters) and the MG's central control system. The LAN will also use a communication system, such as wireless radio frequency (rf) mesh to establish connectivity between the electric meters and stand-alone cell relays that transmit signals to the central control system.

Due to incorporation of two sources of power supply as well as demand response, the MG will be equipped with an active distribution system that can manage the influx of load and bi-directional flows of electricity. The installation of supervisory control and data acquisition (SCADA) at critical points on the MG distribution system (e.g., all circuit breakers and switches) will provide the necessary monitoring, communications and control capabilities for distribution automation.

The major advantage of the MG system is easier implementation of building automation because the major and ancillary equipment is consolidated in one location. Computerized automatic controls will significantly affect the individual building system performance. This will allow the MG controller to monitor performance at many points of the building systems. The software includes the following functions:

- Automatic controls that can interface with other control software (e.g., equipment manufacturers' unit-mounted controls)
- Energy management system (EMS) control
- Hydraulic modeling, as well as metering and monitoring of distribution systems
- Using VFDs on equipment to improve system control and to control energy to consume only the energy required to meet the design parameter (e.g., temperature, flow, pressure).
- Computer-aided facility management (CAFM) for integrating other software (e.g., record drawings, operation and maintenance manuals, asset database)
- Computerized maintenance management software (CMMS)
- Automation from overtrades (e.g., fire alarm, life safety, etc.)
- Regulatory functions (e.g. federal, state and local agencies, etc.).

Automatic controls should include standard equipment manufacturer's control logic along with enhanced energy-efficiency control logic. These specialized control systems can be based on different architectures such as distributed controls, programmable logic controllers, or microprocessor-based systems. Beyond standard control technology, the following control points will be needed for primary equipment, ancillary equipment, and the overall system:

- Supply and return hot/chilled water temperatures
- Head pressure for distribution medium
- Stack temperature
- Carbon monoxide and/or carbon dioxide level
- Differential pressures
- Flow rate of distribution medium
- Peak electric and hourly heat energy output
- Flow rate of water and fuel(s)
- Reset control of temperature and/or pressure
- Night setback
- Variable flow through equipment and/or system control
- Variable-frequency drive control
- Thermal storage control
- Heat recovery cycle.

Computerized energy management and control systems provide an excellent means of reducing utility costs associated with operation of the building HVAC systems. These systems will incorporate advanced control strategies that respond to changing weather, user conditions, and MG rates to minimize operating costs. The building systems should be controlled using a two-level control structure. Lower-level local-loop control of a single set point is provided by an actuator. For example, the pressure differential control valve located at the furthest customer is controlled by adjusting the opening of a valve that provides hot water to the building. The upper control level, supervisory control, specifies set points and other time-dependent modes of operation.

The performance of the building systems can be improved through better local-loop and supervisory control. Proper tuning of local-loop controllers will enhance comfort, reduce energy use, and increase component life. Set points and operating modes for plant equipment will be adjusted by the supervisor to maximize overall operating efficiency.

Hot-water loop consists of pumps, pipes, valves, and controls. Two different types of pumping systems are considered: primary and primary/secondary. With a primary pumping system, a single piping loop is used and water that flows through the boiler also flows through the piping network. The MG customers currently use fixed-speed pumps with their control dedicated to boiler control. Dedicated control means that each pump is cycled on and off with the boiler that it serves systems with fixed-speed pumps and two-way heating valves that incorporate a water bypass valve to maintain relatively constant flow rates and reduce system pressure drop and pumping costs at low loads. The valve is typically controlled to maintain a fixed pressure difference between the main supply and return lines. This set point is termed the hot-water loop differential pressure. Changing the systems to variable- speed pumps will reduce pumping costs and electric demand and consumption.

Multiple boilers, currently arranged in parallel with dedicated pumps, provide the primary source of heating for the customers. Individual feedback controllers adjust the capacity of each boiler to maintain a specified supply water temperature. Additional control variables include the number of boilers operating and the relative loading for each. For a given total heating requirement, individual boiler loads can be controlled by using different water supply set points for constant individual flow or by adjusting individual flows for identical set points.

Primary/secondary hot-water systems should be changed to variable-speed pumping. In the primary loop, fixed-speed pumps will provide a relatively constant flow of water to the boilers. This design ensures good boiler performance and reduces the risk of water vapor condensation on the boiler surfaces. The secondary loop incorporates one or more variable-speed pumps that are controlled to maintain water loop differential pressure set point.

Temperature set point: water supply temperature set points depending on the outdoor temperature. Night setback is often used in winter to lower the building temperature during unoccupied times and reduce the heating requirements. Setup and setbacks can also be used during occupied periods to temporarily curtail energy consumption.

Control of a hot-water heating system is as follows: as the heating load increases, the user controller responds to lower temperatures by opening a control valve and increasing the flow of hot water through the building. Increasing water flow reduces the temperature of the water returned to the boiler. With lower return water temperature, the supply water temperature drops, which causes the feedback controller to increase the boiler firing rate to maintain the desired supply water temperature.

A supervisory controller establishes modes of operation and chooses (or resets) values which cause the feedback controller to increase the water flow. This increases the hot water flow and heat transfer load.

Boiler heating plants will be operated automatically by energy management and control systems to reduce utility costs associated with maintaining proper environmental conditions. Boiler efficiency depends on many factors, such as combustion airflow rate, load factor, and water temperature in hot-water boilers (or pressure for steam boilers). Opportunities for energy and cost reduction in boiler plants include excess air control, sequencing and loading of multiple boilers, and resetting the hot-water supply temperature set point (for hot-water boilers).

The DER's plants located at the Court House and the Train Station will be equipped with supervisory control and acquisition systems (SCADA). SCADA consists of data acquisition (i.e., sensing and communications), data processing, remote control of mechanical devices (i.e., switches), event processing and other data analysis functions required to support the automated operation of a system. On a MG, SCADA will be deployed to monitor and control electric and heat generation, storage devices, distribution equipment and other ancillary services such as capacitors and other VAR-control devices.

The description of the SCADA components is provided below.

1) The SCADA server will communicate with the process control hardware via the plant Ethernet network. Server-1 will contain the tag database, process graphics files, manage alarms and events, which enable the operators to monitor and control the entire building. For reliability, a 2^{nd} SCADA Server-2 that mirrors the primary server, Server-1 will be installed. Server-1 and Server-2 will be configured to operate in a redundant fashion so if the primary fails, the backup takes over in a bump-less transition. The other advantage of having redundant servers is that maintenance can be performed on one server at a time without ever losing the ability to monitor and control the plant. Server -1 is also used as an Engineering Work Station (EWS). The EWS has SCADA and Programmable Logic Controller (PLC) configuration software loaded on it whereby MG technicians can make programming changes and perform system diagnoses.

2) In addition to back-up the SCADA Server-2 will be used as a Customer machine from which plant operators can monitor and control the equipment.

3) The Data Historian will be used to archive plant operating parameters, fuel data, emissions data, production information and energy data. The historian software is specifically designed to compress the data to minimize the amount hard-drive space used. Reports and trends will be generated at any one of the computers on the system via the plant network.

4) The Web Server will be used to display plant information on the internet. This is a useful tool for the operations staff to monitor the plant remotely.

5) The dual screen SCADA system provides another point of access into the plant system. Normally the large screen will display an overview of all the major plant parameters such as import power demand, fuel usage, statuses of major equipment, distribution pressures flows and temperatures. The small display screen is used for day to day plant operation and monitoring.

6) All alarms and events will be stored in the SCADA server and/or plant historian and can be retrieved as needed. A printer will be also available on the plant network so graphics and reports can be printed from any one of the computers.

7) Plant equipment that have communication capability such as variable speed drives, boilers, chillers, metering devices, etc. will be integrated with the plant control system. The connection to this equipment will be through a serial interface or through Ethernet.

8) The Balance of Plant (BOP) PLC system will be used to monitor and operate all control system components outside of the major vendor equipment. For ease of integration, the PLC used for this application will be of the same manufacturer as the type supplied with the boilers, chillers and other major equipment.

9) The BOP remote input/output (I/O) cabinet(s) will be located at a considerable distance from the main cabinet. This is done to reduce the amount of field wiring for the instrumentation and controls.

10) The CHP and other DER's packages are furnished with its own preprogrammed PLC's from the manufacturers. In addition a local touch screen Human Machine Interface (HMI) is provided on the front of the packages so operators can monitor and control this equipment locally.

11) The boiler control system will consist of two PLCs. One PLC will be used for the Burner Management System (BMS) and the other for the Combustion Control System (CCS). The BMS provides the necessary protection for the boiler and burner such as low water trips, high pressure trips and flame safeguard system trips. In accordance with NFPA 85, the BMS must be a separate and independent control system from the CCS. The CCS is used to control the fuel system, combustion air, flue gas re-circulating system, and for monitoring real-time parameters.

12) The existing chillers will be furnished with its own preprogrammed PLC from the manufacturer. The advantages of using a PLC-based system in lieu of a standard chiller control panel are: PLCs are more rugged and robust, custom site specific programming is much easier to do and integration with the plant system is better because the chiller PLC will be the same manufacturer as the other control system hardware.

13) The plant Ethernet network backbone is fiber optic in a ring configuration. If a failure were to occur at any one point in the ring, communication is automatically re-routed through the managed network switches so the system remains on-line.

Preliminary Capital Cost Estimate of the MG System

The capital cost of the MG system (Table 3-5) is based on budget estimates received from different vendors.

Table 3-5
MG Preliminary Capital Cost Estimate

Item	Cost,$
Four(4) 400kW Recip.Package Base	**1,237,600**
Jacket Water and Mixture Coolers	38,234
SS Exhaust Silencer	33,948
SCR Catalytic Convertor inc. Oxi-Cat	278,470
Modbus Interface for Data Exchange	8,200
Gas Meters incl. Monitoring	11,600
Power Meters	9,545
Island Mode Capability	9,284
Master Control for Island Mode	37,430
Demand Control,HMI and Visualization	11,300
Data Monitoring and Data Logging Package	5,000
SCADA System	8,000
Gas Pressure Regulator	4,770
Electric Slam Shut Valve for Gas Line	5,025
Air Inlet and Outlet Louver with Actuator	11,100
AC for Control Cabinet	4,320
Dust Filter for Air Inlet	5,200
Lube Oil Supply	6,540
Initial Supply of Glycol and Oil	5,600
Two (2) CHP 335kW Recip. Complete Packages with SCR's	**1,120,000**
Gas Meters with Pressure Regulator and Monitoring	9,700
Power Meters	2,800
SCADA System	8,000
Solar PV 150kW Panels with Invertors	**475,000**
Electric Battery 250kW with Invertors, transformer and controller, installed	**977,000**
BTU Meters with Sensors	42,000
Propane Storage Tanks	68,000
Sensors and Panels	86,000
Stacks	90,000
MG Interconnection to Electric Utility	68,000
Transportation of Equipment to the Site	23,000
Permits	95,000
Installation of all Equipment and Instrumentation	**3,055,000**
Electric Cable,Hot Water Piping and Fiber Optic Underground Material and Installation	**3,010,000**
Engineering Cost	**1,000,000**
Contingency	**1,180,000**
Grand Total	**13,040,666**

Section 4

Assessment of MG's Commercial and Financial Feasibility

Commercial Viability – Customers

The MG system is located in the oldest part of the City supplied with an aged utility electric and gas distribution infrastructure. The proposed MG includes six (6) customers: the City Court House, the City Police Station, the Memorial Auditorium, the Boehlert Train station, the Federal building and the Newspaper building. All six customers will be continuously (including critical situations) supplied with electricity and hot water by the DER's of the MG. The selected customers are critical to reliable operation of the City and should these loads go unserved (e.g. in a storm event or other emergency with no MG) the number of individuals actually affected will be about 65,000 (all population of the City). The customers are briefly described below:

- **The City Court and Police station** are responsible for public order, safety and transportation in the City.
- **The Utica Memorial Auditorium,** which during normal situation provides entertainment and sporting events, but in critical situations will be used as a public shelter housing about 10,000 to 15,000 people.
- **The Boehlert Train Station (Union Station)** is a regional intermodal transportation center connected to New York, Ontario and Western Railway (southern track) and Delaware, Lackawanna and Western Railroad (northern track). The Station also serves AMTRAK, inter City and City bus passengers, and taxis. Currently the following bus companies utilize the station: Greyhound, Birnie Bus Services Inc., Utica-Rome Bus Company, Adirondack Trail ways, Chenango Valley Bus Co., and Utica Transit Authority. The station is located in the oldest section of the City of Utica referred to as Bagg's Square. The station is located in a NY State Economic Development Zone and is listed on both the State and National Registers of Historic Places. Title to Union Station is now held by Oneida County.
- **The Alexander Pirnie Federal Government Building** currently houses the US Social Security Administration, US Bankruptcy Court, Federal Courthouse, US General Services Administration and Federal Bureau of Investigation. It is a historic post office, courthouse, and custom house. It was listed on the National Register of Historic Places in 2015.
- **The Observer-Dispatch** is the main source of print and online news in the Mohawk Valley in and around **Utica**, **N.Y.** for almost 200 years.

It is proposed that the City of Utica and Oneida County will be joint owners of the MG DER's and all MG infrastructure including the electric and hot water distribution system, and control and communication system (See Sub Task 3.2 below). The MG owner will execute contractual energy purchase agreements with the MG customers and bill the MG customers in accordance with developed electric and hot water rate structure reflecting the recovery of capital, fuel and operating expenses. The customers will purchase electricity and thermal energy continuously during the year including the normal and islanded operations. In addition to electricity the MG owner will supply thermal energy in the form of hot water to all six MG customers.

The major benefits of the MG system to the electric utility and the NYISO will be as follows:

- Reduction in electric peak demand

- Reduction in electric transmission and distribution losses
- Reduction in congestion and deference of upgrades of the electric distribution system in the downtown of Utica, NY.
- Ability to improve reliability and safety of electric supply to other customers in the downtown of Utica, NY.
- The MG will have the capacity to provide ancillary and demand response services to electric utility and NYISO (See Sub Task 3.5).
- Reduction in release pollutants (including GHG) to the environment.

Customer Benefits from the Project will include:

- Increase in energy efficiency (lowering energy consumption) by demand and consumption reduction of electricity, natural gas and water use, implementing building energy management systems, lighting retrofits, HVAC upgrades, and building envelope improvements,
- Electric and thermal energy cost reduction in comparison with current conditions
- Increase of reliability and safety of electric and thermal supply
- Increase in quality of electric supply
- Increase in security of energy supply during natural disasters and other risks
- Increase in energy system sustainability
- Improvement of the environment.

The project will increase community resilience to electric service disruption caused by severe weather and avoid associated substantial economic losses from disruption of customer operations.

All six MG customers identified above will continuously (including emergency situations) purchase electric and thermal services from the MG. The MG operation will allow the electric utility to improve the electric supply to the neighboring customers located in the oldest part of the City downtown with aged utility electric and gas supply infrastructure.

The operator of the MG system will supply electricity and hot water to MG six customers at higher reliability and prices lower than the customers are now paying for electricity supplied by electric utility and natural gas supplied by independent gas suppliers. The MG customers will recognize substantial reduction in electric and thermal peaks and consumption resulting in reduction in energy costs. The MG system will provide substantial improvement in reliability of energy supply particularly during emergency situations like storm event. The current customer energy systems will improve the energy efficiency because of advanced control and communication system of the MG.

The MG six customers are already solicited and registered. They actively participated in the feasibility study providing information about their systems and energy usage. Three (3) of the customers (City Court, Police Station and the Train Station) are owned and managed by the City of Utica and the Oneida County, NY, and the Memorial Auditorium is closely associated with the City. The Federal and the Newspaper buildings expressed interest in connecting to the MG system.

Commercial Viability - Value Proposition

The values that the MG will provide directly to its participants, to the community at large, the local electric distribution utility and the State of New York are:

- The MG system will increase community resilience to electric service disruption caused by severe weather and avoid associated substantial economic losses from disruption of customer operations.
- The MG system will continuously provide uninterruptable electric and heat supply to the connected customers around the year including emergency situations.
- All MG customers' electric and thermal peak and consumption and cost will be reduced as compared to the existing operation (See Sub Task 3.5).
- MG system paired with combined heat and power (CHP) will generate electricity at high efficiency with corresponding reductions in fuel consumption and emissions.
- Currently the selected customers purchase electricity or natural gas from the electric utility. The utility supplied electricity is generated in an inefficient manner by single purpose electric generating plants many miles away, where waste heat from the generation process is discarded into the air or into surrounding water bodies. Natural gas is burned in individual boilers and used in an overall less efficient manner than in a highly efficient MG system using natural gas-fired CHP. The MG system will change the energy generation paradigm, maximizing all of the useful energy in a closed-loop hot water system that matches thermal energy supplies to thermal energy needs.

The Utica community will realize the following benefits from the construction and operation of this project:

- The community will secure reliable and safe operation of the MG customers vital to the wellbeing to the City
- Economic development of the downtown area and job creation
- Improvement of electric supply to neighboring customers
- Improvement of the environmental conditions in downtown and avoidance of greenhouse gases (GHG)
- Reduction of other pollutants in the downtown area (NOx, CO,PM)
- Improvement of property values
- Opportunity to start development of citywide district energy system.

The MG system will provide the following benefits to the utility:

- Reduce peak demand on the system and help avoiding the need to invest in new utility assets to serve that area.
- Reduce capital expenditures necessary to meet the utility's required level of service reliability.
- Energy benefits, including energy cost savings and reductions in the cost of expanding or maintaining energy generation capacity.
- Reliability benefits, which stem from reductions in exposure to power outages controlled by utility.
- Power quality benefits, including reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary power interruptions.
- Environmental benefits, such as reductions in the emissions of GHG and air pollutants.
- Public safety, health, and security benefits, which include reductions in fatalities, injuries, property losses, or other damages and costs that, may be incurred during prolonged power outages. Such outages are generally attributable to major storms or other events beyond the control of the utility.
- Improve the resilience of the electric distribution infrastructure and defer generation, transmission, and distribution investments (upgrades) and congestion in downtown of Utica, NY
- Improve reliability for critical loads

- Provide outage management
- The MG will have the capacity to provide ancillary and price-driven demand response services to electric utility and NYISO
- Reduce peak loads for the interconnected grid.

More specific utility benefits:

Bulk System

- Avoided Generation Capacity (ICAP), including Reserve Margin
- Avoided Energy (LBMP)
- Avoided Transmission Capacity Infrastructure and related O&M
- Avoided Transmission Losses
- Avoided Ancillary Services (e.g. operating reserves, regulation, etc.)
- Reduction of wholesale market price of electricity

Distribution System

- Avoided Distribution Capacity Infrastructure
- Avoided O&M
- Avoided Distribution Losses

Reliability/Resilience

- Net Avoided Restoration Costs
- Net Avoided Outage Costs.

The development of the proposed MG systems in the proposed areas is very timely and can be incorporated and integrated in the overall City economic development plants.

A municipal City/County MG ownership model is recommended for the following reasons:

- The MG customers are critical to the reliable operation of the City and the County during the year, particularly during emergency situations (sever weather, snow storm or hurricane)
- The City owns the Court House and the Police Station facilities
- The County of Oneida owns the Train Station
- The Memorial Auditorium Authority is related to the City
- All MG customers are interested in improving the energy infrastructure and reducing energy cost for their buildings
- The City is planning to develop in the adjacent area a large hospital equipped with a CHP facility
- The City is interested in developing a City-wide district energy system (DES) and the proposed MG system will be the first energy island of the DES in the downtown of Utica, NY
- The City is planning to start separation of the storm and sanitary sewer system and will be conducting extensive reconstruction of the City streets. The installation of MG electric cables, hot water piping and communication cables could be combined in one trench with retrofit of the sewer system
- The City owns the right-of-ways to all streets and can install electric wires and hot water piping at the underground of the streets
- The existing electric, gas and water infrastructure in the proposed MG service area (Bagg's Square and Harbor Point) is the oldest in the City and is subject to limitations for expansion
- The City is actively conducting rehabilitation and economic development in the Bagg's Square and Harbor Point areas

- The City/County can retain a private company development company which will construct and operate the MG system
- The City/County have excess to low cost municipal financing.

Strengths of the Municipal Model:

- City/County procurement guidelines, along with long-term ownership, ensure control and close alignment with the City's goals, including economic development, environmental and social policies
- Development risk can be transferred to a third party via a Special Purpose Vehicle
- City controls zoning, right-of ways and building permits, so can create incentives, lower the cost of capital and prioritize sustainability, efficiency and carbon performance
- City/County ownership enables provision of lower-cost long-term financing compared to private sector borrowing
- Operating profits would flow back to the City/County and support the delivery of other services
- System expansion or modification can be encouraged, coordinated and controlled by the City
- City/County may have access to grants not available to private sector owners
- After development of the MG system the City/County may obtain some revenue in lieu of taxes from system profit.

Weaknesses of the Municipal Model:

- The City/County have to become comfortable with playing the role of energy supplier. The City/County have to embrace the MG system as an economic development and job creation tool linked to energy efficiency, public safety and emission reductions
- Long-term financing costs are reliant on the financial strength (i.e. the credit rating) of the City and County
- Without a clear commitment to finance the project, the system may not reach its full (sustainable) potential and stagnate.

The technologies proposed for the MG system is widely used in the energy industry. The technologies include: on-site efficient, clean, small carbon footprint conventional CHP and renewable generation (solar PV); electric and thermal storage; advanced controls and automatic ability to operate independently from the main grid for an extended period of time (automatic connect and disconnect from main grid; demand response capability; balance system supply and demand; optimization of power system based on performance economics; reduced carbon footprint; improved reliability; advanced metering; distribution supervisory control and data acquisition (SCADA) systems; optimized and balanced in real time electric and thermal system supply and demand.

The project represents a typical neighborhood of a New York State City and can be easily replicated. The project can be expended and replicated in other locations of the Utica and the New York State. The project will also demonstrate the island type development strategy and be integrated with the future central hospital CHP facility to be developed by the City in the adjacent area. The project will demonstrate the advantages of municipal ownership, which can be widely replicated in other NYS municipalities.

There is a major bottleneck in the New York transmission system between Utica and Hudson Valley areas. This congestion first appeared in the mid-1990s and has been increasing over the past 25 years as demand has grown. US DOE have repeatedly identified congestion as a national concern and designated this area as one of only two areas in the country that are Critical Congestion Areas. The winters in Utica are very cold and snowy, as the area is susceptible to Lake Snow effect. The available historic information indicates that creation of the MG districts is of prime importance to the City of Utica and the National Grid. The other important need of the City is reduction of the winter electric peak. Currently about 10% end-users are using electric resistance systems for space heating and domestic hot water.

The MG project will reduce the current electric and thermal cost to its customers by $290,256/yr (20% reduction as compared to current energy cost). The detailed revenue stream to the MG owner and potential savings are presented in Sub Task 3.5.

The proposed MG project directly promotes the objectives of the NY REV and Renewable Portfolio Standard (RPS). With assistance from the State, Utica community have been empowered to create and implement local strategies for rebuilding and strengthening the community against future extreme weather events. In July 2014, plans were completed in Oneida County impacted by severe flooding in 2013. The approach was focusing first on developing long-term resiliency strategies and actions. Locally driven resiliency plans considered damage, future threats, and economic opportunities. The Oneida county NYS Rising Community Reconstruction (NYRCR) Planning Committees consist of representatives from county planning and economic development agencies, human service organizations, soil and water conservation districts, emergency services, highway services, local governments, educational institutions, business and other organizations, who incorporate their community's unique needs into their resiliency strategies. NYRCR Planning Committees took the lead in developing Countywide Resiliency Plans. Planning experts from the New York State Department of State have been assigned to each committee to provide technical assistance.

The winters in Utica are very cold and snowy, as the area is susceptible to Lake Snow effect. For example, in 2011, a powerful ice storm struck Utica area. A dense layer of cold air coupled with heavy rain created ice accumulations in excess of three inches. The storm dumped freezing rain on the region for an unprecedented 5 days. Flooding from heavy rains and significant runoff from melting snow forced the evacuation of many homes and caused widespread damage across the region. The ice coated all outdoor surfaces, destroying electric power infrastructure causing widespread power outages. Due to the severity of damage to roads and bridges from downed trees and flooding, power was not restored in many areas for up to two weeks. Heavy freezing rain and subsequent icing caused damage to transmission and distribution facilities. National Grid reported that 100,000 of its customers were without power on January 8, 2011 and estimated that it would take 5 to 6 days to restore power to most customers. Over the past five years, upstate power customers, have on average experienced one major storm-related power outage every two years.

The proposed MG system will positively contribute to the New York State Renewable Portfolio Standard Policy to increase renewable generation the NYS. The MG system includes a 150 kW solar PV unit and 250kW electric battery storage.

The development of the MG will benefit the economic development of the City of Utica and result in job creation.

The societal economic benefits

The community of Utica will benefit from area economic development, job creation and reduction in pollution particularly reduction of GHG. MG system offers substantial economic benefits to end-user customers and the community of Utica, NY.

Fuel Savings

The proposed MG system allow two sorts of fuel savings: first, the absolute amount of fuel used is reduced through increased efficiency and combined heat and power (CHP) generation and second, part of fuel currently burned will be replaced by renewable energy source (solar PV). In addition the electric cost for running the electric chillers will be reduced by use of ice storage, shifting load away from on-peak hours.

As indicated in Sub Task 2 the MG CHP facility has a combined (electric and thermal) efficiency of 80%. The electric utility generates electricity at the single purpose electric plants with efficiency of 33%. Taking into account the losses in the transmission and distribution electric grid (average 6% based on US EIA information) the overall utility electric generating efficiency is reduced to about 27%

On the thermal side the potential MG savings depend on the seasonal efficiency of existing boilers replaced by CHP. The existing boilers at the Train Station are old and their seasonal (annual) efficiency is about 55%, while the seasonal efficiency of the boilers at the Court House is about 60%. The extensive district heating experience (Jamestown, Buffalo, and Schenectady, NY) demonstrates that fuel saving recognized from replacement of existing boilers with CHP system, amounts to 35-45%.

Local and Regional Employment Increases

The local and regional employment is stimulated both on a short-term basis during construction and continually over the life of the project. The job skills required for MG system construction include heavy equipment, welding, large-scale construction and assembly and straightforward labor. These skills are available and even in surplus in the local labor market.

Local and Regional Retention of Funds

The MG system provides economic benefits at the state, local and federal level far in excess of the simple cost savings. Essentially, this occurs because money spent for labor stays in the local market. Extensive experience with district energy systems (DES) demonstrates that urban district energy allows retaining locally 73% of the energy costs, while for a traditional system with distributed boilers and furnaces this number is only 31%.

As mentioned, the construction and operation of the system provides jobs for workers from the local and surrounding communities. The money from their paychecks, in turn, stays in the local community buying local goods and services. This “multiplier effect” thus has an impact at the local and regional levels. At the local level, the U.S. Department of Commerce estimates that a dollar spent locally will be recycled three times in urban areas.

Keeping the money in the local economy also has a strong positive effect on the finances of local government through sales and income taxes. A maintenance worker in the MG system will pay income tax, and will then spend the money. A substantial portion of the worker’s income goes to items that are taxed, and these revenues flow to the local government. And even for non-taxed items such as groceries, the maintenance workers’ expenditures go in part to the store clerk’s salary, which is taxed, and then to the fraction of his or her purchases which are taxed. Of course the fraction of each original dollar which remains to be taxed is smaller at each step in the iteration, but the result is still a much more substantial contribution to the local government's finances than might be apparent at first glance. The MG project will be combined with and serve as a stimulus to other economic development projects in downtown of Utica, including commercial development and affordable housing.

The combination of MG piping and electric cables installation with the refurbishment of the City sewer system will allow substantial savings in the costs of opening streets and financing integrated projects which is more efficient than doing it for a collection of nominally unrelated activities. And the reliable, cost effective energy supply and environmental benefits inherent in the MG system can serve as an inducement to join in the urban re-development effort.

The extensive experience with district energy systems demonstrated that the economy of Jamestown, Buffalo, and Schenectady, NY benefited substantially from the development of the CHP/district heating systems, the reduction of cost of energy to consumers, and the reliability of the energy infrastructure. For example, during the system operation the district heating customers (close to one hundred) of Jamestown, NY experienced a cumulative savings of $17 million from participating in this system instead of operating their individual equipment. The reduction in energy cost in Jamestown helped to attract new business and made it easier for existing customers to remain in business and expand. Moreover, the increase in business profitability and consumer purchasing power, which results from lower energy costs, stimulated business investment and consumer spending, and furthered employment growth in Jamestown.

Economic Development Potential of Reducing Energy Costs

The reduction of energy costs will make the local businesses more competitive with other states and regions of the nation. As a result, the City is better able to attract new businesses, and to retain and expand existing business. Moreover, lower energy costs increase business profitability and consumer spending, and contribute to continued job growth.

Generally, incremental jobs, wages and output of goods and services created as a result of an energy cost reduction would be sustained over time because the incremental business profits and consumer purchasing power would be available in each subsequent year, resulting in a continued higher level of business investment and consumer spending.

Savings that result from MG system can be used to foster additional business and consumer investment, as well as to increase consumer spending for non-energy related products and services, some of which create additional new jobs in the City. In addition to the jobs created by spending of energy savings, jobs are created by the purchase and installation of new equipment, to the extent that the equipment or its components are installed by City labor.

The total cost of MG construction is estimated at $13 million. The permanent jobs created can be estimated using the following methodology: every clean energy construction job investment of $92,000 creates one permanent direct job (The Economic Benefits of Investing in Clean Energy. Department of Economics and Political Economy Research Institute (PERI), University of Massachusetts, Amherst, June 2009). The above referenced document also indicates that $1 million investment creates 5 indirect jobs and 0.4(direct +indirect jobs) induced jobs. Therefore the construction of the MG project in the City of Utica will result in creation of 211 jobs.

Commercial Viability - Project Team

The MG Project Team Members include:

- Project Manager -The Administration of City of Utica, NY, Utica Department of Urban and Economic Development, Urban Renewal Agency, Industrial Development Agency, Engineering Department - potential owner of the MG system.
- County of Oneida, NY- Engineering Department - active participant and potential co-owner of the MG system.
- Bagg's Square Association – active participant and developer of the area where the MG system is located.
- Utica Harbor Point Local Development Corporation – active participant and developer of the area where the MG system is located.
- National Grid - participant and cooperating partner.
- Mohawk Valley Economic Development Growth Enterprises Corporation (EDGE). EDGE is a vertically integrated economic development organization that assists businesses to locate sites and infrastructure development in Oneida and Herkimer Counties - Project supporter.
- Cornell University Cooperative Extension of Oneida County – project supporter.
- MG customers – end users
- Joseph Technology Corporation – project consultant with extensive experience district energy, involved in development of 25 district energy/CHP systems in the US and overseas.
- Potential Developer/Operator –Cogeneration Power Technologies, Utica; Johnson Control; Synapse Partners, Syracuse.

The City of Utica is the focus of regional economic revitalization efforts, most notably in the Bagg's Square and Harbor Point areas. For a long time the City of Utica, NY is interested in development of a downtown district energy system and is the project manager of the current MG project. The City views the development and implementation of the MG Island as the first step in such a development. Two buildings of the MG system are City owned. The train station- the main MG system customer belongs to the Oneida County. The Auditorium building is owned by an authority partnered with the City. The other two MG customers – the Federal building and the Newspaper building are active participants closely integrated with the City and the County.

The City Mayor and Common Council of the City direct the City activities. The common council has eight (8) standing committees including: economic development, municipal housing and urban renewal; finance and public safety; law and judiciary; public works and transportation; codes and neighborhood preservation; communication and internet computer technology. The committees will be actively involved in the development of the MG system.

Oneida County is a strong, vibrant, and resilient organization. Oneida County is governed by a county executive and a 23-seat county legislature. The county executive is elected by the entire county. All 23 members of the legislature are elected from single member districts.

Bagg's Square Association is an active development group dedicated to the revival of the oldest part of the City where the MG customers are located. The group was resurrected in 2013, with the help and support of the City of Utica, to promote the growth and interest in the neighborhood and to advocate on behalf of it. The Bagg's Square Development is the oldest district in the City and has an old and outdated electric and gas infrastructure, which needs repair and reinforcement.

The Harbor Point is also an old area of the City. In 2008, New York State legislation allowed for the transfer of about 20 acres of land to the Harbor Point Local Development Corporation. Active development of the area started in 2014. The area is a mixed-use development, which includes commercial facilities and residential housing. The redevelopment of both areas is a priority of the City administration. The Utica Harbor Point Development Corporation (UHPDC) is a partnership dedicated to the long-term improvements and enhancements of Harbor Point in the City of Utica.

The UHPDC is committed to assisting and collaborating on the overall development, promotion and management of Harbor Point and its environs with a focus on enhancing the economic development and attraction of new investment and improving the overall quality of life of the citizens of Utica and the surrounding region.

A private, not-for-profit corporation, EDGE is an integral part of the long-term effort by the public and private sectors to strengthen opportunities and open the door for new businesses and industries to locate and grow within the region. EDGE promotes the Mohawk Valley's people, work force, quality of life, infrastructure, sites, and everything else the region has to offer businesses, site selection specialists and industrial developers. EDGE links the area's economic development organizations to streamline projects. EDGE customizes financing and assistance packages to help companies interested in locating or expanding their operations and job base in Oneida and Herkimer Counties.

Cornell Cooperative Extension Oneida (CCEO) is a subordinate governmental agency that operates under a form of organization and administration approved by Cornell University as agent for the State of New York. CCEO programs positively impact key issues linked to the critical social, economic, and environmental needs of the Utica Community. CCEO is a partner in creating strong and resilient economy, practicing environmental stewardship, and guiding sustainable development practices.

Assessment of MG options for these developments is a timely and important undertaking for the City and above listed organizations.

The initial developer/operators under consideration include Cogeneration Power Technologies, Utica; and Johnson Controls.

Cogeneration Power Technologies was formed as part of the Bette Companies, with Bette & Cring Construction Group, one of Upstate New York's largest construction companies. Today, Cogeneration Power Technologies is recognized as an authority in planning, developing, and operating cogeneration systems. The company developed and operates the Burrstone Energy Center, located in the City of Utica, NY. This project is a 3.6 MW CHP system at St. Luke's Hospital with electric service to St. Luke's residential Health Care Facility on the same property, and electric service via privately owned underground wires to Utica College across the street. The thermal output is used on-site at the hospital. When it is economical the system exports power back to utility.

Cogeneration Power Technologies was also involved in the following projects in New York State: Albany Medical Center Cogeneration Plant – Albany; GUSC Energy Biomass CHP Plant – Rome; St. Joseph's Hospital Health Center Cogeneration Plant – Syracuse; and Union College Cogeneration Plant – Schenectady; Avila Active-Adult Community Cogeneration Plant – Albany.

Johnson Controls is the largest provider of energy performance contracting services. Johnson Controls currently manages 730 active performance contracts, reflecting more than $5.4 billion of guarantees in force. Historically, the company implemented 3,000 guaranteed performance contracts. Based on Verify Markets' 2011 ESCO market analysis, Johnson Controls holds 18.2 percent of the performance contracting market – the largest market share of any one single ESCO in North America. Almost all of the projects required that the company design, engineer, install, maintain and repair energy services.

All major MG equipment suppliers are identified and already provided budget estimates for the project. Based on these estimated the project preliminary cost was developed (See Task 2 Progress Report).

The City/County joint venture has substantial financial strength and bonding capacity.

The legal advisor on the team is the Corporation Counsel Mr. William M. Borrill. Under the City Charter, the Corporation Counsel serves Utica as the chief legal adviser for the City and the chief codes prosecutor on behalf of the People of the City of Utica. It has a staff of 9 full-time, part-time, and volunteer public servants in the City Corporation Counsel's. The Corporation Counsel provides legal guidance and support for the Mayor, Common Council, City departments, and boards and commissions.

Commercial Viability - Creating and Delivering Value

The MG technologies were selected based on maximum annual efficiency of the CHP units.
The MG customers currently own substantial number of natural gas fired boilers. The most efficient boiler will be used to supply the thermal peaking capacity and the backup of the MG system. The control and communication technology selected for the MG will allow optimizing the ratio of the electric and thermal loads and maximizing annual energy efficiency. The MG will have the capability to participate in the NYISO demand response program and sell and purchase of electricity from the utility grid to the mutual benefits of the utility and MG.

The permits required for the MG system are typical for any construction project, will be issued by the City and will not cause any delays.

The proposed approach for developing, constructing and operating the MG system is as follows. The City economic development department in close cooperation with the Oneida County will be the general advocates and source of information about the MG system. They will educate the customers about the benefits of MG system, articulating and promulgating the vision to build support. The City/County will also engage other public agencies to provide supportive public policy. This is an extremely important role, because the economic benefits of a municipal-scale, multi-stakeholder MG system is new to motivate any one self-interested party to drive the process. Because MG benefits accrue to the public as well as the private sector, individual developers tend not to take on this time consuming and expensive facilitation role. As a result, without a strong facilitator driving the process, even an economically viable project can easily fall by the wayside.

The City/County or its agent will actively facilitate the development process. The City/County will create an MG Development Working Group staffed by representatives of the relevant departments, property owners who must connect in order to ensure the project’s financial viability. Establishing a Working Group staffed by key personnel gives assurance to property owners and prospective MG owner that the municipality is genuinely committed to the project. The City/County will be the central point of contact for all of the internal and external stakeholders, and will be the entity to which they turn when they need answers.

The City/County will help to accelerate the MG system development process itself and also facilitate integration of the City’s overall infrastructure plan to coordinate improvements to various underground utility services with the MG system. In the next two years the City is planning to separate the sanitary and storm sewer systems in the proposed MG area. Coordinating infrastructure development schedules will significantly reduce costs. Integrating the installation of the sewer mains with the MG infrastructure will result substantial reduction of the excavation costs for the MG system. The City/County will continue to play an active role throughout the entire MG development process. Who is playing this role should be abundantly clear to all of the relevant stakeholders.

The project engineering consultant will build on the current feasibility study and prepare a comprehensive design that looks at site-specific energy data, specific sites for MG DER unit location options and piping and electric cable underground installation route. The consultant will develop electric and thermal rate structure and comparison for each customer current cost with the MG cost, prepare and negotiate power purchase agreements with the customers in order to obtain project financing. It will also develop the financial pro forma, sensitivity analysis, and an analysis of the environmental benefits and fuel sources.

The project developer will deliver the physical assets, such as the MG energy system and the distribution system to the owner. The developer will also be the long-term MG system operator and be responsible for the ongoing technical operation and maintenance of the MG system.

The City will also establish and monitor standards of construction, operational performance, safety and pricing/consumer protection, and ensure compliance with standards and other applicable laws.

The community benefits from the MG project are described above. In order to ensure that this project creates value for the customers and the community the following actions will be required from the electric utility:

- Provide points of common coupling of the MG system with the existing utility feeders
- Evaluate and provide a permit for interconnection of the MG system to the utility feeders at points of common coupling
- Interconnect and interface the control and communication systems of the utility and the MG
- Evaluate and cooperate in utilizing the MG system demand response and ancillary capabilities.

The proposed MG CHP system was widely used in cogeneration systems similar to Burrstone CHP system in Utica, NY. The MG system will be interconnected with the electric utility distribution grid in accordance with utility requirements, which are described in National Grid / *DG Installation Process Guide per NY SIR* / July 2011 ver. 1.0: Distributed Generation Installation Process Guide for Connections to National Grid Distribution Facilities per the New York Standardized Interconnection Requirements (the NY SIR). The interconnection of the MG to the Electric Utility will offer the opportunity, when economically feasible, to participate in regional energy markets (i.e., sell excess power, purchase supplemental power, participate in demand response programs and offer ancillary services).

The MG owner will be supported by developer/operator in the following areas. In close cooperation with the MG owner the project developer will secure electric and thermal energy purchase agreements with the MG customers, secure financing, obtain construction permits, solicit construction bids from construction companies (in accordance with approved specifications), supervise the system construction, commissioning and operation of the MG system. The operator will be responsible for efficient operation of the MG system providing energy savings to the MG customers.

Preliminary estimates indicate that the MG customers will save about 20% on their electric and thermal energy bill (See Sub Task 3.5). The electric and thermal rates will include peak demand, energy consumption, and operation and maintenance components. The rates will include widely accepted annual escalators for fuel, labor and materials.

The MG owner will develop a road map for replication of the proposed system to similar communities.

The following technologies are used in the MG system: CHP units, single purpose electric generating units and electric battery storage. Ice storage systems will be also considered. The selection of the CHP units is based on combined electric and thermal load duration curves. The capacity of the CHP units will supply the electric and thermal base loads for 85% of the year. The single purpose electric generating units will supply the intermittent, peaking and back-up electric loads. The existing boilers will supply intermittent, peaking and back-up thermal loads. Back-up fuel supply in the form of one-week propane storage is also included in the project. Selection of the solar PV capacity is based on the available roof space at the Train Station and desire to reduce the total fossil fuel consumption by the system. The electric battery storage will provide demand-response and back up capacity. All DER's are integrated optimally into one system allowing maximum system efficiency with substantial fuel saving, and resilience to sever weather situations. The selection of DER's type and capacities is based on detailed load duration curves developed from interval electric meter information.

Currently the MG customers own a substantial number of natural gas fired boilers, which will supply intermittent, peaking and back-up thermal loads and leverage the MG development.

The benefits created by the MG system are described in Sub Task 3.2. The community will not incur any costs associated with the construction and operation of the MG system.

The proposed MG technologies are widely used in district energy/CHP systems. The supplementation of those technologies with advanced control and communication system will enhance and maximize their efficient use. The lessons learned indicate that the local electric utility cooperation is of prime importance to the MG project success.

The MG system operator will develop annual budget of the MG system including the revenues and expenses. The budget will be reviewed and approved by the owner of the system. The system owner, who will have the ultimate decision making responsibility, will also approve the electric and thermal energy rates. Smart meters integrated in the MG system control and communication system will continuously meter the customer electric and thermal energy peak and consumption. The operator will be responsible for MG system reliability and optimum load dispatch with maximum fuel and cost efficiency.

The major barriers to development and implementation of the MG system that needs to be overcome are:

- Obtaining close cooperation of the electric utility and engage them as a partner. The City, County and the community at-large will provide substantial support in overcoming this barrier
- Limited experience of the City/County with development of community energy systems. This barrier will be overcome during the second phase of the project by demonstrating to the City, County and community at-large of the benefits of the MG system.

Financial Viability

The business model of the project is based on created by MG energy, reliability, environmental and economic development benefits to the MG customers and the community. The created benefits will be shared between customers and the City of Utica, NY. While the MG system provides substantial benefits, it is a capital-intensive project.

Potential Revenue Streams to the MG Owner

Electricity Sales Revenue Stream

The MG system will allow avoiding purchases of electricity and transmission and distribution services from the electric utility. MG system equipped with CHP units will generate electricity and thermal energy with higher efficiency and fewer emissions than the current system. Currently the customers use purchased electricity and natural gas to power on-site hot water boilers. Electricity is generated in an inefficient manner many miles away, where waste heat from the generation process is discarded into the air or into surrounding water bodies. Natural gas is currently burned in individual boilers and used in a less efficient manner than in a highly efficient MG natural gas-fired CHP. The MG system maximizes all of the useful energy in a closed-loop hot water system that matches thermal energy supplies to thermal energy needs.

The MG customers will also avoid electric utility reactive power charges, competitive transition charges or other surcharges). Moreover, addition of fuel-free solar PV unit will benefit the customers from reduced energy market price volatility.

The preliminary analysis indicates that the MG system will reduce the total customers current cost of electricity from $738,000 to $590,400 providing about 20% savings. **So the electric revenue stream to the MG owner will be $590,400.**

Thermal Energy Sales Revenue Stream

The extensive district energy experience indicates that the MG customers will benefit from reduction of the total thermal energy cost currently paid for self-generation of thermal energy. Typically the comparison of MG thermal energy cost to individual building cost takes into consideration the potential fuel savings from use of more efficient MG energy generation system. However, the current thermal self-generation cost of the customers contains a number of hidden components, which have to be taking into consideration. The major components of the current on-site self-production cost of useful thermal energy include:

- Boiler plant initial and replacement capital
- Fuel purchases
- Boiler seasonal efficiency
- Operating labor
- Condensate return system (when applicable)
- Blow down and sewer
- Make-up water/water discharge sewer fees
- Chemical water treatment of make-up water and condensate
- Equipment repair and maintenance
- Insurance
- Inspections/annual recordkeeping
- Environmental and construction permits
- Lost building space.

More detail description of the above components is presented in Table 4-1.

Table 4-1

Description of Individual Building Thermal Self-Generation Cost Components

Capital Costs	
Construction costs of the building boiler plant vs. MG hot water supply	Includes the materials and labor for boilers, stack, piping, pumps, heat exchangers, valving, instrumentation, controls, cost of electric, gas, water and sewer services, cost of structural due to equipment weight on building floors, fuel storage (if back-up fuel is provided), etc.
Value of increased mechanical space that houses the boiler plant equipment	Includes value of basement, roof and vertical chases for flues, etc.
Cost of financing	Amount of project that is financed at the loan interest rate of the duration of the loan
Construction permits and fees	Typically a percentage of construction
Life of major equipment overhauls and replacement costs (where any of the boiler or other equipment determined to fail within the 20 year life)	This includes the replacement or overhauls of boilers, pumps, etc. over the life of the individual boiler plant.
Contract vs. installed capacity (only pay for what you need or use)	The MG contract capacity will be less than the installed in-building equipment capacity as dictated by the consultant due to many reasons, but mostly over sizing.
Cost of redundant equipment for emergency or standby capacity	Similar to above, N+1 redundancy requirements should be accommodated and added to the first cost of the in-building alternative
Energy and Utility Costs	
Electric Rate	From rate schedule of local electric utility
Natural Gas Rate	From rate schedule of local gas utility
Water and Sewer charges for thermal energy production	Water is increasingly becoming an important resource, hence makeup water and equipment blow down/sewer discharge amount are estimated.
Operations and Maintenance Costs	
Labor and benefits of operations staff assigned to in-building plant activities	This includes any staff that is assigned to the duties of maintaining and operating the in-building plant including supervisors overtime due to unplanned outages, annual permitting, environmental filings and general staff support
Insurance costs	Added insurance costs associated with on-site

	fuel burning equipment and fuel storage where applicable.
Spare parts and supplies	Boiler and auxiliary equipment require replacement of parts for normal maintenance procedures including, tubes, seal, bearings, etc.
Cost of chemical treatment for boiler water systems including daily water chemistry sampling	Includes scale and corrosion inhibitors, biocides, oxygen scavengers, etc.
Cost of contracted maintenance	Some owners outsource specific tasks to service companies such as boiler maintenance and overhauls
Energy and Resource Usage	
Peak heating loads	Used to apply the heat demand rate and the sizing of the plant equipment (boilers, pumps, electrical service, water service, etc.)
Annual heating usage	Used to apply the heat consumption rate of the utilities to the equipment meeting the thermal loads
Annual water and sewer usage	Makeup water usage and blowdown discharge pertinent to the boilers
Other Costs	
Architectural and engineering design services inclusive of Structural Engineer to evaluate floor loading of the boiler plants	Specifically for new or retrofit applications
Fees and licenses	Air and water permits, operator licenses, City franchise fees for running piping in street, etc.
Insurance of equipment	Typically a percentage of construction costs

Preliminary estimates for the Utica MG customers indicate that the current self-generation cost of thermal energy amounts to $24/MMBtu (total cost of thermal energy components listed in Table 1) x 29,719 MMBtu/yr (current annual natural gas consumption by the MG customers) =$713,256/yr. Assuming that the MG system will provide 20% savings to the customers, **the potential revenue of thermal energy to the MG owner will amount to $570,600/yr.**

Power Quality Improvement

The power quality improvement to the MG customers is estimated by the Industrial Economics Incorporated (IEC) to be $295,930/yr.

Avoided Electric Transmission and Distribution Capacity Investments by Electric Utility

The MG system will defer or avoid electric transmission and distribution capacity investments by the utility. Removing the MG load will help the utility to reduce peak demand or system load growth and avoid or defer new power delivery capacity investments. **The value of deferred generation capacity is estimated by IEC to be $169,912/yr.**

Reduction of Utility Electric Transmission and Distribution Losses

By removing the MG load from utility system will result in load that will be served by the MG system, will reduce the utility electric transmission and distribution losses. **The potential value of these losses is estimated by IEC to be $74,876/yr.**

Reliability Cost Savings

The MG will reduce power interruptions and provide reliability cost savings estimated by **the IEC to be $44,933/yr.**

Avoided Emission Damages

The MG system will reduce CO2 emissions as compared to the current electricity and thermal energy supply. The Regional Greenhouse Gas Initiative (RGGI) is an active market to reduce CO2 emissions. Using IEC CO2 emission factors **the value of avoided emission damages is estimated at $185,765/yr.**

Additional Potential Revenues of the MG System not Estimated at Present Time May Include:

Participation in Demand Response Markets

The MG system may also benefit from reduced overall energy costs by participation in demand response markets. Using the MG ability to precisely control sources of supply and demand in response to market signals, the grid interconnected MG system may be able to participate in organized demand response markets. These programs will pay the MG owner for the ability to shed load during emergency periods and bid their demand reduction into day-ahead energy markets to compete directly with power supply resources.

Sales of Excess Power to the Utility System and Ancillary Services.

The MG system will be interconnected to the electric utility electric distribution system and may be able to capture the value of sales of electric generation either directly to utility or other electric customers, or into wholesale energy markets managed by the NYISO. Sales of excess electricity will help the MG to optimize energy production, particularly when the heat-to power ratio of MG CHP system is not coincident with the utility demand.

The MG system may be able to provide certain ancillary services to the utility grid and receive financial remuneration from utility or the NYISO.

Enhanced Electricity Price Elasticity

Through the use of dispersed generation, the MG system may be able to provide value to all ratepayers in the form of enhanced electricity price elasticity. By reducing its consumption of electricity from the utility, particularly when system demand is high, MG will be able to reduce the output from high marginal cost or "peaking" plants, thereby reducing the clearing price for electricity in wholesale energy market or reducing the marginal cost of energy consumed. Other wholesale "power" market benefits will include mitigating capacity shortages and minimizing peaking plant owners' market power (effectively by expanding the pool of competition that existing plant owners face). The MG will receive compensation for providing these services in the NYISO's Installed capacity (ICAP) and demand response programs.

Reduce the Cost of Meeting the State's Renewable Energy Target

By improving energy efficiency and reducing the amount of electricity delivered by utility, the MG system may benefit from the integration of renewables particularly if the renewable energy credits produced by the MG may be sold into the renewable portfolio standard program.

Potential Sales of Thermal Energy to Neighboring Buildings

The substantial excess of combine boiler capacity of the MG customers may allow the MG system sell thermal energy to the neighboring buildings. These sales will begin the development of the citywide district heating system. The district energy experience has clearly demonstrated that interconnection of buildings boiler plants offers the opportunity to maximize the efficiency of boiler operation and reduce the cost of energy to the customers.

Capital Investment Cost of the MG Project

The capital cost of the project includes energy generation equipment, energy storage equipment, energy distribution infrastructure, upgrades to customer existing equipment. The initial investment also includes the following costs: project planning and administration costs, project design, building and environmental permits, efforts to secure financing, marketing the project and negotiating and administering customer contracts.

The total investment cost of the MG project is estimated at $13,040,000 (See Task 2, Progress Report # 2). The MG system capital cost will be reduced by the NYSERDA CHP system incentive of $972,000 and Solar PV NYSERDA incentive and Federal Income Tax Credit of $180,000. Total initial capital cost of the MG system will be $13,040,000- $972,000-$180,000=11,888,000.

Annual Expenditures

Capital Carrying Charges

The annual capital carrying charges of the capital cost of $ 11,888,000 (using municipal financing with interest rate of 4% for 20 years the capital recovery factor of 0.0736) are estimated to be $874,957/yr.

Fuel Cost

Fuel cost for the DER electric generating units at fuel cost of $6.34/MMBtu (IEC recommended) is estimated to be $488,453.Our experience with district energy systems indicates that by coagulating the customers into one system it is possible to negotiate a lower price of natural gas.

Labor Cost

Labor cost of four (4) operators at $80,000/yr is estimated to be $320,000/yr.

Operating and Maintenance Cost

The vendors of the DERs offered service maintenance contracts at $0.015/kWh. At this unit cost the vendor's maintenance contracts will amount to $102,733. For our analysis this O&M cost was doubled to $ 205,466.

All the above outlined revenue streams and expenses are summarized in Table 4-2.

The economic analysis indicates that the proposed MG system may be profitable if the potential revenue streams described above are credited to the MG project. However, considering the novelty of the project to the potential owner a MG incentive will be required.

Financial Aspects

Because MG system is capital intensive, it requires complex financial arrangements to ensure that the project is undertaken and succeeds, even when its technical advantages are obvious. The funds required to build the project must be borrowed on the capital markets before construction can begin. However, most lenders insist on seeing the revenue stream that will allow loan payments to be made, and this means that signed, long-term energy purchase contracts with the potential customers are a prerequisite to financing the project.) These contracts can only be prepared if tariff schedules and even billing procedures have been developed and, to the extent possible, finalized.

During the system development, a variety of efforts should be undertaken:

- Procurement by the City of Community Development Block Grants (CDBG) applications
- Through not-for-profit Municipal Development Corporation, low interest revolving loan funds can be established to provide assistance to the MG system. A Commercial Energy Incentive Program (focused in the City's downtown area) can be used. Through the City Renewal Agency, a number of agreements can be signed with the MG customers to construct the MG system.

As discussed above, it is proposed that the MG Company will be owned and governed by the City/County. The City/County will create a separate, wholly owned and operated subsidiary to shield their general fund from direct and unlimited financial liability. Under this model the subsidiary will own the MG Company, while the technical design, construction and the operation will be contracted out to a developer. It is possible that a private developer backed by private investment funds might use a project finance structure to build the system. This might involve a Special Purpose Vehicle (SPV) to finance and develop the system that, once completed and fully operational, could be transferred to the City/County's full ownership and control. The City/County would thereby shed the construction risk and purchase the completed system with low-cost bonds secured either through contracted energy purchase agreements or by the City's full faith and credit. In either case, the City/County would repay the relatively low-cost bonds over time.

Project finance will be with no-recourse loans, meaning that they are secured only by the project assets and are paid entirely from the project's cash flow rather than from the general assets or credit worthiness of the City/County. There is also a possibility to use New Clean Renewable Energy Bonds or DOE Qualified Energy Conservation Bonds.

Table 4-2: Preliminary Benefit to Cost Ratio Estimates

Cost Component	Parameters and Cost
Key System Parameters	
system electric peak,kW	1,761
MG installed electric capacity,kW	2,490
CHP plant electric capacity,kW	670
non-CHP plant electric capacity,kW	1,408
total annual electric generation,kWh/yr	6,848,877
electric generation by CHP plant,kWh/yr	5,821,545
electric generation by non-CHP plant,kWh/yr	1,027,332
heat rate of CHP unit,MBtu/kWh	3,187
heat rate of non-CHP units,MBtu/kWh	3,869
heat recovery of CHP unit,MMBtu/hr	1,408
operating hours of CHP units,hr/yr	8,689
operating hours of non-CHP units	642
system peak heat load, mmbtu/hr	13
CHP plant thermal capacity,MBtu/hr	2.82
total existing boilers thermal capacity,MMBtu/hr	22.80
annual useful heat consumption,mmbtu/yr	17,831
annual useful heat production by CHP units,mmbtu/hr	5,632
annual useful heat production by boilers	12,199
maintenance cost for boiler plant , $/mmbtu/hr	700
maintenance cost for MG district piping and cable, $/foot-year	1.0
cost of electricity for boiler plant, $/mmbtu/hr	2,160
cost of water and sewer for boiler plant, $/mmbtu/hr	160
water treatment cost for boiler plant,$/mmbtu/hr	450
cost of natural gas for the MG plant, $/mmbtu	6.34
total natural gas consumption by the MG palnt,MMBtu/yr	77,043
capital cost of the MG system,$	13,040,000
NYSERDA and Federal incentives,$	1,152,000
final capital cost of MG system$	11,888,000
capital recovery factor at 4% for 20 years	0.0736
current utility and customers CO2 release,ton/yr	8,436
MG system CO2 release,ton/yr	4,468
MG system avoided CO2 release,ton/yr	3,967
MG Energy Production Cost	
Fixed Costs:	
annual capital carrying cost of MG system,$	874,957
insurance @ 0.5 %,$	65,200
labor cost, $	320,000
maintenance cost for MG plants,$	205,466
maintenance cost for boiler plant,$	14,210
maintenance cost for district piping and cable,$	5,000
Variable Costs:	
fuel cost for the MG plant,$/yr	488,453
electric cost for boiler plant,$	28,080
water and sewer cost for boiler plant,$	2,080
water treatment cost for boiler plant, $	5,850
Total MG system annual production cost,$/yr	**2,009,296**
MG electric energy revenue,$/yr	590,400
MG thermal energy revenue,$/yr	570,600
power quality improvements,$/yr	295,930
MG avoided emission demages,$/yr	185,765
MG generation capacity cost savings,$/yr	169,912
MG distribution capacity cost savings,$/yr	74,876
MG reliability cost savings,$/yr	44,933
Total MG system benefits,$/yr	**1,932,416**

Legal Viability

It is recommended that the City and the County will be the combined owner of the MG system. The proposed ownership structure has to be approved by City Common Council and County Legislature. The City and the County own the sites where the MG DER's will be installed. The City also owns the streets where the MG hot water piping and electric cables will be installed. The MG system owner will protect the privacy rights of the MG customers.

After the approvals, the City/County will select the system developer/operator through a competitive bidding process.

The anticipated regulatory hurdle is the potential regulation by the PSC of the electric sales by the MG owner to its customers. It is assumed the PSC will clarify this issue by the time the MG system should be constructed. Hot water district heating systems are not subject to regulation in the New York State.

Section 5
Benefit-Cost Analysis

The Contractor has developed and provided information for the facility and microgrid (MG) questionnaire sheets required to support independent evaluation by the Industrial Economics, Incorporated (IEC) on January 13, 2016.

On March 1, 2016 the Contractor received from IEC the results of the benefit-cost analysis for the proposed MG in Utica (Site 71). The IEC completed BCA spreadsheets and the summary report are provided below.

During the review of the IEC report the Contractor has determined that IEC used the CO_2 marginal emission rate of 0.538456 tons/MWh for estimating the cost of emission damages for current electric supply by the utility. The emission rate of the MG CHP system provided by the Contractor in the January 13, 2016 questionnaire was erroneously much higher (0.808 tons/MWh). Also during January-February 2016 the Contractor optimized the selected DER's and estimated more accurately the input data for the MG questionnaire. Using the corrected input the Contractor revised the benefit cost analysis using the IEC computer program. The Contractor completed BCA spreadsheets and the revised summary report are provided below in section 5.2.

5.1 Industrial Economics, Incorporated (IEC) Summary Report

Project Overview

As part of NYSERDA's NY Prize community MG competition, the City of Utica has proposed development of a MG that would enhance the resiliency of electric service for six facilities in this Oneida County community:

- A courthouse;
- A police station (which shares a building with the courthouse);
- Boehlert Train Station;
- The Federal Building;
- The Observer-Dispatch Newspaper facility; and
- Memorial Auditorium, which would serve as a place of refuge in the event of an emergency.

The MG would be powered by five new 0.4 MW natural gas cogeneration units located at the courthouse and train station, and a 100 kW solar photovoltaic (PV) array also located at the train station. In addition, the MG would incorporate a 250 kW battery storage system. The project's proponents anticipate that the natural gas and PV units would produce electricity for consumption during periods of normal operation. During a major outage, the system would have sufficient generating capacity to supply 100 percent of average electricity use at all six facilities served by the MG. Project consultants also indicate that the system would have the capability of providing ancillary services to the grid, including frequency regulation, reactive power support, and black start support.

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.

Methodology and Assumptions

In discussing the economic viability of MGs, 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 MG, 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 MGs in New York State. The model evaluates the economic viability of a MG 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.

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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.]

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]

Results

Table 5-1 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 4.8 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 5-1. BCA IEC Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 4.8 DAYS/YEAR
Net Benefits - Present Value	-$13,700,000	$159,000
Benefit-Cost Ratio	0.6	1.0
Internal Rate of Return	-26.6%	7.5%

Scenario 1

Figure 5-1 and Table 5-2 present the detailed results of the Scenario 1 analysis.

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.

Figure 5-1: IEC Detailed Results of the Scenario 1 analysis.

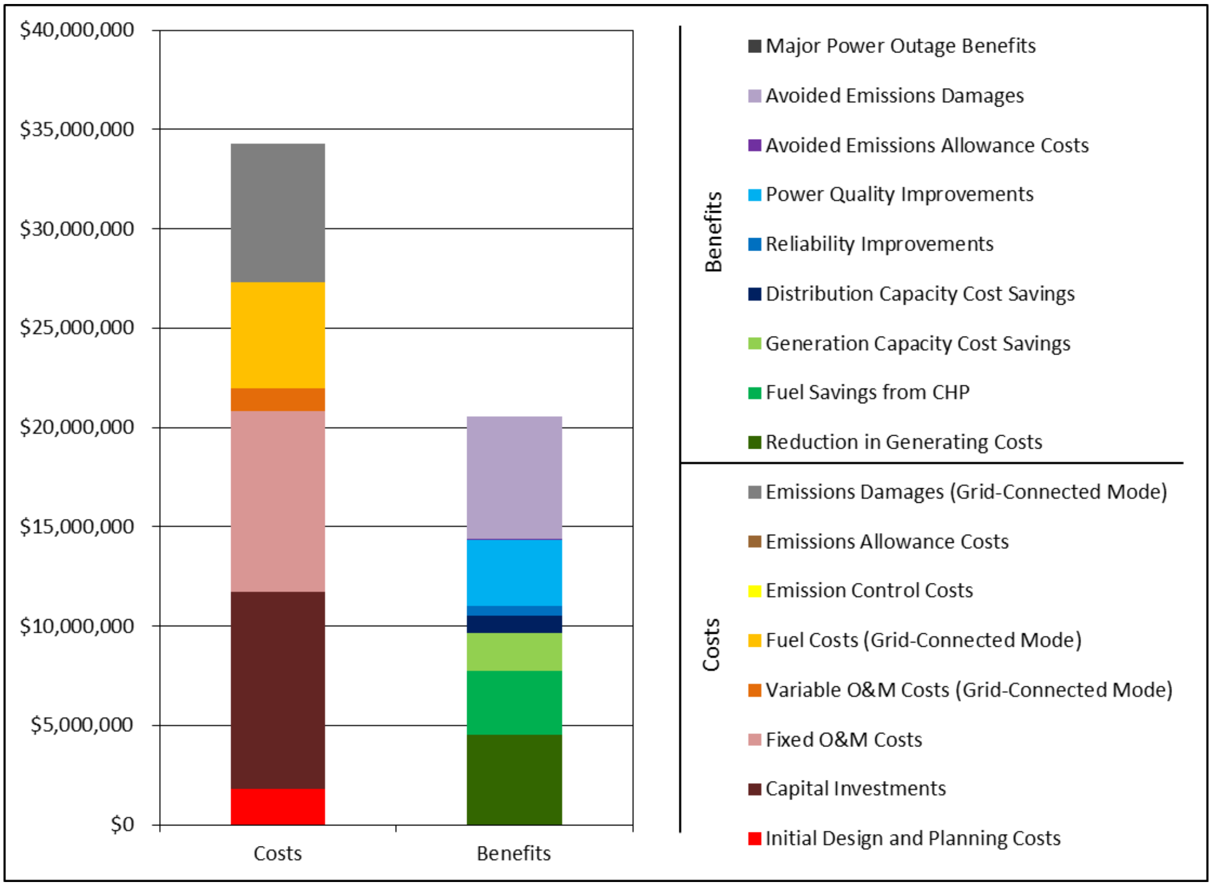

Table 5-2: Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,800,000	$159,000
Capital Investments	$9,930,000	$876,000
Fixed O&M	$9,070,000	$800,000

Variable O&M (Grid-Connected Mode)	$1,190,000	$105,000
Fuel (Grid-Connected Mode)	$5,300,000	$468,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$7,010,000	$457,000
Total Costs	**$34,300,000**	
Benefits		
Reduction in Generating Costs	$4,520,000	$399,000
Fuel Savings from CHP	$3,210,000	$283,000
Generation Capacity Cost Savings	$1,930,000	$170,000
Distribution Capacity Cost Savings	$849,000	$74,900
Reliability Improvements	$509,000	$44,900
Power Quality Improvements	$3,350,000	$296,000
Avoided Emissions Allowance Costs	$2,370	$209
Avoided Emissions Damages	$6,210,000	$405,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$20,600,000**	
Net Benefits	**-$13,700,000**	
Benefit/Cost Ratio	**0.6**	
Internal Rate of Return	**-26.6%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the MG. The project team's best estimate of initial design and planning costs is approximately $1.8 million. The present value of the project's capital costs is estimated at approximately $9.9 million, including costs associated with installing the five new natural gas units, new PV array, battery storage system, and energy distribution and interconnection infrastructure. The present value of the MG's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at $9.1 million, or $800,000 annually.

Variable Costs

A significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's five cogeneration units. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.3 The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $5.3 million.

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

The BCA also considers the project team's best estimate of the MG'svariable O&M costs (i.e., O&M costs that vary with the amount of energy produced). The present value of these costs is estimated at $1.2 million, or approximately $15 per MWh.

In addition, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the MG, 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 MG's fuel-based generators are estimated at approximately $457,000 annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $7.0 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $4.5 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. Cost savings would also result from fuel savings due to the combined heat and power system powered by the new natural gas generators; the BCA estimates the present value of fuel savings over the 20-year operating period to be approximately $3.2 million. These reductions in demand for electricity from bulk energy suppliers and heating fuel would also avoid emissions of CO_2, SO_2, NO_x, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $2,370 and avoided emissions damages with a present value of approximately $6.2 million.4

In addition to the savings noted above, development of a MG could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.5 Based on the project team's application of standard capacity factors for the PV system and natural gas generators, as well as the capacity of the storage system, the analysis estimates the present value of the project's generating capacity benefits to be approximately $1.9 million over a 20-year operating period. The present value of the project's potential distribution capacity benefits is estimated to be approximately $849,000.

The project team has indicated that the proposed MG would be designed to provide ancillary services, in the form of frequency regulation, reactive power support, and black start support, to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide

4 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.

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

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, in particular black start support, are highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing this service.

Reliability Benefits

An additional benefit of the proposed MG 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 MG would yield reliability benefits of approximately $44,900 per year, with a present value of $509,000 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:6

- System Average Interruption Frequency Index (SAIFI) – 0.96 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 116.4 minutes.[7]

The estimate takes into account the number of small and large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a MG. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[8] It assumes that establishment of a MG 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 MG would insulate the facilities the project would serve from outages of the type captured in SAIFI and CAIDI values. The distribution network within the MG 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.

Power Quality Benefits

The power quality benefits of a MG may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the MG would avoid each year. In the case of the City of Utica's proposed MG, the project team has indicated that approximately 24 power quality events would be avoided each year. Assuming that each customer in the proposed MG would experience these improvements in power quality, the model estimates the present value of this benefit to be approximately $3.4 million over a

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6 www.icecalculator.com.

7 The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for National Grid.

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

20-year operating period.[9] In reality, some customers for whom power quality is important (e.g., the train station) may already have systems in place to protect against voltage sags, swells, and momentary outages. This assumption could therefore lead the BCA to overstate the power quality benefits the project would provide.

Summary

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

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a MG 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 MG would serve. It calculates the economic damages that development of a MG 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.[10,11]

As noted above, the City of Utica's MG project would serve six facilities during an extended outage. The project's consultants indicate that at present, four of these facilities – the courthouse, police station, Boehlert train station, and Memorial Auditorium – are equipped with natural gas backup generators. These units can support approximately 75 percent of the ordinary level of service at the courthouse and police station, 85 percent at Boehlert Train Station, and 70 percent at Memorial Auditorium, which would operate as an emergency shelter in the event of a prolonged outage. Operation of the courthouse/police station generator would entail a one-time cost of $500 and additional costs of $600 per day. Operation of the generator at the train station would entail a one-

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9 Importantly, the model relies on average costs per power quality event for customers across the United States, based on meta-analysis of data collected through 28 studies of electric utility customers between 1989 and 2005. These costs therefore incorporate assumptions about the distribution of customers across economic sectors and other key characteristics, such as the prevalence of backup generation and power conditioning, that may not reflect the characteristics of the proposed microgrid. This is likely to be the case for the City of Utica. Based on information provided by the site team, the proposed microgrid will not serve any customers in the construction, manufacturing, and financial/insurance/real estate sectors, which typically have the highest costs per power quality event. Instead, the proposed microgrid's customers are more likely to fall into the public administration or services sectors, which typically have substantially lower costs of power quality events. [See: Sullivan, Michael J. *et al*. Estimated Value of Service Reliability for Electric Utility Customers in the United States. LBNL-2132E: June 2009.]

10 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.

11 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.

time cost of $450 and additional costs of $500 per day. Operation of the generator at Memorial Auditorium would entail a one-time cost of $1,250 and additional costs of $1,500 per day.

Should these existing units fail, the team indicates that all four facilities could maintain operations by bringing in portable generators with sufficient power to maintain all services. The operation of the portable units would cost approximately $2,500, $4,000, and $6,000 per day at the courthouse/police station, train station, and auditorium, respectively. In the absence of backup power – i.e., if the backup generators failed and no replacements were available – the courthouse and police station would experience a 70 percent loss in service capabilities, and the train station and auditorium would experience a complete loss in service capabilities.

The remaining two facilities - the Federal Building and Observer-Dispatch Newspaper building – would not bring in portable generators and would instead choose to shut down, resulting in a total loss of service.

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

- The courthouse and police station would rely on their existing backup generator, experiencing a 25 percent loss in service capabilities while the generator operates. If the backup generator fails, the facilities would experience a total loss of service.
- Boehlert Train Station would rely on its existing backup generator, experiencing a 15 percent loss in service capabilities while the generator operates. If the backup generator fails, the facility would experience a total loss of service.
- Memorial Auditorium would rely on its existing backup generator, experiencing a 30 percent loss in service capabilities while the generator operates. If the backup generator fails, the facility would experience a total loss of service.
- The Federal Building and Observer-Dispatch Newspaper building would shut down and experience a total loss of service.
- In all cases, the supply of fuel necessary to operate the backup generators would be maintained indefinitely.
- In all cases, there is a 15 percent chance that the backup generator would fail.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities of interest. The analysis calculates the impact of a loss in the city's police services using standard FEMA values for the costs of crime, the baseline incidence of crime per capita, and the impact of changes in service effectiveness on crime rates. The impact of a loss in service at other facilities is based on the following value of service estimates:

- For the courthouse, a value of approximately $78,000 per day. This figure is estimated using the ICE Calculator, assuming 24 hours of MG demand per day during an outage.[12]

- For Boehlert Train Station, a value of approximately $104,000 per day. This figure is also estimated using the ICE Calculator, assuming 24 hours of MG demand per day during an outage.[13]

- For the Federal Building and Observer-Dispatch Newspaper building, a value of approximately $151,000 per day. This figure is also estimated using the ICE Calculator, assuming 24 hours of MG demand per day during an outage.[14]

- For Memorial Auditorium, a value of approximately $71,000 per day. This figure is based on an estimate of the facility's shelter capacity (1,425 people, assuming 40 square feet per person) and American Red Cross data on the cost of providing overnight shelter ($50/person/day).[15]

Based on these values, the analysis estimates that in the absence of a MG, the average cost of an outage for the six facilities is approximately $257,000 per day.

Summary

Figure 2 and Table 3 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 4.8 days per year without power. If the average annual duration of the outages the MG prevents is less than this figure, its costs are projected to exceed its benefits.

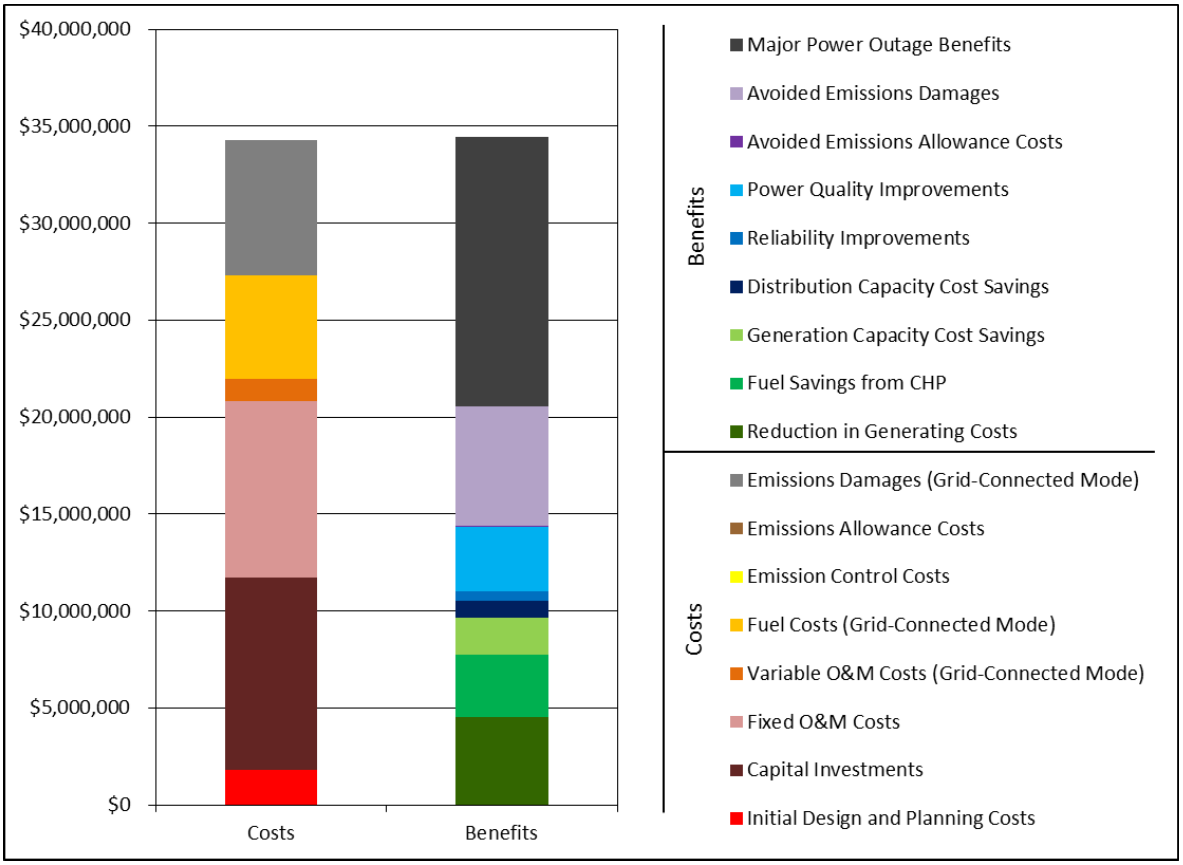
Figure 5-2. Present Value Results, Scenario 2 (Major Power Outages Averaging 4.8 Days/Year; 7 Percent Discount Rate)

12 http://icecalculator.com/

13 http://icecalculator.com/

14 http://icecalculator.com/

15 American Red Cross. Fundraising Dollar Handles for Disaster Relief Operations, Revised March 2014 – based on FY14 Figures.



$40,000,000
$35,000,000
$30,000,000
$25,000,000
$20,000,000
$15,000,000
$10,000,000
$5,000,000
$0
Costs
Benefits
Benefits
Major Power Outage Benefits
Avoided Emissions Damages
Avoided Emissions Allowance Costs
Power Quality Improvements
Reliability Improvements
Distribution Capacity Cost Savings
Generation Capacity Cost Savings
Fuel Savings from CHP
Reduction in Generating Costs
Costs
Emissions Damages (Grid-Connected Mode)
Emissions Allowance Costs
Emission Control Costs
Fuel Costs (Grid-Connected Mode)
Variable O&M Costs (Grid-Connected Mode)
Fixed O&M Costs
Capital Investments
Initial Design and Planning Costs

Table 5-3: Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 4.8 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$1,800,000	$159,000
Capital Investments	$9,930,000	$876,000
Fixed O&M	$9,070,000	$800,000
Variable O&M (Grid-Connected Mode)	$1,190,000	$105,000
Fuel (Grid-Connected Mode)	$5,300,000	$468,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$7,010,000	$457,000
Total Costs	**$34,300,000**	
Benefits		
Reduction in Generating Costs	$4,520,000	$399,000
Fuel Savings from CHP	$3,210,000	$283,000
Generation Capacity Cost Savings	$1,930,000	$170,000
Distribution Capacity Cost Savings	$849,000	$74,900
Reliability Improvements	$509,000	$44,900
Power Quality Improvements	$3,350,000	$296,000
Avoided Emissions Allowance Costs	$2,370	$209
Avoided Emissions Damages	$6,210,000	$405,000
Major Power Outage Benefits	$13,900,000	$1,230,000
Total Benefits	**$34,500,000**	
Net Benefits	**$159,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.5%**	

5.2 Contractor Revised Benefit Cost Analysis

Results

Table 5-4 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 by smaller amount than estimated by IEC. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 1.55 days per year (Scenario 2).

Table 5-4. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 1.55 DAYS/YEAR
Net Benefits - Present Value	-$8,622,418	$47,752
Benefit-Cost Ratio	0.65	1.0
Internal Rate of Return	-5.56%	7.5%

Scenario 1

Table 5-5 present the detailed results of the Scenario 1 analysis (Revised by Contractor)

Scenario 2

Table 5-6 presents the detailed results of the Scenario 2 analysis (Revised by Contractor)

Table 5-5: Detailed Results of the Scenario 1 Analysis (Revised by Contractor)

Results Summary

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,800,000	$158,792
Capital Investments	$10,548,349	$930,551
Fixed O&M	$3,400,679	$300,000
Variable O&M (Grid-Connected Mode)	$1,186,837	$104,700
Fuel (Grid-Connected Mode)	$5,054,257	$445,875
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$2,748,128	$179,337

Total Costs	**$24,738,250**	**$2,119,255**
Benefits		
Reduction in Generating Costs	$4,523,093	$399,017
Fuel Savings from CHP	$895,996	$79,043
Generation Capacity Cost Savings	$1,815,511	$160,160
Distribution Capacity Cost Savings	$745,256	$65,745
Reliability Improvements	$509,908	$44,996
Power Quality Improvements	$3,354,542	$295,930
Avoided Emissions Allowance Costs	$2,368	$209
Avoided Emissions Damages	$4,269,158	$278,597
Major Power Outage Benefits	$0	$0
Total Benefits	**$16,115,832**	**$1,323,696**
Net Benefits	**-$8,622,418**	**-$795,559**
Benefit/Cost Ratio	**0.65**	
Internal Rate of Return	**-5.56%**	

Table 5-6: Detailed Results of the Scenario 2 Analysis (Revised by Contractor)

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,800,000	$159,000
Capital Investments	$10,500,000	$931,000
Fixed O&M	$3,400,000	$300,000
Variable O&M (Grid-Connected Mode)	$1,160,000	$103,000
Fuel (Grid-Connected Mode)	$5,050,000	$446,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$2,700,000	$176,000
Total Costs	**$24,700,000**	**$2,110,000**
Benefits		
Reduction in Generating Costs	$4,440,000	$392,000
Fuel Savings from CHP	$3,210,000	$283,000
Generation Capacity Cost Savings	$1,820,000	$160,000
Distribution Capacity Cost Savings	$745,000	$65,700
Reliability Improvements	$510,000	$45,000
Power Quality Improvements	$3,350,000	$296,000
Avoided Emissions Allowance Costs	$2,320	$205
Avoided Emissions Damages	$6,140,000	$401,000

Major Power Outage Benefits	$4,500,000	$397,000
Total Benefits	**$24,700,000**	**$2,040,000**
Net Benefits	**$47,800**	**-$74,500**
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.0%**	

FACILITY BACKGROUND INFORMATION

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
CHP UNIT 1	City Court House	Natural Gas	0.335	5,256	8.04	9.51	MMBtu/MWh
CHP UNIT 2	City Court House	Natural Gas	0.335	876	8.04	9.51	MMBtu/MWh
UNIT 3	BOEHLET TRAIN STATION	Natural Gas	0.4	239	9.6	9.67	MMBtu/MWh
UNIT 4	Boehlert Train Station	Natural Gas	0.4	239	9.6	9.67	MMBtu/MWh
UNIT 5	Boehlert Train Station	Natural Gas	0.4	239	9.6	9.67	MMBtu/MWh
UNIT 6	Boehlert Train Station	NATUARAL GAS	0.4	0	0	0	MMBTU/MWH
UNIT 7	Boehlert Train Station	SOLAR PV	0.15	131	0.6	0	MMBTU/MWH
UNIT 8	BOEHLET TRAIN STATION	ELECTRIC STORAGE	0.25				

DER'S BACKGROUND INFORMATION

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
CHP UNIT 1	City Court House	Natural Gas	0.335	5,256	8.04	9.51	MMBtu/MWh
CHP UNIT 2	City Court House	Natural Gas	0.335	876	8.04	9.51	MMBtu/MWh
UNIT 3	BOEHLET TRAIN STATION	Natural Gas	0.4	239	9.6	9.67	MMBtu/MWh
UNIT 4	Boehlert Train Station	Natural Gas	0.4	239	9.6	9.67	MMBtu/MWh
UNIT 5	Boehlert Train Station	Natural Gas	0.4	239	9.6	9.67	MMBtu/MWh
UNIT 6	Boehlert Train Station	NATUARAL GAS	0.4	0	0	0	MMBTU/MWH
UNIT 7	Boehlert Train Station	SOLAR PV	0.15	131	0.6	0	MMBTU/MWH
UNIT 8	BOEHLET TRAIN STATION	ELECTRIC STORAGE	0.25				

PROVISION OF PEAK LOAD SUPPORT

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does DER currently provide peak load support?
TWO(2) CHP UNITS	City Court House	0.67	No
FOUR(4) RECIP UNITS	Boehlert Train Station	1.2	No
One (1) PV Solar Unit	Boehlert Train Station	0.015	No
One (1) Electric Storage	Boehlert Train Station	0.25	No

MG CAPITAL COSTS

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
0.7 MW CHP	$ 3,000,000	20	670KW CHP PLANT INSTALLED AT COURT HOUSE
1.2 MW RECIP UNITS	$ 5,540,000	20	1200 KW RECIP ENGINES INSTALLED AT BOEHLERT TRAIN STATATIO AND CONNECTED WITH THE CHP PLANT
0.15 MW PV Solar Unit	$ 500,000	20	150 PV SOLAR INSTALLED AT BOEHLERT TRAIN SATATION AND CONNECTED WITH THE CHP AND RECIP PLANT UNITS
0.25 MW Electric Storag	$ 1,000,000	10	250 kW Electric Storage installed at Boehlert Train Station and connected with the CHP AND RECIP ENGINE MG plant Installed at Court/Police Station

Appendix

Description of Energy Systems of Industrial Group Customers not included in the MG (The customers are shown on Figure 2-1)

7. CENTRO

CENTRO is the local bus company. They have 34 buses and run 28 busses per day. Employ 60 people. They also pick-up handicapped people. In case of no electric supply they cannot dispatch the buses. For bus fueling they have a 10,000 gal diesel tank but buses may also fill-up at the gas stations.

Have 2 DE Dietrich (France) hot water boilers with capacity each 826,000 Btu/hr. The boilers are equipped with combustion control system from Siemens. The hot water is supplied to the offices and to unit heaters in the garage. In addition they also have natural gas fired overhead radiant heaters. Originally the boilers burned diesel, now natural gas and they are not happy. Cooling is supplied by one Lennox 15 ton unit on the roof plus carrier AC unit in the offices.

Have flooding problems after the rain and snow melting. It comes from sewer water flooding and they have special gates to close the garage. When it is flooding they cannot use the lifts for car repair, cannot do inspections and run busses, and also cannot supply the parts. If they are not working the service may go to Syracuse.

The electric and gas consumption and cost are provided in Tables A-1 and A-2.

Table A-1: Centro Electric Consumption and Cost

Month	Consumpt. kWh	Peak, kW	Total Cost,$
Jan	27,040	55	2,975
Feb	26,080	59	5,218
Mar	25,360	58	4,654
Apr	24,320	53	2,922
May	24,160	48	2,102
June	19,280	48	1,239
July	19,440	55	2,299
Aug	22,960	50	2,114
Sept	20,000	49	1,959
Oct	18,240	52	1,700
Nov	19,920	46	1,666
Dec	25,600	54	2,155
Total	272,400		31,001

Table A-2: Centro Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan	668	4,758
Feb	679	5,058
Mar	759	5,825
Apr	696	5,222
May	362	2,929
June	25	262
July	1	34
Aug	1	33
Sept	3	43
Oct	7	78
Nov	68	156
Dec	469	3,038
Total	3738	27,435

8. FUEL TANK FARM

The farm belongs to Clifford Fuel Company. They have 7 large tanks. Each tank has a capacity of 105,000 gal of pure fuel which come by oil pipe line from Auburn, NY. They can't keep the fuel in the tanks for a long time. In order to use the fuel they add additives. Very busy in the winter in summer no activity.

Have 5x50 HP pumps typically need 2-3 pumps and 3x1 HP pumps for additives. Their fuel supply cannot be interrupted.

They have a natural gas supplied hot water suspended unit to heat the office. They have no emergency generator. When electric supply is down they get from Marcy temporary generator.

9. CITY DPW GARAGE

They do repair and maintenance of the DPW transportation vehicles. Employ 49 people. Have no back-up generator when need use portable generators for lighting.

Have about 10 gas fired unit heaters.

The electric and gas consumption and cost are provided in Tables A-3 and A-4.

Table A-3: City DPW Electric Consumption and Cost

Month	Consump. kWh	Peak, kW	Total Cost,$
Jan	42,160	118	1,555
Feb	41,440	107	1,460
Mar	33,360	106	1,360
Apr	25,280	74.4	1,000
May	16,960	83.2	1,066
Jun	12,400	46.4	623
Jul	13,600	42.4	633
Aug	13,520	52.8	674
Sep	17,120	62.4	826
Oct	21,520	77.6	1,008
Nov	38,400	115	1,483
Dec	44,800	106	1,394
Total	**320,560**		**13,081**

Table A-4: City DPW Gas Consumption and Cost

Month	Consump. MMBtu	Total Cost,$
Jan	1,125	12,393
Feb	1,200	13,646
Mar	1,126	11,005
Apr	662	7,652
May	160	5,507
Jun	47	2,084
Jul	1	426
Aug	2	99
Sep	18	218
Oct	168	2,094
Nov	523	3,665
Dec	1,140	12,374
Total	**6,173**	**71,163**

10. NYS Canal Corp

The Canal is active from 1933. Perform boat maintenance from St.Johnesville to Oneida Lake. Have 2x1000 gal tanks of fuel outside. In addition have 2x3000 gal in another location. The operation is by telemetry. The fuel supply is used for thruway supply troupers and boats. Do not operate in the winter and bring the boats in. Navigation is from May to Nov. 15.Have two tanner gates along the Mohawk River for any emergency. All locks have 208 3 phase AC rectifiers.

Have 1x50kW and 1x25kW 3 phase 208V diesels for lights and heat. Service is 900 amps. In the winter gas supply is interrupted.

Have three natural gas fired hot water boilers: 2x150,000 Btu/hr and 1x124,000 Btu/hr. In addition they have electric and infrared heating. The facility suffers from periodic flooding. The current electric and gas consumption and cost are provided in Tables A-5 and A-6.

Table A-5: NYS Canal Building Electric Consumption and Cost

Month	Consumpt. kWh	Peak,kW	Total Cost,$
Jan.	16000	48.00	1,364
Feb	34720	89.60	3,645
Mar	38080	86.40	4,904
Apr	32640	81.60	2,831
May	17440	60.80	928
Jun	7200	36.80	824
Jul	6560	40.00	1,053
Aug	7520	35.20	925
Sep	6400	33.60	850
Oct	6720	33.60	810
Nov	8640	40.00	959
Dec	12640	49.60	1,327
Total	194,560		20,421

Table A-6: NYS Canal Building Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan.	824	2,273
Feb	973	2,522
Mar	609	2,769
Apr	634	1,594
May	267	726
Jun	35	151
Jul	20	113
Aug	24	119
Sep	16	81
Oct	21	101
Nov	86	412
Dec	442	1,347
Total	3,951	12,209

11. Sewage Waste Treatment Plant

The Oneida County municipal plant removes contaminants from wastewater, primarily from household sewage. It includes physical, chemical, and biological processes and produces environmentally safe treated effluent. A by-product of sewage treatment is sludge, which undergoes further treatment before being disposed. They also have two pumping stations which belong to them but located not at this facility.

The City of Utica has a combined waste water system that collects the sewage and urban runoff (storm water) and transports it to the sewage treatment plant. This design requires much larger and more expensive treatment facilities than sanitary sewers because precipitation causes widely varying flows, reducing sewage treatment plant efficiency.

The raw waste pumping station delivers the sewage to the sand and grit tanks, where the velocity of the incoming sewage is adjusted to allow the settlement of sand, grit, stones, and broken glass. These particles are removed because they may damage pumps and other equipment.

The plant also includes the primary settling tanks for temporarily holding the sewage in quiescent basins where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface. The settled and floating materials are removed and the remaining liquid is subjected to secondary treatment.

Secondary treatment removes dissolved and suspended biological matter. Secondary treatment is performed in aeration tanks by indigenous, water-borne micro-organisms in a managed habitat. Secondary treatment includes a separation process to remove the micro-organisms from the treated water and return them back into the process.

The sludge accumulated in a wastewater treatment process must be treated and disposed of in a safe and effective manner. Currently the Incineration process is used. Before incineration the sludge is passed through thickeners which de-water the sludge. Afterwards in order to increase the dewaterability they add a polymer to the sludge. Dewatered sludge is incinerated in a fluidized bed tanks followed by a scrubber. The cost of sludge incinerator was $9.5 million. The fluidized bed incinerator burns oil, but preheating is with gas. The incinerators are equipped with four (4) blowers with 600 HP motors. They used to have a heat recovery system but it was abandoned. After chlorination and disinfection the clean water is discharged into Mohawk River. The current control room is 1970 vintage.

The facility is a 24/7 operation, during the summer processing 48 million gallon per day (MGD), in the winter when snow melts the capacity reaches the 53 MGD limit. The administration is currently developing the plant expansion up to 110 MGD within 5 years at $117 million cost. The city of Utica is planning to separate the storm and sanitary sewer system.

The existing plant has a 2.2 MW CAT emergency generator installed in 2006 and a small 150 kW generator supplying the lights. In the new facility two 2 x 2.2 MW CAT emergency generators fired by diesel fuel are planned.

The plant is equipped with two 2x20,000 gal above ground oil tanks, the tanks typically feed the incineration kilns. There are two CB boilers with dual fuel: 7.5 MMBtu/hr on gas and 9.5 MMBtu/hr. The plant has a hot water loop with constant speed pumps supplying 190-200F water, and 1x50 ton chiller and 2 large air units, but the management is leaning now toward distributed chilling and heating units.

Electricity is provided from the 46 KV substation which has two feeders (Skay and Mercy) but the facility is supplied from a common feeder. The 46 KV transmission line is owned by National Grid. The plant owns the transformers and the 4,160V local distribution network. In each building the voltage steps down to 460V.The new system is planned for 15 KV substation and 460V distribution system for all facility. They are also planning to use the digester gas to run 3x200kW micro turbines.

The current electric, gas and oil consumption and cost are provided in Tables A-7, A-8 and A-9.

Table A-7: Sewage Waste Treatment Plant Electric Consumption and Cost

Month	Consumpt. kWh	Peak,kW	Total Cost,$
Jan	1,353,019	2064	115,007
Feb	1,075,502	1737	91,418
Mar	1,157,749	1951	98,409
Apr	1,419,348	1999	120,645
May	1,195,827	2056	101,645
Jun	1,394,460	2375	118,529
Jul	1,447,335	2338	123,023
Aug	1,528,900	2363	129,957
Sep	1,450,594	2326	123,300
Oct	1,440,367	2355	122,431
Nov	1,441,608	2415	122,537
Dec	1,682,011	2500	142,971
Total	16,586,720		1,409,871

Table A-8: Sewage Waste Treatment Plant Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan.	1502.3	10,409
Feb	1485.4	10,292
Mar	1431.4	9,918
Apr	581.6	4,030
May	106.9	741
Jun	28.3	196
Jul	28.3	196
Aug	36.6	254
Sep	38	263
Oct	101	700
Nov	660.3	4,575
Dec	1237	8,571
Total	7237.1	50,146

Table A-9: Sewage Waste Treatment Plant Oil Consumption and Cost

Month	Consumpt. MMBtu	Total Cost,$
Jan.	5,600	100,600
Feb	2,800	50,300
Mar	8,400	150,900
Apr	2,800	50,300
May	5,600	100,600
Jun	2,800	50,300
Jul	5,600	100,600
Aug	2,800	50,300
Sep	2,800	50,300
Oct	2,789	50,104
Nov	7,000	125,750
Dec	2,800	50,300
Total	51,789	930,354

12. Oneida – Herkimer Solid Waste Authority

The facility processes all county garbage, if the garbage is not separated at this facility it goes to the landfill. Have a small 15 kW gas fired diesel that serves the scales and the computer.

The facility processes about 300 tracks of garbage per day from 7 am to 3 pm, about 600 ton plus

200 ton per day recycling separation; the rest goes to Rome. The garbage is manually separated, after magnet and different screens and the rest is baled.

Facility has about 120 motors, typical 5HP each plus two big balers with 200HP motors.The electric supply is above ground and for 20 years they had one day outage. The facility has no flooding problems. Without electric supply can retain 600 ton of garbage on the floor plus 200 ton outside.

They heat four (4) rooms including the sort room. 2 small chillers provide AC in summer.
12-14 people work in the sort room.

The electric and gas consumption and cost are provided in Tables A-10 and A-11.

Table A-10: Solid Waste Authority Building Electric Consumption and Cost

Month	Consumpt. kWh	Peak, kW	Total Cost,$
Jan.	131,810	482	27,607
Feb	126,989	499	26,224
Mar	117,408	511	14,399
Apr	107,145	456	12,759
May	97,715	435	8,300
Jun	104,586	452	13,191
Jul	104,476	450	11,238
Aug	107,955	449	16,290
Sep	90,631	441	11,368
Oct	97,680	411	9,539
Nov	108,826	432	11,681
Dec	136,528	466	17,448
Total	1,331,749		180,045

Table A-11: Solid Waste Authority Building Gas Consumption and Cost

Month	Consumpt. MMBtu	Total Cost
Jan.	249	1,322
Feb	291	1,758
Mar	251	1,516
Apr	160	858
May	20	111
Jun	1	6
Jul	0	1
Aug	0	1
Sep	8	38
Oct	36	174
Nov	157	792
Dec	348	1,631
Total	1,522	8,208

13. CITY HALL

The building occupies 30,000 sq.ft and has 3 floors plus basement and garage. The building has one 30 kW ONAN stand-by generator, producing 25 kW at continuous operation. The generator provides only emergency lighting of the building. In 2000 there was a big storm and it was demonstrated that the generator is good for emergency lights to get the people out of the building. The city is considering a new larger stand-by generator with capacity of 200 kW. The current generator is supplied with 2x250 gal oil tanks. The generator is tested every week.

The building is equipped with 2x3,198,000 Btu/hr hot water HBS MIT natural gas fired boilers (gas input 4,433,00 Btu/hr max and 1,477,000 Btu/hr min) dated 1963. The boilers are in good conditions. The hot water supply temperatures at the coldest days are 190-200F. In the basement there is one Trane cooling unit (12 years old) which supplies the city council and computer rooms with hot and cold air. In the basement there are 3x5HP HW pumps.

The building has one 250 ton York screw type chiller (3 phase 208 V) 3 years old with a cooling tower. The chiller is installed at the penthouse. The refrigerant is 134a.The chiller was installed by Johnston Control who provides the maintenance and service. There are one 15 HP CW pump and one 15HP cooling water pump. Chilled water supply temperature is about 46F.

Hot and chilled water are supplied to 134 window units with two coils for HW and CW installed about 3 years ago during the retrofit of the HVAC system for $2.3 million.

In the basement there is an A.O.Smith 100 gal DHW heater with gas input of 250,000 Btu/hr and recovery rate of 242 gal/hr. There is also a large Johnson Control Panel.

Water Authority of the county located on the 3rd floor has a lease for 25 years in the building with a computer center.

During the day the building is occupied by about 125 people.

The building roof is flat may be a good place for solar collectors with estimated capacity of 80 kW.

The electric service in the building is 3000 amps 120/208, installed in 1963.In the basement there are two (2) compressors which supply air for pneumatic valve control.

The electric and gas consumption and cost are provided in Tables A-12 and A-13.

Table A-12: City Hall Electric Consumption and Cost

Month	Consump .kWh	Peak, kW	Total Cost,$
Jan	67,708	185	2,532
Feb	64,610	175	2,426
Mar	70,238	241	3,155
Apr	80,301	304	3,958
May	92,806	293	3,934
Jun	93,454	312	4,098
Jul	100,127	300	3,954
Aug	91,996	311	3,124
Sep	66,600	276	3,933
Oct	64,889	234	3,124
Nov	63,123	160	3,954
Dec	68,864	182	2,419
Total	**924,716**		**40,610**

Table A-13: City Hall Gas Consumption and Cost

Month	Consump. MMBtu	Total Cost,$
Jan	1,151	11,453
Feb	923	10,919
Mar	1,030	9,541
Apr	242	5,691
May	11	3,731
Jun	15	1,822
Jul	10	74
Aug	18	151
Sep	135	751
Oct	487	2,560
Nov	690	4,337
Dec	1,124	5,582
Total	**5,836**	**56,612**