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Notice

NY Prize Syracuse Community Microgrid Stage 1 Feasibility Study

Prepared for: **The New York State Energy Research and Development Authority**

Prepared by: **The Central New York Regional Planning and Development Board**

ASI Energy

GE Energy Consulting

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Legal Notices

Foreword

This report was prepared for the Central New York Regional Planning and Development Board by ASI Energy and General Electric International, Inc. ("GEII"); acting through its Energy Consulting group ("GE Energy Consulting") based in Schenectady, NY, and submitted to the NYSERDA. Questions and any correspondence concerning this document should be referred to:

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EXECUTIVE SUMMARY

Located on the South Side of the City of Syracuse and part of Onondaga Hill, the Syracuse Community Microgrid presents an extraordinary opportunity to reduce costs, increase resiliency and reliability for the community, and advance clean energy and environmental goals of New York State. The project is designed to provide resilient energy services to a cluster of critical facilities distributed over a wide geographic area while supporting innovation and providing positive economic and environmental impacts.

The project is anchored by the Onondaga County Resource Recovery Authority (OCRRA) 39.6 MW waste-to-energy (WTE) facility, one of the region's largest distributed energy resources (DERs), as well as three major critical facilities: Upstate University Hospital Community Campus (UUHCC), Onondaga Community College (OCC), and several Loretto Long Term Care facilities. In addition, there is a mix of additional customers served by the project, including: a nursing home, a senior housing complex, a fire station, the Onondaga County consolidated 911 dispatch center, an elementary and middle school, public housing and apartment buildings, and approximately 2,000 residential and small commercial customers.

Key features and benefits of the Syracuse microgrid include:

Large Area and Customer Base: The proposed project, including the transmission and distribution (T&D) infrastructure investment, is a low cost investment that will significantly enhance the reliability of electric service for a large geographic area consisting of over 600 commercial customers and approximately 1700 residential homes, leveraging the existing OCRRA WTE.

Low Capital Expense: The proposed project includes significant enhancements to the transmission and distribution (T&D) system while leveraging a significant existing generation source keeping capital costs extremely low while providing flexibility and a decreased risk of stranding assets.

Serves Critical Services and Facilities of Refuge: Critical loads supported during an outage include multiple places of refuge such as the Onondaga Community College, the County Consolidated 911 Call Center, several elderly care centers, and SUNY Upstate University Hospital Community Campus.

Solid Financial Benefits: The benefit-cost analysis (BCA) results highlight the potential of the project to provide a significant return on investment and to support the County WTE facility by providing new business opportunities**.** The business model is achievable and has a net positive return, while ensuring that the capital costs of the T&D infrastructure investment required to construct the microgrid are allocated fairly between microgrid customers and operators.

Improved System Design Redundancy: The microgrid will increase the resilience of electric service for all customers within the footprint, functionally improving redundancy from "N-0" (typical of radial distribution systems) to "N-1" (typical of transmission systems and substations)[1]. Alternative solutions with commensurate benefits – e.g., building a feeder or substation – would cost an order of magnitude more to implement.

Provides Platform for Implementing REV Framework: The focus on capital efficiency mitigates the risk of stranded assets while also providing a flexible platform for implementing the

[1] N-1 redundancy is a level of resilience that ensures system availability when a component fails.

REV framework. Potential REV related attributes to consider with the development of the Syracuse microgrid include design of rates that ensure utilities are compensated for operating costs - e.g., Active Network Management (ANM) costs - similarly to capital costs. Ancillary or grid-edge services could be an important feature of the microgrid. Depending on future regulatory and market developments in New York State, the microgrid owner may have opportunities to create new revenue streams similar to those being pursued by Community Choice Aggregation entities.

Several key lessons and recommendations have also been identified through the process of completing this feasibility study. They include:

- Microgrids can support significant community services not related to typical energy supply and delivery services.
- Financial models exist and can be supported by these systems.
- Partnerships are necessary between utility, public, and private parties to make these systems achievable.
- Modification of incentives need to be developed to encourage utilities to favor capital investments over operating expenses.
- Resiliency should be recognized as a distinct service class.
- Service class rates should be developed for allocating infrastructure investments required for microgrid to customers equitably.
- Credit enhancements, such as municipal bond insurance, would assist microgrids ability to access to capital markets.
- Regulatory framework is needed for defining and valuing grid-edge services.
- Microgrids can provide platforms for implementing REV objectives, particularly the interface between the local balancing market and wholesale markets.
- Microgrids can be a valuable test bed for implementation of NY REV LMP+D pricing schemes and DER market animation.

Problem Statement

The proposed microgrid will serve a diverse mix of customers (residential, institutional, and commercial) many of which would experience extended loss of power during a widespread emergency (such as a transmission failure) forcing critical facilities to reduce vital services to the community. For example, Loretto, a comprehensive healthcare provider with several facilities in the area, would experience loss of critical services including 80% loss of in-facility meal services, loss of HVAC, elevator services, water supply to upper floors, lighting and use of program space, loss of sprinkler systems, and shut down of the commissary kitchen that serves 40,000 meals throughout Central New York each week. Even with backup generation, extended outages can result in 50% loss of meal services to patients and 385 residents on site. As a 24/7 facility, Loretto estimates that the cost of emergency measures in the event of a widespread power outage could be more than $200,000 per day.

Another facility, Upstate University Hospital Community Campus (UUHCC) currently experiences periodic power outages from National Grid. In 2014, the hospital experienced ten outages combined for the two utility feeds serving the campus. There were six outages 2013 and five in 2012. There have been two instances in the last 50 years when both National Grid feeders have failed at the same time leaving the hospital on 100% backup power, leading to a 50% reduction in services. Service to this critical facility is also insufficient to accommodate expansion projects currently planned by the hospital. Based on preliminary discussions with National Grid, the Team understands that facility expansion projects under consideration by the hospital might further strain the hospital’s electric service.

Summary of Facility Loads

The following table lists the major facilities in the microgrid. Small residential and commercial loads that happen to be on the feeder in between the critical facilities, and will not be isolated, are aggregated into a single entry labelled "Extra Feeder Load" in the second-to-last row of the table.

Summary of Syracuse Community Microgrid Loads

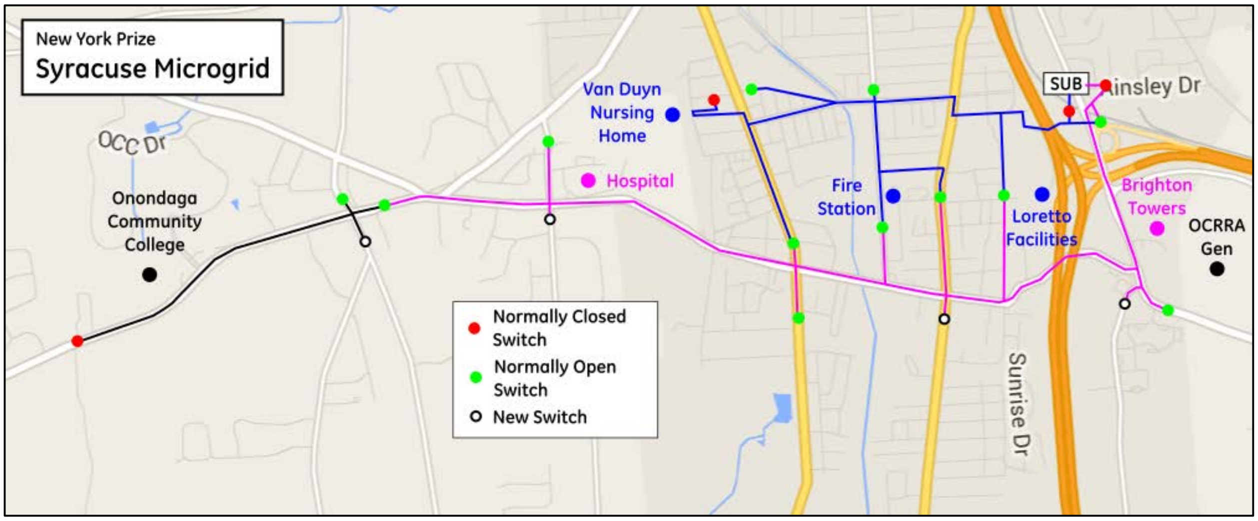
Facility Name	Facility/Customer Description
USPS	Federal. Mail
Onondaga Community College	Community College
Upstate University Hospital - Community	Hospital
Van Duyn Center for Rehab and Nursing	Nursing home
Valley Vista Apt	Senior Housing
Mobil Gas Station	Fuel, food, ATM
Loretto Campus	Senior Housing
Faith Heritage School	School / Place of Refuge
Syracuse Community Police Department	Police Dept., Tops Market, Family Dollar store
Onondaga Hill Fire Department	Fire Department
Betts Branch Onondaga Public Library	Library / Place of Refuge
Brighton Towers	Apartments
Nob Hill Apartments	Apartment
Kinney Drugs	Drug Store, Food,
Onondaga Middle School	School / Place of Refuge
Onondaga County Consolidated 911 Center	911 Emergency Dispatch
St. Michaels Church	Place of worship / Place of Refuge
Extra Feeder Load: 31,740 MWh Energy, 7,244 MW Peak	Mixed, Residential, Commercial
TOTAL Microgrid Load:	72,270 MWh Energy, 14.97 MW Peak

T&D Infrastructure

The OCRRA WTE Plant directly feeds into the National Grid Rock Cut Road Substation, which in turn is the central point of interconnection for two of the three feeders that serve the microgrid facilities. In order to form a microgrid when the main grid is down, the generation from OCRRA would have to be re-directed to serve only the portions of the Rock Cut station feeders with critical loads. This is accomplished in the following manner:

1. OCRRA is isolated from other feeders in the Rock Cut station and directly connected to the main microgrid feeder (shaded in pink in the figure below)
2. Existing and new switches are used to connect adjacent portions of two other feeders (shaded in blue and black) to create the microgrid power delivery system.

The infrastructure layout is shown in the figure below. Some of the major facilities, especially those with existing or proposed (new) generation are labeled.



Map Showing Critical Facilities and Infrastructure for Syracuse Community Microgrid Project

Generation Resources

The OCRRA Waste-To-Energy (WTE) Plant will be the principal source of power generation for the microgrid. OCRRA has been providing a comprehensive solid waste management and resource recovery system to Onondaga County since 1990. In 1992, OCRRA issued more than $178 million in bonds for the purpose of underwriting the construction costs of a state-of-the-art Waste-to-Energy Facility (WTE), including $15 million in environmental controls. The WTE Facility recovers energy from non-recyclable trash and converts it into electricity. OCRRA is not funded by tax dollars and must raise its own revenue for operation. The total plant generates enough electricity during regular operations to serve 25,000 - 30,000 households while at the same time reducing the volume of material that needs to be landfilled by 90%.

The OCRRA WTE plant has a capacity of about 39.6 MW when burning waste, and a capacity of about 9 MW on natural gas. OCRRA has four boilers and can keep on generating at maximum capacity as long as trash is available. There is trash storage capacity for three full days of generation at rated output, but which can last more than seven days during emergency operations, due to the fact that the microgrid load will vary throughout the day, and therefore, the WTE plant will run at partial load most of the time during the emergency period. OCRRA has indicated that three days of trash storage is not always kept in inventory. However, during all historical emergencies on record, OCRRA continued to receive trash delivery and was never shut down for lack of waste to burn.

A new 2-MW CCHP system (consisting of 2 x 1-MW units) is planned at UUHCC to supplement the OCRRA generation, and support anticipated expansion at the hospital campus. The proposed design includes indirect fired absorption chillers to allow for thermal usage (hot to chilled) in the summer for year UUHCC round performance.

Controls & Communications Infrastructure

The proposed microgrid control and communications architecture consists primarily of a Microgrid Energy Management System (or microgrid controller) which orchestrates all control actions and provides the utility interface, and Microgrid Edge Control Nodes (multifunction controller/IEDs) that provide automation and physical interface to switchgear and sensors and existing generation. The suggested communication infrastructure design assumes industrial-grade, long range, point-to-multipoint wireless communication with MIMO (Multiple-In, Multiple-Out) antennas.

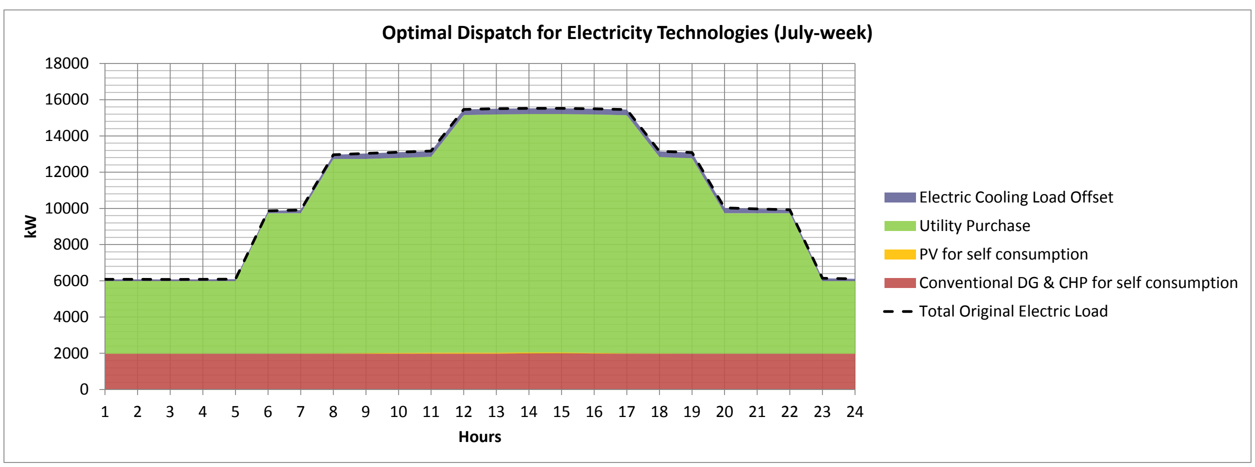
The control hierarchy will use the generation resources to maintain frequency and voltage in islanded mode. Both the CCHP units and the OCRRA plant tend to be better suited to baseload operation than frequency control. That means the majority of fast frequency regulation would come from the standby generation. However, the 2 x 1-MW CCHP units could also provide frequency regulation when operated at part-load. To augment this fast frequency regulation, load may need to be controlled (10% is designated as curtailable). Additionally, it may be necessary for solar production to be curtailed. The specific demands for power matching/frequency regulation will be determined through study, and the microgrid controller will manage assets in response to changing conditions.

Normal and Emergency Operations

Under normal conditions, the facilities that will be part of the microgrid are energized by National Grid's distribution feeders. OCRRA is connected to the National Grid system via a 115-kV line into the Rock Cut substation, and sells power to the main grid. The new 2 MW of new CCHP at UUHCC and the existing 75 kW of PV generation at OCC will generate power, allowing both facilities to reduce peak demand and lower energy costs. Existing diesel backup generation at UUHCC, OCC, and Loretto are not expected to operate during normal conditions, but will be available to provide peak load support.

Under emergency condition (such as a widespread outage or substation failure), the distribution feeders will be slightly reconfigured to shed some laterals and to add portions of two adjacent feeders that serve other critical facilities. The principal source of power for the microgrid during emergency periods is the 39.6 MW of generation at the OCRRA WTE facility that will be reconfigured to directly feed only the microgrid loads.

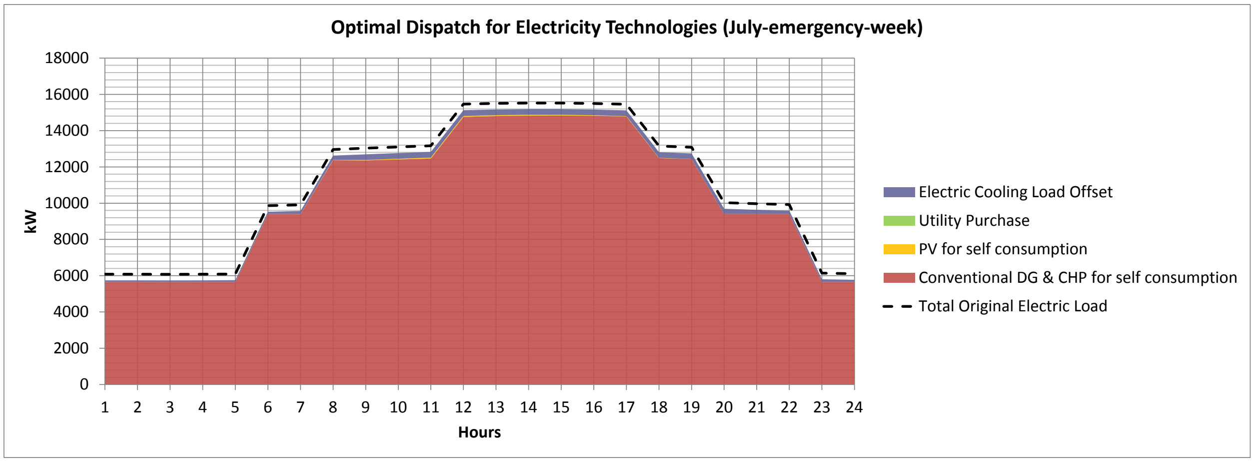
The figure below shows the load and supply balance over a weekday of operation on a normal day in July (which is the peak electrical load month based on the assumed load shapes).



Microgrid Dispatch to Meet Electrical Load – July Normal Weekday

The burgundy colored area represents the available on-site generation in the microgrid during normal days (CCHP, but not OCRRA which sells to the grid during non-emergencies). The yellow colored area (very small and hence not readily visible) is the solar production from the existing 75-kW PV system. The green colored area is the electric energy purchased from the utility. The very thin purple colored area above the green area is the reduction in the original electric load due to use of absorption chillers, which replaces the electric usage by central chillers.

By contrast, the figure below shows the microgrid operation during an emergency weekday in July (the month with the highest microgrid load based on the assumed load shape. As can be observed all microgrid load is met by on-site generation OCRRA, CCHP and solar PV (very small, and hence not invisible).



Microgrid Dispatch to Meet Electrical Load – July Emergency Weekday

It should be noted that due to their very small relative sizes, the solar PV and absorption chiller's cooling load offset are not discernable in the figure. The blank space between the dashed line and the shaded area is the load curtailment applied during emergency

Microgrid Business Model

The business model envisioned for the Syracuse microgrid project is scalable and creates a platform where the owner could become a "network coordinator" or "microgrid coordinator" that incentivizes customers to provide the highest value energy supply, load management, and ancillary services to the microgrid system by providing differentiated price signals. The key elements of the microgrid business model described below include (1) ownership arrangements, (2) financing structure and (3) capital recovery mechanisms.

Ownership Arrangements

The ownership structure imagined for the operation of the microgrid involves a Special Purpose Vehicle (SPV) which would manage and coordinate principal operators of the microgrid (mainly National Grid and OCCRA). As a partner in the SPV, National Grid would own a majority equity stake in the SPV and would thus retain operating control over the microgrid's T&D infrastructure assets. OCRRA would continue to own and operate the main distributed energy resource (DER) assets, not including the 2 MW CCHP system at UUHCC.

Financing Structure

There are several potential avenues towards financing. One would be through the issuance of Clean Renewable Energy Bonds (CREB's) or other public finance mechanism made available through the State to provide the initial capital to support the project. The debt would then be transferred to the SPV who in turn would use income form the microgrid customers to pay off the debt over time. Alternatively, the SPV could use a combination of equity (grants) and debt to finance the project, however it is important to note that initial analysis suggests that this project could be supported with no grant assistance and potentially through traditional financing mechanisms.

Capital Recovery Mechanisms for T&D

Under the unbundled utility microgrid ownership model, the SPV is a joint entity created by the microgrid's distribution infrastructure owner (the utility) and the DER owners (OCRRA and others). The SPV would be able to recover the T&D capital investment in several ways including:

1. **Resiliency Reserve:** The proposed structure is to create a "resiliency reserve" mechanism for allocating costs equitably between microgrid and non-microgrid customers. Subject to regulatory approval, the SPV would collect a monthly resiliency surcharge from the microgrid customers. The size of the surcharge would be calculated every month according to a formula designed to ensure that the SPV always collected sufficient revenues to make the necessary bond payments (and maintain favorable credit ratings).

2. **Distribution Network Use of System (DNUoS) Charges**: Distribution Network Use of System (DNUoS) charges provide a framework for allocating the incremental cost of establishing a microgrid based on how each of the microgrid's customers use of the microgrid's distribution assets affects the total system cost.

3. **PPA arrangements with all Microgrid Participants:** One potential arrangements involves PPA arrangements with all Microgrid participants providing a capital stream to the SPV to pay off debt associated with capitalization and operations of the microgrid assets. PPA contracts are typically 20 years and can provide a reliable sources of income. However given the scope of the project, potential regulatory changes may be necessary to create an "opt-out" PPA arrangement similar to Community Choice Aggregation (CCA), particularly for residential customers within the microgrid service area, which would require review and approval by the PSC.

Capital Recovery Mechanisms for DER

Existing DERs outside of the proposed new 2-MW CCHP system at the hospital are not projected to be part of the integrated system design, and the direct benefits to the hospital are anticipated to support the CCHP. However, several revenue streams that may be available to pay for additions to the microgrid's DER assets, including solar PV, initially include the first three of the four categories below. The fourth revenue stream does not currently exist, but DER owners connected to the microgrid could pursue those revenues if local energy markets exist in the future.

1. **Demand response/Capacity-based revenues**: Demand Response (DR) participation represents a mature revenue opportunity for microgrids. Depending on the characteristics of its load and DER, a microgrid could participate in one of many DR programs offered by the utility or the NYISO.
2. **Energy sales/power exports**: On-site generation creates an opportunity to export power back to the grid. A PPA/CCA hybrid would provide the customer base for addition of DER assets.
3. **Resilience against outages**: Loss of load can create high costs for consumers; the societal and economic values of mitigating these lost loads can be very significant, depending on the nature of the operations occurring within the microgrid.

4. **Local energy markets**: These markets create the potential for future revenue streams for peer-to-peer transactions between DER owners connected to the microgrid.[2]

Benefit Costs Analysis

Industrial Economics, Incorporated (IEc) completed a benefit-cost analysis for all of the feasibility studies completed under Phase 1of NY Prize based on information provided by the project teams under Task 4. The analysis relies on an Excel-based spreadsheet model developed for NYSERDA to analyze the societal costs and benefits of developing microgrids in New York State. The model evaluates the economic viability of a microgrid based on the user's specification of project costs, the project's design and operating characteristics, and the facilities and services the project is designed to support over a 20-year operating period. 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.

According to the BCA completed by IEc, the Syracuse Community Microgrid Project yields a benefit/cost ratio of 2.6 and an internal rate of return (IRR) of 222% i.e., the estimate of project benefits is more than twice that of project costs.

The results indicate that *even if there were no major power outages* over the 20-year period analyzed, the project's benefits would exceed its costs by a factor of more than two. The complete IEc results are included in Appendix A.

The project team's best estimate of initial design and planning costs is approximately $840,000. The present value of the project's capital costs is estimated at approximately $6.18 million, including costs associated with the new 2 MW CHP system and absorption chiller; utility interconnection; upgrades to the distribution circuit; and other system software and controls. The BCA also considers the project team's best estimate of the microgrid's variable 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 approximately $3.35 million, or $17 per MWh (see completed Task 4 questionnaires in Appendix B).

Given the high rate of return and the significant BCA ratio, this project should be considered to be substantially financially viable, financeable, and could provide substantial benefits to the community.

Conclusion

To say that the Syracuse Community Microgrid Project is technically and financially feasible may be a significant understatement. Technology enhancements to the existing system, incorporation of existing and new DER resources, financial and capital attraction models, and evaluation of benefits all suggest this project has the potential to provide significant benefits to the community while advancing the State's clean energy goals.

Inclusion of the WTE facility only enhances these benefits. The potential financial and business operation model provides a significantly enhanced revenue stream for OCRRA which in turn provides a sustainable model of operation where additional landfills are not necessary and we have a cleaner, healthier community.

While the project clearly has multiple benefits, there are some challenges that need to be addressed, including additional evaluation and legal exploration of the SPV, clearing of regulatory hurdles with the utility, the NYS PSC and the NYS DEC, and new service class rate structures.

[2] See Michael Stadler, *Value Streams in Microgrids: A literature Review*, APPLIED ENERGY (Oct. 2015).

These challenges are in no way insurmountable, however. With support from NYSERDA, the Governor's Office, the NYS PSC, and the Joint Utility Board, our team is confident that the proposed Syracuse community microgrid project can be implemented over the next 2-5 years.

Our team is excited to continue to explore implementation of this project and the data and information provided in this report support that sentiment. Projects like this will change the future of communities in New York State and this project could serve as a model for communities across New York to emulate.

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PREAMBLE

The Central New York Regional Planning and Development Board (CNY RPDB) is pleased to submit this feasibility study to NYSERDA under NY Prize Stage 1 for an innovative microgrid, the Syracuse Community Microgrid Project, to serve three critical anchor facilities in Syracuse, including SUNY Upstate University Hospital-Community Campus ("UUHCC"), Onondaga Community College ("OCC"), and Loretto Health and Rehabilitation Center ("Loretto"). The proposed project will provide important resiliency and reliability benefits to these anchor facilities as well as to a diverse mix of other public and private facilities, including a 911 call center, fire station, public school, and private homes.

The completed study evaluates the technical and financial issues related to including one of the Region's largest distributed energy resource ("DER") generation facilities, the 39.6 megawatt ("MW") waste-to-energy ("WTE") plant owned by the Onondaga County Resource Recovery Agency ("OCRRA"). Successful development of the envisioned microgrid promises to demonstrate the value of distribution-automation and smart-grid technologies and dynamic load management approaches to provide resiliency throughout the State.

The following report addresses each task as described under the NY Prize scope of work and incorporates elements of the Benefit Cost Analysis (BCA) completed by Industrial Economics, Incorporated (IEc).

1 DESCRIPTION OF MICROGRID CAPABILITIES

1.1 Minimum Required Capabilities

1.1.1 Critical Facilities

The proposed CNY Syracuse Community Microgrid project, located in the southern part of the Syracuse metropolitan area, is being designed to provide resilient energy services to a cluster of critical facilities. The project includes the Onondaga County Resource Recovery Authority (OCRRA) 39.6 MW waste-to-energy facility (the "WTE Plant"), one of the region's largest DERs, which is connected to the National Grid Rock Cut Road Substation (the "Rock Cut Substation"). All the candidate microgrid facilities are powered by feeders emanating from this Substation.

The candidate facilities, as shown in the map below, include a mix of various critical facilities including:

- SUNY Upstate University Hospital Community Campus (UUHCC)
- Onondaga Community College (OCC)
- Loretto Nursing Home and Senior Housing
- Onondaga County Sheriff's Office South Station
- Onondaga County 911 Administration Center
- Southwood Fire Department
- Iroquois Nursing Home
- Nob Hill Apartments (a large multifamily apartment building) ()
- Kinney Drugs Pharmacy
- Van Duyn Elementary School
- Onondaga Middle School
- Van Duyn Center for Rehabilitation and Nursing
- Onondaga Free Library
- St. Michael's Church
- ~approximately 600 small commercial and 1700 residential customers

These facilities are shown on the map in Figure 1-1 below and detailed in Table 1-1.

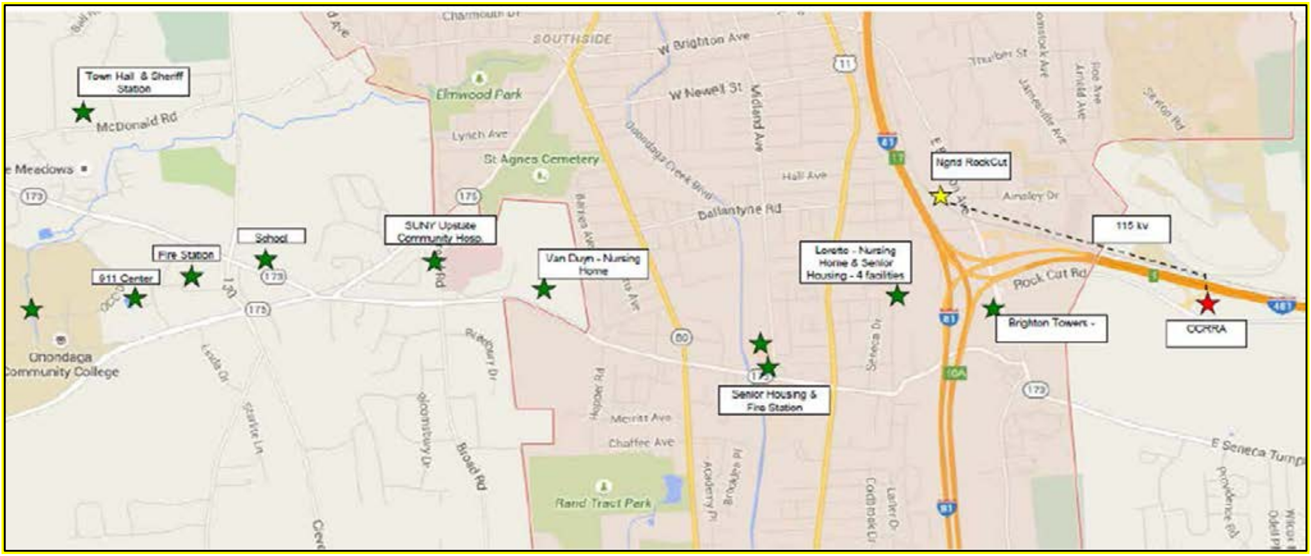

Figure 1-1: Map Showing Critical Facilities for Syracuse Community Microgrid Project

The OCRRA WTE Plant will be the principal source of power generation for the planned microgrid. The WTE Plant directly feeds into the Rock Cut Road Substation, which in turn is the central point of interconnection for multiple feeders. The proposed microgrid critical loads are served primarily from one or more of these feeders emanating from the Rock Cut substation. OCRRA is connected to Rock Cut substation via a 115 kV express feeder. In order to form a microgrid when the main grid is down, the generation from OCRRA would have to be re-directed to serve the critical loads on the Rock Cut station feeders. The configuration to make this *technically* possible was evaluated in Task 2. The economic implications for OCRRA and stakeholders, as well as regulatory implications and barriers are addressed in the following tasks. Based on the current microgrid design, the WTE Plant will feed the load via feeder branches until those branches tally up a load greater than WTE Plant can generate in its two modes of operation.

In the waste-to-energy mode the microgrid can be sized up to 39.6 megawatts of peak power supply. In the natural-gas-use mode, which comes into effect when the WTE Plant runs out of trash, the facility can burn natural gas and generate 9 MW at peak. However, based on load and supply analysis during emergency outage periods, there will be enough trash in storage to feed OCRRA for at least 7 days. The main reason why typical 3-day storage of trash during normal days can last 7 days during emergency is that OCRRA will be operating at below capacity loading most of the time during emergency. This is because the only load to serve during emergency is microgrid load, with a variable hourly load shape, which, most of the time, particularly during off-peak periods, is below the total microgrid generation capacity. The microgrid will be configured to utilize required sets of automatic transfer switches in the distribution network in order to be able to operate in the two modes.

Table 1-1: Critical and Other Facilities Included in the Syracuse Community Microgrid

Facility Name	Facility/Customer Description
USPS	Federal. Mail
Onondaga Community College	Community College
SUNY Upstate University Hospital - Community	Hospital
Van Duyn Center for Rehab and Nursing	Nursing home
Valley Vista Apt	Senior Housing
Mobile Gas Station	Fuel, food, ATM
Loretto Campus	Senior Housing
Faith Heritage School	School / Place of Refuge
Syracuse Community Police Department	Police Dept., Tops Market, Family Dollar store
Onondaga Hill Fire Department	Fire Department
Betts Branch Onondaga Public Library	Library / Place of Refuge
Brighton Towers	Apartments
Nob Hill Apartments	Apartment
Kinney Drugs	Drug Store, Food,
Onondaga Middle School	School / Place of Refuge
Onondaga County Consolidated 911 Center	911 Emergency Dispatch
St. Michaels Church	Place of worship / Place of Refuge
Extra Feeder Load: 31,740 MWh Energy, 7,244 MW Peak	Mixed, Residential, Commercial
TOTAL Microgrid Load:	**72,270 MWh Energy 14.97 MW Peak**

As noted, one of the potential challenges to implementation is the relatively long distances between participating facilities. Leveraging existing utility power lines to distribute power from a microgrid to multiple customers can actually simplify the microgrid design. Traditionally it is the utility regulations and project costs that prevent well positioned microgrid opportunities from moving forward, not the technical difficulty of supplying power to multiple customers from DERs. The proposed microgrid will be scalable and replicable to a majority of projects, and provide a demonstration of DER and microgrid participation in the future REV framework based animated market on envisioned Distributed System Platform (DSP) and also in NYISO energy, capacity, and ancillary markets. The standardized and transparent methodologies, processes and analytic procedures developed to model the Syracuse Community Microgrid and the types of services developed and implemented to support the microgrid, will provide an excellent model for deploying microgrids, most particularly in urban environments.

1.1.2 Primary Generation

The primary generation source for the microgrid during emergency is OCRRA's 39.6 MW WTE Plant.

Instead of going right to a landfill, most of our community's trash is sent to OCCRA's Waste-to-Energy Facility, which generates enough electricity for 25,000 – 30,000 households a year. This reduces the amount of material that needs to be landfilled by ninety percent. It also allows extraction of metals for recycling, which would otherwise go to a landfill. The plant is also capable of running on natural gas, although current regulations limit utilization of this option. In the natural gas mode of operation, the plant's operating capacity is capped at 9 MW. During emergencies (when waste delivery trucks is not possible, due to flooding for example), the WTE Plant can switch to using natural gas. However, as noted earlier, it is expected that the normal day 3-day trash storage will last for at least seven days during protracted emergencies due to the fact that the microgrid load will vary throughout the day, and therefore, WTE plant will not be running at full load most of the time. It is also possible for the plant to operate utilizing a combination of natural gas and garbage via configuration of the boiler system utilized at the plant.

The conceived microgrid also includes installation of a 2 x 1-MW Combined Cool and Heat and Power (CCHP) plant paired with a 400-ton indirect fired absorption chiller located at UUHCC. In the past the Hospital shared a heating district with its neighbor Van Duyn Nursing Care Facility and there is existing infrastructure to move waste heat generated from the CCHP system to loads at the Hospital or the Nursing home. Recycled heat from the prime mover is used for:

- Space Heating (Steam or Hot Water Loop)
- Space Cooling (Absorption Chiller)
- Process Heating and/or Cooling (in hospitals this might include equipment sterilization, laundry, kitchen, general hot water needs, etc)
- Dehumidification (Desiccant Regeneration)

The WTE plant is capable of significant load variation by turning on and off combination of its three boilers. Additional load following will be provided by the CCHP. In islanded mode, OCRRA would serve as base-load generation, but capable of running at different load points, with the CCHP units providing additional load-following and regulation under the supervision of the microgrid controller.

When the larger grid goes down, there are several ways of forming the microgrid depending on the mode of failure. There are stability implications that are addressed in Task 2, and will be further studied and evaluated in Stage 2 (The GE team performed a similar detailed engineering study in their Potsdam microgrid feasibility study). In Task 2 the Team has further defined and addressed additional design and operation issues. For example, if there is a transmission outage, it is possible that OCRRA will be exposed to the entire Rock Cut station load (depending on the configuration). In this event, fast-load-shedding the other feeders to achieve a stable operation point should be possible without OCRRA taking an outage. If there is a substation failure, OCRRA might see total loss of load (again, depending on the station configuration). In this case, OCRRA might go offline and critical facilities would run on CCHP until the island is formed. In either case, some potentially complex switching operations will be performed to redirect OCRRA generation to serve the microgrid facilities.

The Team also evaluated the potential for renewable resources, particularly solar PV. The Onondaga Community College campus currently has installed PV arrays, with a total capacity of about 75 kW. Some of the facilities have been identified as possible candidates for rooftop solar (multiple buildings at Loretto, UUHCC, and OCC), and there are open spaces that may be good candidate sites for ground-mounted solar PV arrays. This could result in another 250 kW of solar PV which could be integrated into the microgrid. However, since OCRRA is already a renewable facility with large enough capacity to meet the peak load of microgrid during emergencies, it was decided that additional renewable resources were not only unneeded; they would unnecessarily increase the underlying cost of the microgrid.

1.1.3 Operational Variability

The inclusion of OCRRA's 39.6 MW WTE Plant in the Syracuse Community Microgrid project provides significant variability in the operation of the microgrid. During normal (i.e., blue sky) days, the excess electricity produced by the WTE plant (net of internal electricity usage) is exported to the larger grid. Total (gross) electricity generated for 2013 was 216,401 megawatt-hours (MWh). Of this amount, 188,529 MWh, or 87%, was sold to National Grid (net electricity). The balance, or 13%, was used for the Facility's electrical needs. The Facility's 19-year average net electricity production is 627 kilowatt-hours per ton of refuse processed (kWh/ton).

The WTE Plant typically has three full days of supply of municipal solid waste (MSW) on hand. In the event that severe weather or disaster-related emergency prohibits the delivery of MSW, the Plant could operate at approximately 9 MW using only natural gas as the fuel source. The Plant could potentially also use its large supply of woody yard waste as fuel source. Use of wood waste and natural gas would require state regulatory approval. As noted earlier, the WTE plant has enough MSW at any given moment to provide connected facilities over 7 days of emergency energy.

Additional generation proposed is a CCHP at UUHCC that would have enough capacity to supply all its normal operational needs, and also cover the needs of a future (~90,000 square foot) build-out space, and the neighboring Van Duyn Nursing Care Facility. Fully redundant normal power would obviate the need for additional costly backup power, at about $2,000/kW-installed, as required by NFPA 99 (the existing emergency power infrastructure required during the loss of all external power sources would be retained). Microgrid would allow full operational capabilities that have to be restricted when operating on backup power. In addition to being able to maintain full patient-care service, it also minimizes the economic impact on the facility in that services will not have to be postponed due to service reduction. Since the OCRRA WTE Plant could also be used to all of the facilities' normal power requirements, it is also likely that it will avoid the need for capital investment form the utility to provide additional power service to this hospital.

A number of commercial microgrid control system platforms are available as candidate solutions, in addition to advanced control systems being developed by GE, NREL and others. These include hardware and software solutions from large and small players such as ABB, Encorp, Schweitzer, Spirae and others. The available commercial platforms vary in functionality. A complete control solution is typically comprised of an integrated suite of both hardware and software components. Depending on the microgrid site use cases, the control solution may require some level of custom code development or configuration scripting to support integration with electric distribution equipment, the building energy management systems (BEMS), controllable loads, and generation assets within the microgrid, the ISO control center, as well as National Grid enterprise systems which include energy management systems (EMS), distribution management system (DMS), and outage management systems (OMS).

1.1.4 Intentional Islanding

Islanding is the situation where distributed energy resources or a microgrid continues energizing a feeder, or a portion of a feeder, when the normal utility source is disconnected. For a microgrid to sustain an islanded subsystem for any extended duration, the real and reactive power output of the generation must match the demand of that subsystem, at the time that the event occurs. Without active voltage and frequency regulation controls providing stabilization, an island is very unlikely to remain in continuous operation for long. Moving forward the Team will evaluate switching technologies (transfer switches and isolation switches) that would allow the microgrid to seamlessly and quickly transition to islanded mode, and also incorporate appropriate communications and controls technologies (discussed above) that would allow the microgrid to remain electrically viable and persist for the duration of the emergency (subject to fuel availability).

A particular challenge identified in the process of completing the feasibility study was addressing the instance where current National Grid distribution network feeders would be utilized and all the non-microgrid facilities on the same feeders had to be switched off at the onset of larger grid outage, and switched on again after the restoration of power to the larger grid. It was decided it would be simpler to including the additional loads in the design since the WTE Plant's capacity and its typical MSW storage would be sufficient to cover all the loads on an entire feeder. The final design plan includes energizing entire neighborhoods which are on the same feeders as the originally identified critical facilities. To further refine this approach, the Team examined information from National Grid and other sources to determine the extent of additional loads on the relevant feeders. During grid outage mode the main feeder out of the Rock Cut that hosts the most critical facilities with societal significance (28651) will be energized, as well as portions of other feeders (28652 and 23551) that have critical facilities. This configuration will pick up additional neighboring loads on the feeders that otherwise would be too difficult or costly to isolate. The business model considered includes the option where National Grid can continue to transparently bill the customers during microgrid mode, and UUHCC, OCC, and Loretto can be compensated for their generation through net metering or other means. These concepts are further explored in Task 3.

1.1.5 Automatic Separation

The final functional design of the microgrid is based on the configuration of an electrical, control, and communications network. National Grid's 115 kV line between its Rock Cut Road substation and OCRRA's WTE plant is sufficient to handle the entire electrical load of the microgrid. The project team is recommending utilization of the National Grid distribution lines to continuously provide power to the critical facilities and other customers on the feeder(s). This required configuring the existing network so that the microgrid that can operate in islanded mode during emergencies and larger grid outages and reconnect when the emergency is over.

Three networking options initially considered include the following scenarios:

1. The WTE Plant power will be delivered to the microgrid through the National Grid Rock Cut substation. During major emergencies, the substation itself and the feeders emanating from the substation may be affected by the same events as the rest of the grid and may not be available to power the microgrid facilities. Hence to ensure resilient operation of the microgrid, portions of the Rock Cut substation and relevant sections of feeders will also have to be hardened against major events.
2. In the event of an emergency, the feeders emanating from the Rock Cut substation that are not serving the microgrid facilities may need to be switched off from the substation if OCRRA WTE Plant does not have capacity to serve them. If the plant has enough waste to burn throughout the outage, then the plant can generate up to its maximum operating capacity. If the nature of the emergency, such as severe weather conditions or major floods, does not allow for continued delivery of waste, then OCRRA WTE Plant will switch to natural gas mode and operate with the ability to handle a load up to 9 MW. However, as noted earlier, a load and supply analysis indicated that the WTE can continue operations with MSW as fuel for at least 7 days of emergency.
3. At the start of an emergency, all the facilities which are not part of the microgrid, but are on the same feeders as the microgrid facilities, may have to be isolated from the microgrid feeders if there is not sufficient capacity. They will also need to be restored at the end of the emergency.

When the utility source is lost, the controller monitoring voltage at the Points of Interconnection (POIs) would initiate the transition process from grid-connected to islanded mode. This could include switching operations to redirect OCRRA generation to supply the feeders serving microgrid facilities, switching non-critical loads off (where it makes sense) and isolating portions of the feeder(s) that do not serve critical loads.

The specific nature of the transition (e.g., make-before-break vs. break-before-make) were considered in Task 2, but it can be stated that the design will include power and communication equipment necessary to facilitate the transition from parallel to islanded operation mode, which would appear seamless to microgrid customers.

1.1.6 Operators Requirements for Scheduled Maintenance

OCRRA has fulltime operations and maintenance staff, and procedures dedicated to keep the plant running 365 days. Maintenance is typically done by unit in the spring, with turbine takedown every 5-7 years. Turbine availability has averaged 99.7% uptime per year for the last twelve years. This includes both modes of operation. A minor outage occurs every 2.3 years for a few hours, but a cold iron outage is a very rare event. The Hospital, Loretta and OCC also employ fulltime facility personnel to maintain and operate their physical plant systems.

The maintenance plan will adhere to and comply with manufacturer's requirements for scheduled maintenance intervals for all generation in the microgrid. We are recommending reliability-centered maintenance (RCM) strategies that focus more attention on critical pieces of equipment that could affect the microgrid operation (such as rotating machines, transfer switches, breakers) but will recommend periods during the day, week, and year when routine maintenance would be less likely to coincide with an outage event. Most routine maintenance activities can be accomplished during off peak periods, eliminating the possibility of incurring peak demand penalties from system down-time. Longer duration maintenance can be scheduled for off peak hours. This is a data driven task that is likely to become more effective given a longer operating history.

1.1.7 Load Following

The WTE Plant can operate independently and as base load in both grid-connected and islanded mode. It can ramp up and down and operate constantly at different loadings points based on the combination of firing one or more of its three boilers. The plant has 3 boilers which produce steam to the turbine. These boilers modulate on and off as required. Additionally, the microgrid could employ existing backup diesel generators for load-following when islanded. Diesel engines are good choices for load following applications for systems in this size range as they can ramp nearly instantaneously in response to sudden changes in demand. There is collectively over 2,500 kW of installed backup diesel engines at UUHCC and Loretto facilities; including almost 1,000 kW installed since 2013.

In connected mode (parallel to the grid), microgrid generation resources would typically not be required to regulate frequency or voltage or follow load. These services are provided by generators under governor control. However, in islanded mode, microgrid resources must switch from baseload power control to frequency control and the bus voltage must be controlled either by a generator's voltage regulator or by some supervisory control (such as a microgrid controller). To avoid a collapse of the island, some generators would switch from baseload to frequency control; some voltage regulators would switch from power factor control to bus voltage regulation; and excess loads should be shed to maintain balance. With multiple DERs of various types, and controllable loads in an area, a microgrid control system may be preferable for successful islanded operation. We will explore these operational issues in the analysis tasks.

When considering the load/generation balance, several classifications of load may be considered. Generally, these classifications fall into critical, discretionary, and deferrable. At a minimum, the DER mix must be sufficient to meet critical load at all times, i.e. the microgrid will be sized to meet the critical load (constituting the baseload) at all times during normal and emergency periods. The microgrid will attempt to meet the discretionary load during the emergency period, provided there is sufficient supply from internal generation. However, in a variety of likely circumstances, available generation might exceed critical load. In such cases, additional load may be served, but sufficient controllability must be incorporated in the design to shed load if the need arises. In a contingency, the microgrid will incrementally shed discretionary loads until load and supply balance is achieved. Curtailable load is the load that will be immediately dropped at the onset of the interruption of power delivery from the larger grid. Additionally, some load has flexibility to be scheduled which adds an additional layer of control to the load/generation mix.

1.1.8 Two-Way Communication

We considered design options for this task. The microgrid's information network will leverage the in-place networks and protocols to support the control and communication functions, with a view to cost saving and interoperability. Elements of the existing building automated systems at the Hospital and elsewhere will be integrated in the microgrid control system.

The first step was to determine whether the microgrid solution would leverage existing networks or if there was a need to design and deploy new communications systems. Details of the functional design of the control and communication network are provided in Task 2.

We evaluated the use of existing communications systems in two important areas as described below.

Cost Savings and Interoperability

Reuse of existing communications systems can provide cost savings as the microgrid developer will not be required to deploy an entirely new communications fabric. Individual network segments or complete reuse of the communications system can be applied and significant cost savings can be achieved. Additionally, where reuse is leveraged, protocols and data models can be selected to achieve maximum interoperability and performance.

Security and Resilience

There is a trade-off between cost savings acquired via reuse of existing communications systems and the reduced security and resilience attributes in older communications technology and design approaches. This will be analyzed, and cost and security considerations will be balanced to accommodate the site-specific functional requirements.

Maximum weather resilience and performance is achieved when underground fiber optic networks are deployed. Additional surety can be obtained by creating redundant fiber rings and including two-way communications. The use of fiber, redundant networks, and underground deployment makes this the most reliable and resilient method, but it is also the most costly option. The generation portfolio for the microgrid and potential use cases during connected and islanded modes would go a long way in determining the performance requirements for the communications infrastructure.

Cyber security addresses protection against hacking and malicious intent. We considered options such as: modern hardware platforms and network nodes that incorporate device level authentication and authorization; adding security services to the microgrid control nodes and control center to address encryption of data at rest and data in motion; and adding a security architecture that applies defense in depth design principles which includes segmenting of data and system components across different levels of security zones to offer a hierarchy of authorization constraints and system access barriers. Note that cyber security services can be added as a security layer on top of existing communications when reusing networks but cannot change the existing physical security, resilience or performance limitations of the existing networks or device nodes.

1.1.9 Customer Type Connectivity

The proposed microgrid extent is identified in Figure 1-1 and includes the entirety of all customers on the feeder line out of the Rock Cut substation as well as a number of customers west of UUHCC. IN total over 2000 facilities are located on our proposed microgrid with a mix of critical facilities and small commercial and residential customers.

1.1.10 Uninterruptible Fuel Supply

During a 7-day emergency, the 3-day MSW storage of the normal day operations would be sufficient to meet the fuel requirements of the WTE plants during the 7 days of emergency, because of many hours of low microgrid load during off-peak periods. We explored the reliability and resiliency of natural gas supplies for use by the OCRRA WTE Plant and potential CHP installations. The WTE Plant is able to switch to natural gas, and no issue has been raised with regard to the availability of natural gas for the plant use. As noted, we do not expect that WTE Plant would switch to natural gas during a 7-day emergency and variations of WTE and Natural Gas utilization are available to provide more flexibility and operation variation based on available fuel supplies. Resiliency to Forces of Nature

Since the proposed microgrid is to be powered mainly by the WTE Plant through the Rock Cut Substation, it will be necessary to ensure resiliency of the Plant and the Substation and the interconnecting feeders by additional reinforcements, if required. The GE Team will rely on the results of a study they performed for the New Jersey Board of Public Utilities on "NJ Storm Hardening Recommendations and Review/Comments on EDC Major Storm Response Filings"[3], issued on November 26, 2014.

OCCRA's waste is stored in an indoor facility and is not susceptible to weather related events. In fact, during storm event it has been normal for OCCRA to continue to receive trash delivery and in some cases increased amounts.

CHP systems have proven to be very resilient during these types of storm events. During Hurricane Sandy in 2012, six New York City hospitals and 12 New Jersey residential care facilities went dark despite diesel backup. As a result, 8% of NYC hospital beds were unavailable, and 1,408 patients had to be evacuated. However, among all the sites where the CHP unit was designed to operate during grid outage, there was not a single site that lost power.

In Stage 2, the Team will work with National Grid and stakeholders to develop a resilient network design that incorporates hardening strategies commonly practiced by systems engineers in areas exposed to storms and outage events. This includes fault-tolerant and self-healing network designs, redundant supply or reconfigurable supply where it makes sense, remote monitoring and diagnostic equipment, robust construction, use of submersible equipment in underground construction, and a number of other time-tested measures.

1.1.11 Black-Start Capability

The OCRRA WTE Plant has black start capabilities. The Plant is designed to operate continuously, with maintenance performed on one out of three boilers at a time. Hence, it is expected that the Plant will

[3] http://nj.gov/bpu/pdf/reports/NJ_Major_Storm_Response-GE_Final_Report-2014.pdf

continue operations in the event of a larger grid outage. The Plant usually has three days of stored waste/refuse (for normal day operations). After waste storage runs out, the Plant can switch to natural gas. The WTE Plant has a 1.5 MW dual-fuel diesel and natural gas start-up generation sufficient for black-start for the rare occasion when the Plant is not online at the start of the emergency. Once the plant is online, the start-up generator is no longer needed.

In general, the microgrid start-up will be automatic after either a specified time frame of sustained utility outage and/or based on a command from the microgrid operator to transfer from grid-connected to microgrid operations. Other on-site power systems will have the ability to start and operate using battery power and UPS devices and controls to start from a state of zero power to a state of sustained power production as matched to the microgrid load. Based on criticality and necessity, certain critical loads such as Hospital and life support services will be given a priority during startup operations.

1.2 Preferred Capabilities

1.2.1 Operational Capability

The application of advanced automation and control technologies were explored to enable enhanced visualization, monitoring, control and interaction. The ultimate goal of advanced and innovative technologies is to enable safe, reliable, economic operation of the microgrid, in both connected and islanded mode. This includes: consideration of best in class distributed energy resources, including demand response, energy efficiency measures and energy storage to meet the instantaneous demand; smart grid and distribution automation technologies, such as automated switching and automatic fault location isolation and service restoration (FLISR) schemes, to ensure reliability and power quality; smart relays, adaptive protection, special protection schemes to ensure flexibility and safety.

Innovative characteristics of the envisioned Syracuse Community Microgrid include:

- Integration within a microgrid system of a large DER that currently provides wholesale power to the larger grid;
- The diversity of facilities that will be served
- Financing of the infrastructure in a multiparty community microgrid with large institutional participants
- Ability of the approach to be replicated in similar communities across New York State
- Potential use of the project in education and outreach programs

1.2.2 Network Control System

We evaluated the current set of available commercial microgrid controllers. From our recent microgrid studies we are aware that available commercial microgrid controllers primarily support various levels of the most fundamental operating functions such as load shedding, optimal dispatch, integration of renewables or energy storage, forecast and scheduling, and basic situational awareness. Advanced functions like deep control integration with external SCADA or DMS systems or deep monitoring integration with AMI and other data collection and analysis systems is typically a custom developed adapter built to support a specific microgrid use case and system configuration.

Furthermore, the GE team is participating in a separate DOE-funded project on development and testing of microgrid controller. The project is managed by the GE Global Research Center in Niskayuna, NY. Additional work on developing various microgrid controller functionalities is being done by GE Digital Energy in the GE Markham Grid-IQ office in Ontario. Moreover, GE Energy Consulting is a collaborator in development and testing of an off-grid microgrid decision tool being developed by Lawrence Berkeley

National Laboratory and a number of other national laboratories. Section 2.5 provides a fuller characterization of the microgrid controls and communications design.

1.2.3 Clean Power Supply

The Team has considered all opportunities to incorporate clean power and renewable resources into the generation mix for the microgrid.

The OCRRA WTE plant burns trash 24/7 all year long (subject to waste availability) producing 500-600 kWh per ton of waste processed (kWh/ton). When the plant is not burning waste, it is able to run on clean natural gas at half the rated capacity and also uses natural gas for startup and shutdown.

The facility uses state-of-the-art pollution control technologies, and all emissions are carefully monitored with oversight by the NYS Department of Environmental Conservation.

Results of the facility's annual air emissions and ash residue tests consistently demonstrate the facility's exemplary environmental track record.

With respect to greenhouse gas emissions in particular, waste-to-energy provides mitigation through three separate mechanisms: 1) by sending material to a waste-to-energy facility, it avoids sending materials to a landfill where organic materials anaerobically degrade and generate methane emissions, 2) by generating significant quantities of electricity, waste-to-energy offsets carbon dioxide (CO_2) emissions from fossil fuel based electrical generation, and 3) by recovering ferrous and nonferrous metals for recycling, waste-to-energy avoids energy consumption and greenhouse gases associated with extracting and processing virgin metals.

A recent US EPA-authored journal article published in ***Environmental Science and Technology*** applies a life-cycle analysis model to evaluate whether it's better to burn or bury MSW. The article is titled, "Is It Better to Burn or Bury Waste for Clean Energy Generation?" and the analysis compares greenhouse gas emissions and emissions of other pollutants for WTE and landfill gas-to-energy (LFGTE), using a life-cycle analysis model. The study states that MSW is a viable source for electricity generation and finds that WTE is a better option than LFGTE because WTE generates significantly more electricity from the same amount of waste, with fewer emissions. Though not immediately intuitive, emissions from LFGTE are due to fugitive methane emissions in a landfill, as well as emissions from combusting landfill gas in an internal combustion engine. The last paragraph of the article provides a good summary (Kaplan, Decarolis, and Thornloe, 2009):

> *"Despite increased recycling efforts, U.S. population growth will ensure that the portion of MSW discarded in landfills will remain significant and growing. Discarded MSW is a viable energy source for electricity generation in a carbon constrained world. One notable difference between LFGTE and WTE is that the latter is capable of producing an order of magnitude more electricity from the same mass of waste. In addition, as demonstrated in this paper, there are significant differences in emissions on a mass per unit energy basis from LFGTE and WTE. On the basis of the assumptions in this paper, WTE appears to be a better option than LFGTE. If the goal is greenhouse gas reduction, then WTE should be considered as an option under U.S. renewable energy policies. In addition, all LFTGE scenarios tested had on the average higher NOx, SOx, and PM emissions than WTE. However, HCl emissions from WTE are significantly higher than the LFGTE scenarios."*

Several graphs from the article are provided below and on the next page. These graphs compare the relative emissions of greenhouse gas emissions, NO_x, and sulfur oxide (SO_x) for WTE, LFGTE, and several conventional electricity generating technologies.

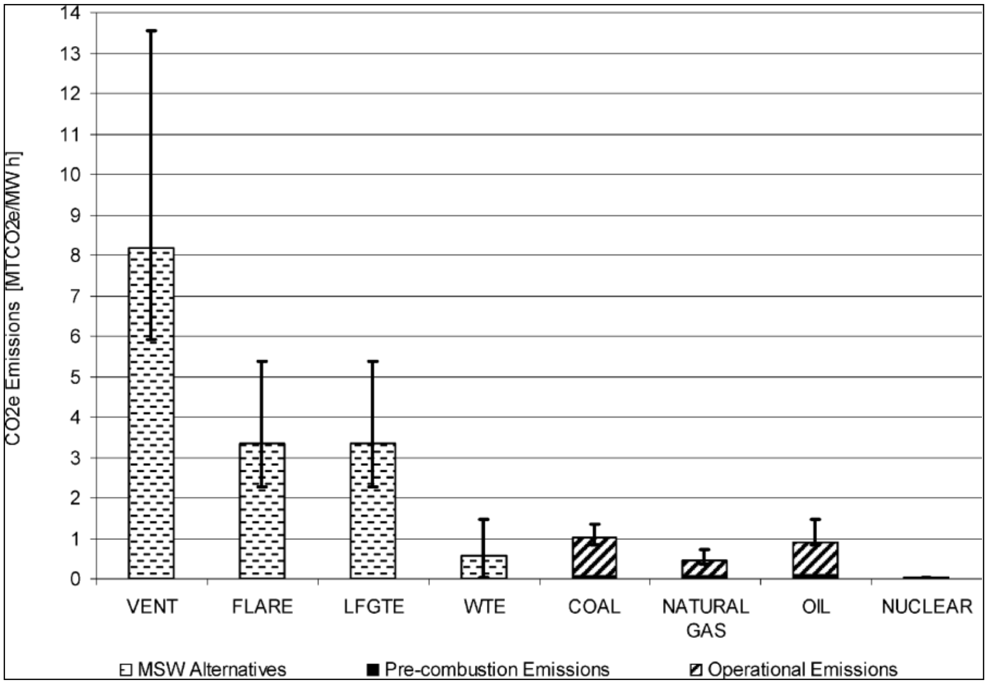

Figure 1-2 Comparison of GHG emissions for LFGTE, WTE, and conventional generation technologies[4]

An option to consider in Stage 2 is to co-locate a new facility with high thermal usage close to OCRRA that can purchase and capture part of the reject heat currently lost in the waste-to-energy process. Potential facilities that would utilize process heat include manufacturing process, greenhouses, and sterilization, vulcanization, and bottling processes among others.

1.2.4 Energy Efficiency and Demand Response Options

As the project moves forward into Stage 2, the facilities will be evaluated for deployment of green-building upgrades. Proposed upgrades will include measures such as lighting upgrades, daylighting, water, pump and motor efficiency, boiler and chiller optimization, HVAC upgrades, building envelope and insulation improvements, and advanced building- and energy-management system installations.

The three anchor facility participants within the project have participated in lighting, motor, VFD, and boiler/chiller installation incentive programs available through NYSERDA and National Grid. Loretto employs a Carrier-developed Energy Management System (EMS). University Upstate Hospital has implemented or identified over $3.6 million in energy efficiency projects with total annual electric savings of nearly 1.8 million kWh. OCC has established a LEED requirement for new buildings, purchased 30% of campus electricity from renewable sources, built charging stations for electric cars, implemented a sustainable landscape plan, installed a 21 kW solar PV array on the roof of the Whitney Applied Technology Center in 2011, and earned LEED Gold certification for the new SRC Arena and Academic II building in 2014. Most recently, the college was named by Princeton Review as one of its Green Colleges.

[4] Source: Kaplan, Decarolis, and Thornloe, 2009 (Figure 2)

The microgrid has the ability to provide generation/load reduction to support a substation during critical periods as an alternative to distribution-system reinforcement; payments for islanding as a demand response (DR) service, payments for exporting power as a generation service, and payments for maintaining critical loads during a larger system outage. A contract could call for immediate response in local crises, not just to reduce peak system demand. Short-term markets for local service could be local voltage/VAR support, short-term substation relief, and emergency services (e.g., agreements to make agreed-upon energy exports or to assume prescribed load shapes). Through distributed storage systems (DSSs), the microgrid could provide grid restoration services that are more flexible than typical black-start capabilities and ultimately, ensure local reliability, circuit by circuit, across the larger grid. All of these different market constructs need to be discussed with National Grid, and an appropriate mix of services agreed to in order to support both National Grid and microgrid participant requirements.

This project enables demand response options, both within the utility programs and also in NYISO markets, based on the allocating a portion of the load of the largest facilities to load curtailment and demand response. In Stage 2 design, a deeper technical review will be performed to assess feasibility of incorporating the existing EMS systems in these facilities that include current load shedding options, in order to minimize cost of additional investment.

The GE Team met with NYISO representatives to discuss the potential for NYISO market participation by microgrids and behind the meter DG. NYISO is still working on the applicable market rules. The GE Team will maintain the relationship with NYISO and monitor on-going developments and impact on the Syracuse Community Microgrid. Based on the latest information, the team will explore ways for the proposed microgrid to actively participate in the NYISO's energy, capacity, and ancillary services markets.

1.2.5 Electric System Interconnection

As discussed earlier, the proposed microgrid facilities are positioned on one or more distribution feeders emanating from the Rock Cut Substation. The proposed design is based on using the existing National Grid infrastructure with the option of switching off the non-microgrid facilities with the objective of limiting the number of connections to non-microgrid facilities and the main grid. In Task 2, the Team assessed the need for isolation switches, transfer switches, motor operated breakers and other switchgear, relays, transformers and other equipment. The installation requirements and resulting cost for additional equipment were examined in Task 2 and the estimated costs were reported in the BCA documents

During an emergency, the WTE plant's generation will be directed to the serve all the critical and additional facilities on the feeders which are part of the microgrid. OCRRA is connected to the Rock Cut substation via a 115 kV line and the microgrid facilities are assumed to be supplied by distribution feeders at medium voltage levels out of Rock Cut substation.

In Stage 2, the Team will work with National Grid to develop an understanding of the relevant features of the electric distribution system and identify the current distribution network challenges in terms of parsing out a microgrid out of the current grid and ensuring that the larger grid will not be adversely impacted.

In Stage 2, the audit-grade engineering design of the details of the configuration of the underlying electric network of the microgrid will be highly dependent on the current distribution network, locations and distances of the microgrid facilities on the feeders, and the technical requirements that need to be considered in the functional design of the microgrid electrical infrastructure. A very important consideration in selecting final parts and equipment will be the overall cost of various grid type options.

We have also conducted initial assessment of the requirements for the interconnection or interconnections between the microgrid and the larger grid, in terms of installation, operations, maintenance, and communication.

1.2.6 Coordination with REV

We believe that this project will advances REV objectives and will be a showcase project in New York State for demonstrating and validating new utility business models and associated market constructs discussed in the REV proceedings. We have taken into account the latest REV developments in considering various business models and operational modes of the microgrid within the REV framework. The GE Team members are on weekly calls set up by Advanced Energy Economy (AEE) to review and discuss recommendations for the NY REV Framework development, including contribution to the Clean Energy Standards (CES) and Clean Energy Credits (CEC), and LMP+D recommendations. We understand that details of REV framework will keep evolving, which we will take into account in our development of the microgrid functionalities. This project is unique in that it involves islanding a large WTE plant that is normally connected to the main grid, to serve a group of critical facilities. This exposes several technical, economic, and regulatory issues that go the heart of REV.

We are working collaboratively with National Grid as well as community stakeholders to develop win-win-win approaches to the implementation of the proposed microgrid. There are opportunities to begin to test and validate certain key REV market constructs and associated new potential revenue streams and profits moving bi-directionally between consumers and the Utility through a phased-in, utility-as-distributed-services-platform-provider ("DSPP") business model.

There are numerous outstanding regulatory issues, as evidenced by the comments filed by active parties in response to the Commission's request for comments on microgrids. Some outstanding issues include:

1) Types of payments for the services to be provided by the microgrid to the utility and those to be provided by the DSPP to the microgrid.
2) Type of payment for utilizing existing distribution wires both in normal and islanded modes.
3) Control of the communications and control system when in normal operating and in islanded modes.
4) Existing tariffs such as electric and steam standby rates, gas-delivery rates and others to ensure that the microgrid is not economically disadvantaged because of existing approaches.
5) Interconnection processes and procedures for microgrids and the timetables in place that might impede interconnection.

We expect other project will identify similar barriers that will be used to inform necessary regulatory and tariff changes in the State of New York.

1.2.7 Comprehensive Cost/Benefit Analysis

As part of the complete evaluation of our projects feasibility Industrial Economics, Incorporated (IEc) completed a benefit-cost analysis to evaluate both the net societal benefits and also the costs and benefits from the perspectives of the various stakeholders.

An important feature of the proposed Syracuse Community Microgrid is that the main source of power generation, OCRRA's WTE Plant, is already in operation and therefore the investment, installation, and commissioning cost of new major baseload generation for the microgrid is avoided. Furthermore, the WTE Plant has already established a history of continuous operations during normal days as a renewable generation resource, with minimal variable operating costs and zero - or even negative - fuel costs, since OCRRA WTE Plant actually gets paid to take in municipal waste.

Facilities in the project area are served primarily from 13.2-kV-class feeders emanating from National Grid's Rock Cut Road substation. Based on preliminary discussions with National Grid, capacity issues are likely to arise if UUHCC implements several facility expansion projects currently under consideration. It is well acknowledged that distribution facilities are aging, and that it is National Grid's general practice to retire substations of this type when assets reach the end of their useful lives. The approach typically used by National Grid is to replace aging 5 kV facilities with existing or new distribution feeders emanating directly from alternative 115kV-13.2 kV transmission sources, as with OCRRA's facility. From a utility planning perspective, the envisioned microgrid has the potential to extend the life of the Rock Cut Road substation by reducing the load on the substation and associated feeders. This will be further explored with National Grid planning and engineering personnel in Stage 2. In addition, the envisioned microgrid design, incorporating controlled switches, has the potential to improve service reliability in this neighborhood, potentially exceeding regulatory requirements for service reliability improvements for years to come without significant additional capital expenditures.

Based on exploratory discussions with National Grid, the Team believes that the neighborhood is representative of the Utility's Upstate NY service territory, which according to the National Grid 2012 Reliability Report, are characterized by a SAIFI of about 0.9 and a CAIDI of about 120 minutes/customer/year. These metrics are based on the IEEE 1366 distribution reliability metrics standard, which specifically exclude storm-caused outages. The feasibility study will evaluate neighborhood specific quality and reliability issues for both electric and gas distribution. UUHCC experiences periodic power outages from National Grid. In 2014, the hospital experienced ten (10) outages combined for the two utility feeds serving the campus. There were six (6) outages in 2013 and five (5) in 2012. In review with National Grid, no trends have been identified. There have been two (2) instances in 50 years when both National Grid feeds have failed at the same time leaving the hospital on 100% backup power. Both were relatively short durations. Based on preliminary discussions with National Grid, however, the Team understands that facility expansion projects under consideration by Community Campus may further strain the hospital's electric service.

The proposed resilient microgrid is expected to eliminate the prolonged outage periods of the microgrid critical facilities and minimize any short-term interruptions. Hence the experience of microgrid facilities will be improved significantly, not only during the extended outage periods caused by natural or man-made disasters, but possibly also during normal operating times when the larger grid experiences shorter interruptions due to extreme weather or equipment failure.

An extended power outage would force all three anchor facilities to reduce services. OCC, for example, would experience approximately 95% loss in services during outages. Loretto enacts its existing emergency plans but staffing is an issue. Loretto maintains a service agreement with Airside Tech and Kone, for its HVAC system and elevators, respectively, but only one of its elevators is connected to the generator feed. Even with backup generation, extended outages can result in 50% loss of meal services to patients and 385 residents on site, as well as the loss of HVAC all but one elevator service. Without backup, Loretto would experience 80% loss of in-facility meal services, HVAC, no elevator services, loss of water supply to upper floors, loss of lighting and use of program space, loss of sprinkler systems, and shut down of the commissary kitchen that serves 40,000 meals throughout Central New York each week. As a 24/7 facility, Loretto estimates that the cost of emergency measures in the event of a widespread power outage (i.e., a total loss of power in the area surrounding the facility lasting at least 24 hours), could be more than $200,000 per day.

The daily cost of maintaining service while operating on backup power alone is likely to be very high and potentially prohibitively so for the facilities hooked up to the proposed microgrid location. During typical power outages, Community General Hospital is served by a combination of secondary National Grid feeders and emergency generator power, allowing the hospital and campus buildings to operate at about 90% of full services.

In the event both National Grid feeds to UUHCC fail, the hospital would be on 100% emergency power, leading to a reduction in services of approximately 50%. The hospital's Chilled Water Plant is not currently served by emergency power due to its size. This means that should the campus lose both of its electrical feeds from National Grid, cooling could not be provided to the hospital and other buildings. During summer months, in particular, this could create a need to shut down medical equipment and to evacuate patients. The microgrid will improve community resilience by ensuring operations at three anchor facilities that provide critical services to the entire Syracuse community. In addition to serving the anchor facilities directly, the microgrid will enhance resilience during extended grid outages that originate outside of the neighborhood by serving a diverse mix of public and private facilities that provide essential services. As one example, twin 18-story apartment buildings in the Brighton Towers apartment complex are home to low income elderly and/or disabled residents, which make these facilities a high priority for providing a shelter-in-place emergency response.

In preliminary discussions with OCRRA and Covanta Onondaga (the group that operates the waste to energy plant), it has been determined that the WTE facility can potentially serve as source of base load power and backup power during emergencies. The facility typically has three days of supply of municipal solid waste (MSW) on hand. In the event that severe weather or disaster-related emergency prohibits the delivery of MSW, the facility can operate at 9 MW capacity using its natural gas supply as the fuel source. However, the load and supply analysis has shown that the 3-day storage of normal sky blue day type operation will be sufficient for a 7-day emergency period operation, mainly because the WTE Plant will be operating at below maximum load many hours of the day as the microgrid load drops below its peak most of the hours.

In addition, the facility could potentially also use its large supply of woody yard waste as fuel source, although this may require state regulatory approval.

1.2.8 Private Capital Options

We explored a range of ownership and control models for what is inherently a complex and difficult type of project to finance, resulting from multiple asset types with varying productive lives. The goal is to finance directly as much as possible using shared-savings contracts and PPA structures that eliminate up-front payments for microgrid participants. Some of the new compensation mechanisms may be developed jointly between the Team and the Utility/DSPP to support these arrangements.

Financing microgrid requires creative financial mechanisms to bundling various participants into an integrated entity, helping to reduce risks for all investors. Financing sources explored include Property Assessed Clean Energy (PACE) financing, shared energy savings models for energy-efficiency projects, securitized portfolio of assets that bundle natural gas and renewable energy assets, federal and state tax incentives, grants, low-cost loans and so on; infrastructure funds, large hedge funds, long-term asset investors such as pension funds, the NYS Green Bank credit-enhancement products, and municipal Bond financing mechanisms.

The current business model considered proposes to structure the financing to produce returns on investment and debt coverage that will attract private financing needed to complete the project. The team also evaluated different ownership models that will help attract third party funding. The final financial analysis to be completed in Stage 2 will determine the amount of capital needed, and they type of debt most appropriate to capitalize the project.

In Task 3, a business model has been proposed that delineates the ownership structure for the envisioned microgrid. It is expected that National Grid will continue to own and operate electric distribution lines. Microgrids are unique from a financing perspective because of the diversity of kinds of assets, with very different “financeability” profiles and perceived levels of risk. This translates into complexity in terms of how a financing package is put together, particularly one that needs to be standardized, transparent, and based on a methodology which investors will understand. It is also rare that implementation of a microgrid occurs as one project with one common investment vehicle. Instead, the value proposition of microgrids evolves over multiple phases, centered on demand and consumption reduction, on-site generation and storage, advanced control systems and automated grid independence. Development phases can also overlap, leading to additional complexity. In addition, not all phases or asset components will qualify for incentives or grants, and the overall capital investment could be substantial. Financing of microgrids in general and in New York State in particular will require a creative approach to bundling various sources into an integrated package, which will effectively reduce risks for all investors.

1.2.9 Tangible Community Benefits

The proposed project has the potential to provide tangible benefits to the community including the owners of generation assets, participants on the grid, infrastructure owners, and surround neighbors. Specifically, anticipated benefits include:

- OCRRA- This facility is currently exploring other opportunities to increase revenue streams, including selling of electricity in the retail market. This project would give them a clear and identifiable customer base with a load that can be matched nicely with their production/generation capacity.
- SUNY-UUHCC - Current infrastructure in this area is currently constrained in regards to capacity. SUNY-UUHCC and National Grid have been exploring opportunities to accommodate expansion of the Hospital campus and this project provides them with a tangible solution. Increased onsite generation and smart gird technologies will allow for more precise load following and onsite utilization of waste heat to supplement peak load requirements. Connection to the microgrid will allow for future addition of generation sources to accommodate further expansion on the Hospital Campus as well as the surrounding properties.
- National Grid- This project will allow the utility to accommodate expansion at the Hospital otherwise severely constrained. It will also provide a platform for exploration of new smart grid technologies will minimizing capital expenses and the risk of stranded assets.
- Community- The project involves powering of an entire feeder and parts of two others allowing for maintaining of service in the event of an outage to approximately 2,000 residential and commercial customers, including several facilities of refuge including OCC, while maintaining power to additional critical facilities including the Hospital, 911 call center, and several elderly care centers owned by Loretto.

1.2.10 Innovation that Strengthens Surrounding Grid

The microgrid will incorporate monitoring and control technology to allow other DERs to supply the load in the network without putting the grid operation at risk. This will create opportunities for customers on the microgrid to interact with the main grid, participate in the market, and define new streams of revenue and value.

The Team has considered the options for interaction of the microgrid with the surrounding power grid, including both the distribution utility and the NYISO. The interaction with the surrounding grid across a Distribution System Platform (DSP) through market animation is a major aspect of the New York

Reforming of Energy Vision (REV). For instance, one possible innovation that may be considered within the REV framework is optimal economic operation of the resilient microgrid during blue sky days (i.e., during normal, non-emergency periods), by participation in the utility demand response programs and also NYISO's energy, ancillary services, and capacity markets.

An active and dynamic scheduling of microgrid operations that would maximize the economic efficiency and technical reliability of the microgrid and the surrounding system will require both technical innovations and also reform of regulatory and policy regime that would enable market participation. The Team will elaborate on needed innovations and requirements that would enable such market participation. These may include complementary hardware that would provide more flexibility, such as integrated energy storage, and the smart scheduling software.

The Stage 2 design will specify the actionable information that would need to be made available to customers for economically efficient and technically reliable operation and scheduling of the microgrid generation. These include real-time load and supply status of the microgrid and the underlying variable costs of operations and the applicable seller and buyer prices on the DSP and/or NYISO. It should also be noted that such actionable information, although accessible to customers when requested or queried, would function and used mostly in the background in automated microgrid systems.

2 PRELIMINARY TECHNICAL DESIGN COSTS AND CONFIGURATION

The primary DER for our proposed microgrid is an existing 39.6 MW WTE plant connected to an existing distribution system substation via a 115 kV line. In addition to the WTE plant, the microgrid will contain 2MW of natural gas fueled CCHP with 400 tons of absorption chilling at SUNY-UUHCC.

The microgrid is designed to include an entire feeder out of Rock Cut and portions of two adjacent feeders. When the microgrid forms, existing and new transfer switches will be used to isolate the feeder sections with critical facilities from the rest of the distribution system, and redirect OCRRA's generation to serve the microgrid load.

A microgrid control system (or energy management system) will be employed for monitoring the microgrid resources in grid connected mode, and for controlling the voltage and frequency in islanded mode. This will be accomplished via a hierarchy of controller devices that communicate through a new dedicated wireless or fiber-optic network. Besides dispatching optimal levels of generation and managing load in the microgrid facilities, the main task of the control system will be to coordinate the switching devices at the interconnection points with the surrounding distribution network.

2.1 Proposed Microgrid Infrastructure and Operations

2.1.1 Simplified Equipment Layout

The figure below shows a simplified layout of the Syracuse microgrid. The microgrid is based around the OCRRA facility which can provide up to 39.6 MW of power when burning waste, and 9 MW when being fueled by natural gas. The OCRRA waste-to-energy plant has been operating continuously in Onondaga County since 1990, burning trash that is produced in most towns and villages in the County. Power generated by OCRRA is evacuated to National Grid's system via a 115 kV line connecting OCRRA to the Rock Cut substation. During a widespread emergency such as a bulk power system failure of a Rock Cut substation event, the generation at OCRRA would be stranded while critical customers in the area suffer prolonged outages. The microgrid design will redirect the generation from OCRRA to provide power to the majority of a distribution feeder (shown in pink in Figure 2-1below), plus portions of two other feeders with critical loads (shown in blue and black).

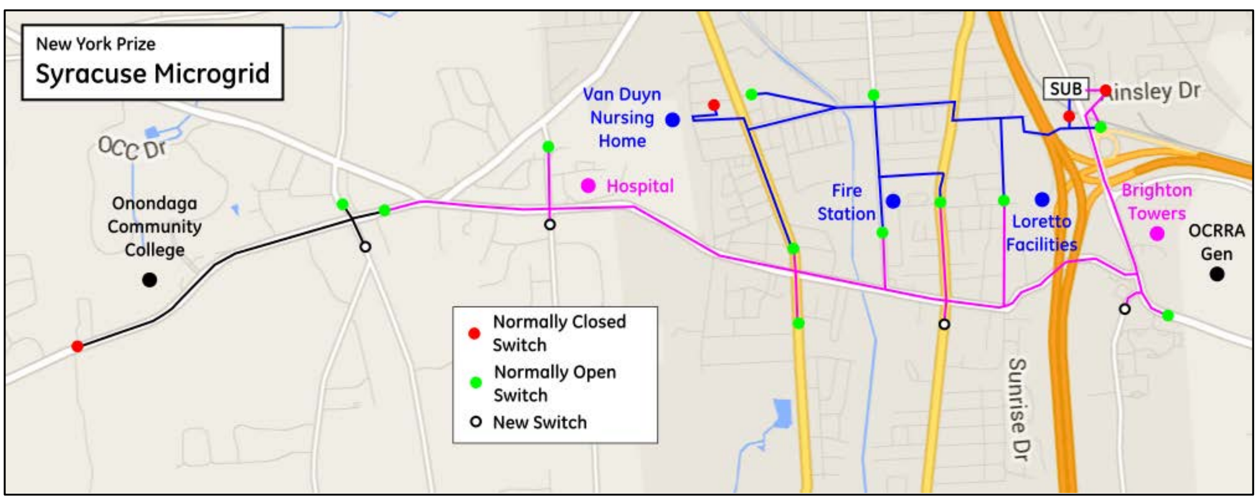

Figure 2-1: Simplified Layout of Syracuse Microgrid Showing Electrical Connections and Select Facilities

Figure 2-2 below shows a simplified one-line diagram with the location of the distributed energy resources (DERs) and the utility interconnection points. The major addition is a 2 MW of Combined Cooling and Heating and Power (CCHP) plant at Upstate University Hospital with 400 tons of absorption chilling. There are a number of existing diesel-fuel generators at various the microgrid facilities, totaling 1,900 kW, but these are expected to be used mostly as second-order back up units, and are not expected to operate for any significant amount of time during an emergency period (microgrid islanded mode) or during normal blue sky days (grid connected mode).

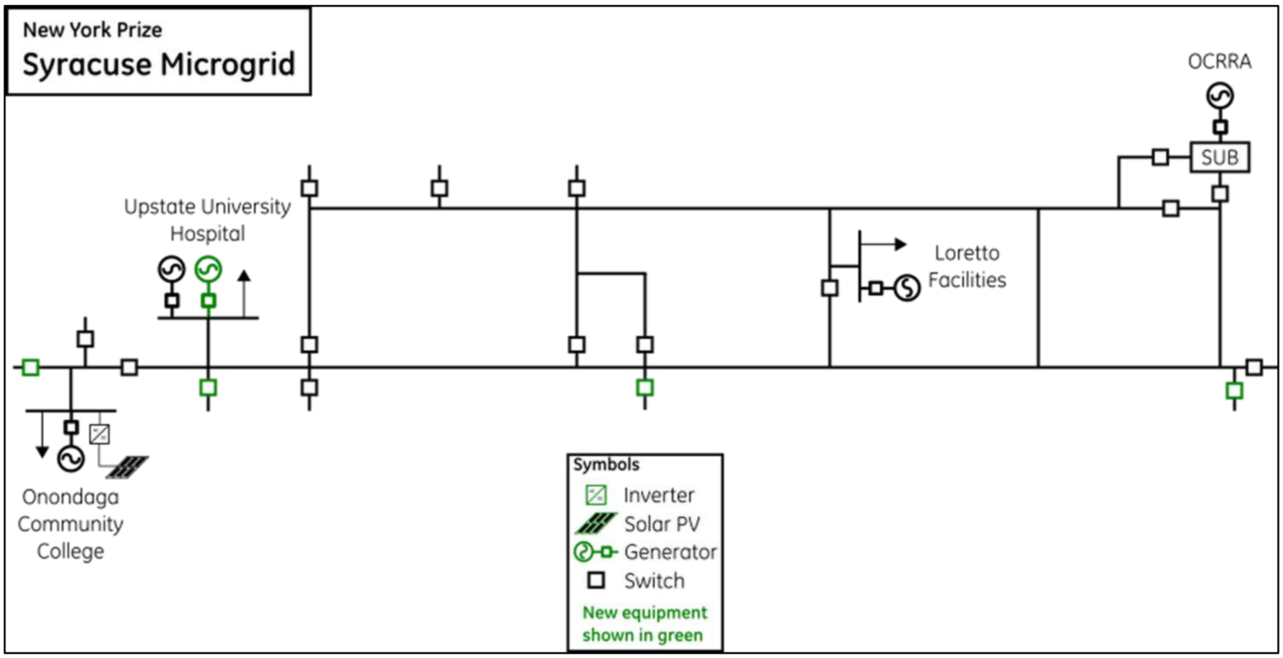

Figure 2-2: Syracuse Community Microgrid One-Line Showing Generation Sources and Major Equipment

2.1.2 Normal and Emergency Operations

Normal Conditions

Under normal conditions, the facilities that will be part of the microgrid are energized by three National Grid distribution feeders. OCRRA is connected to the National Grid system via a 115 kV line into the Rock Cut substation, and sells power to the main grid.

The proposed 2 MW of new CCHP at the SUNY Upstate University Hospital-Community Campus (UUHCCC) and the existing 75 kW of PV generation at Onondaga Community College (OCC) will generate power, allowing both facilities to reduce peak demand and lower energy costs. In addition, waste heat from the CHP will be used to supply thermal energy needs for SUNY-UUHCC and the nearby Van Duyn Nursing Home. Existing diesel backup generation at SUNY-UUHCC, OCC, and Loretto are not expected to operate during normal conditions, but will be available to provide Peak Load Support.

Emergency Conditions

Under emergency condition (such as a widespread outage or substation failure), the distribution feeders will be slightly reconfigured to shed some non-critical laterals on the feeder serving SUNY-UUHCC out of Rock Cut station, and to add portions of two adjacent feeders that serve other critical facilities including OCC, Van Duyn, the Fire Station and the 911 call center (Figure 2-1). New and existing 15-kV class isolation switches will be used to reconfigure the feeders. The principal source of power for the microgrid during emergency periods is the 39.6 MW of generation at the OCRRA waste burning facility. The OCRRA facility connection into Rock Cut will be reconfigured such that OCRRA can directly feed only the main microgrid feeder out of Rock Cut.

OCRRA has four boilers and can keep on generating at maximum capacity as long as trash is available. There is trash storage capacity for three full days of generation at rated output. Analysis of the load profiles during an emergency (see Section 2.2.2) indicates that this amount of inventory can last more than seven days during the emergency period based on the estimated energy use and peak load of the microgrid during the period. However, OCRRA has indicated that three days of trash storage is not always kept in inventory. Nevertheless, during all historical emergencies on record (including snow related events) OCRRA continued to receive trash delivery and was never shut down for lack of waste to burn.

In the rare event that OCRRA runs out of trash, the boilers can also be fired with natural gas. The maximum rated capacity on natural gas is 9 MW and special dispensation is required for this mode of operation. Based on the analysis and historical records, it is not anticipated that OCRRA will have to run on natural gas for an event short of a seven-day emergency period.

When power is lost to the feeder, the microgrid controller which is monitoring the points of interconnection (POIs) with the main grid will sense loss of voltage and the CHP generation and PV will go off-line (in accordance with anti-islanding protection procedures). Interconnection points with the utility at the critical facilities will open and diesel backup generators at the UUHCC, OCC and Loretto will start up to supply critical facility loads. Once UUHCC is isolated from the utility system, the CHP unit will restart in islanded mode and synchronize with the backup generation. Switching operations will be performed to connect OCRRA to the microgrid loads; backup generators will shut down as load at all locations are sequentially picked up by OCRRA. Once the island is stable and active, the PV at OCC would reconnect and begin generating. During islanded operation, the microgrid controller would actively monitor voltage and frequency in the island, which is largely determined by OCRRA’s plant control system.

2.2 Load Characterization

2.2.1 Electric and Thermal Loads

The table below summarizes the microgrid electrical and thermal loads.

Table 2-1: Monthly Microgrid Electrical, Heating, and Cooling Load

	Electrical Load		Heating Load		Cooling Load	
	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)
JAN	5,553,630	11,264	2,172,350	5,210	0	0
FEB	4,919,747	11,033	1,895,778	5,027	0	0
MAR	5,265,322	10,679	1,607,472	3,855	0	0
APR	5,413,131	11,273	970,518	3,768	17,925	50
MAY	6,594,756	13,375	432,459	1,635	129,954	354
JUN	6,940,491	14,453	110,629	429	470,523	1,316
JUL	7,382,700	14,973	16,762	63	909,678	2,477
AUG	7,114,646	14,430	41,905	158	708,025	1,928
SEP	7,140,467	14,870	264,839	1,028	215,096	601
OCT	5,640,628	11,440	771,050	1,849	13,444	40
NOV	5,239,023	10,910	1,253,795	3,084	0	0
DEC	5,065,456	10,273	1,865,606	4,474	0	0
YEAR	**72,270,000**	**14,973**	**11,403,162**	**5,210**	**2,464,644**	**2,477**

Within the microgrid there are two principal source of electric energy: the OCRRA WTE plant and the proposed 2 MW CCHP unit at SUNY-UUHCC. The existing diesel generators at OCC, SUNY-UUHCC, and the Loretto Nursing Care Facility are not expected to operate for any significant amount of time in either microgrid islanded mode or grid connected mode. This is mainly due to the fact that OCRRA typically has enough trash (on-hand and delivered) for a seven-day emergency period, and also that the diesel engines and too expensive to operate during normal blue sky days. There are also environmental restrictions on how long diesel engines can run during non-emergencies.

During grid parallel mode OCRRA will be running in business as usual mode, burning trash, providing power to the grid, and participating in the available markets. The CCHP at UUHCC will supply baseload thermal loads at the campus. This will produce the electricity that will meet a large portion of the hospital's electrical load, and lower the overall cost of energy. The average simple payback for CCHP is seven years. The electricity produced is on average 75% of the facility's total electrical load for the year. The 2 MW CCHP at UUHCC can be connected to the nearby Van Duyn Nursing Care Facility to supply thermal loads, allowing for more efficient operation of the CCHP plant. The team will consider creating a dedicated electrical connection so that excess power from UUHCC can be sold back to National Grid.

In the future, SUNY Upstate can add another 1 MW CCHP unit to their plant once they construct the planned 100,000 square-foot addition. This will allow greater energy savings and better financial return, in addition to reducing the need for additional investment by the utility.

It should be noted that microgrid's thermal loads (heating and cooling) include only Van Duyn's and UUHCC's thermal loads. It was determined that inclusion of the thermal loads of other facilities in the microgrid would be financially prohibitive, due to the additional cost of generation capacity and thermal network infrastructure.

OCRRA rejects waste heat to the atmosphere and makes no use of the heat used to spin the turbine. There is a potential opportunity for a high-energy-use business such as an inland port, green house, bottling plant, or sterilization facility, as a business development concept, to set up shop adjacent to OCRRA and purchase the waste thermal energy at a discount.

2.2.2 Hourly Load Profile

The main sources of electrical load data for critical facilities are the feeder-level hourly electrical data provided by National Grid. The main source of thermal data is the estimates/interpolation based on the hospital's fuel bills. However, since the Team decided to include in the microgrid other non-critical loads that happen to be on the same feeder(s) as the originally identified critical loads, the entire aggregated feeder load had to be modeled. The information provided by the National Grid was used to estimate the annual peak load of the microgrid and to determine (using a reasonable estimate of a load factor between 50% and 60%) the annual energy demand on the grid. Consequently, a 12x24 (month x hour) load shape was developed, resulting in an annual peak load of about 15 MW and a load factor of 55%.

The total annual heating and cooling load of the hospital were projected over different months based on the monthly Heating Degree Days and Cooling Degree Days data for the Syracuse Area, downloaded from the NYSERDA website[5]. The monthly loads were then projected over a 12x24 load shape based on seasonal load shapes developed by EPRI for each region of the USA by customer class and for different end uses[6].

The charts in Figure 2-3 to Figure 2-8 show weekday and weekend profiles for microgrid electrical, heating, and cooling loads.

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[5] http://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Weather-Data/Monthly-Cooling-and-Heating-Degree-Day-Data

[6] http://loadshape.epri.com/enduse

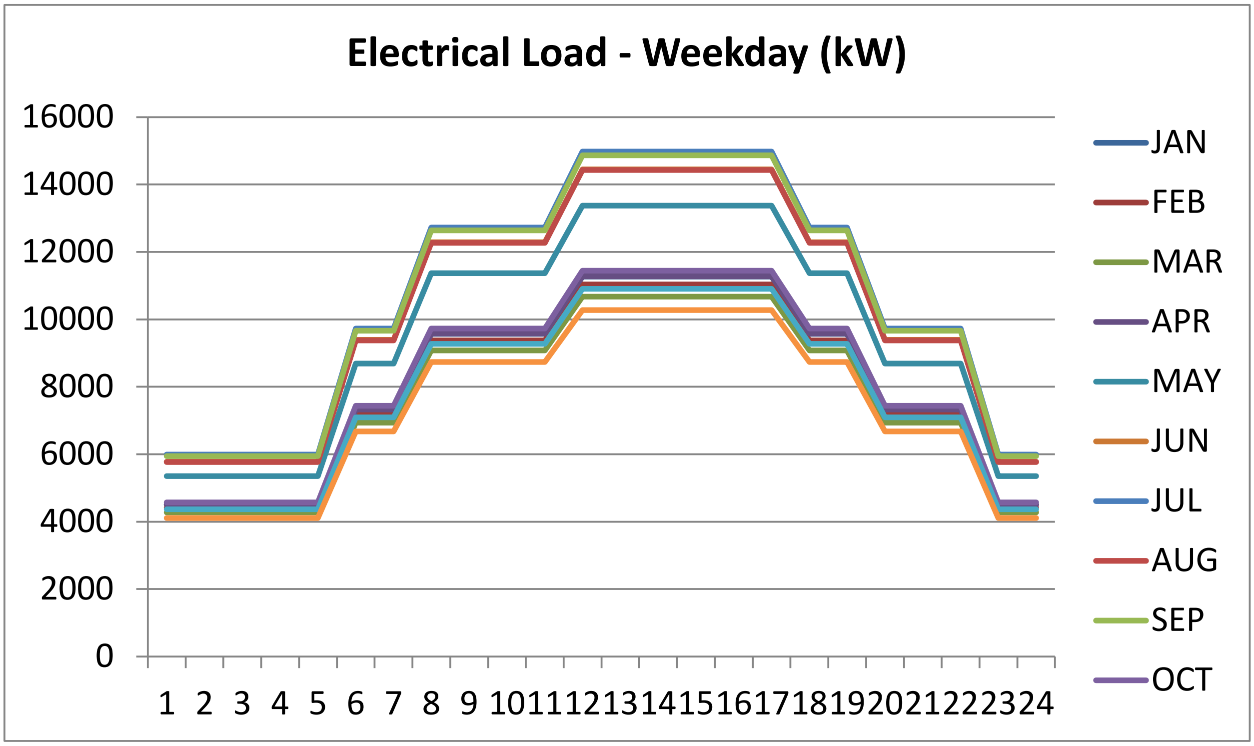

Figure 2-3: Microgrid Weekday Electrical Load Profile (kW)

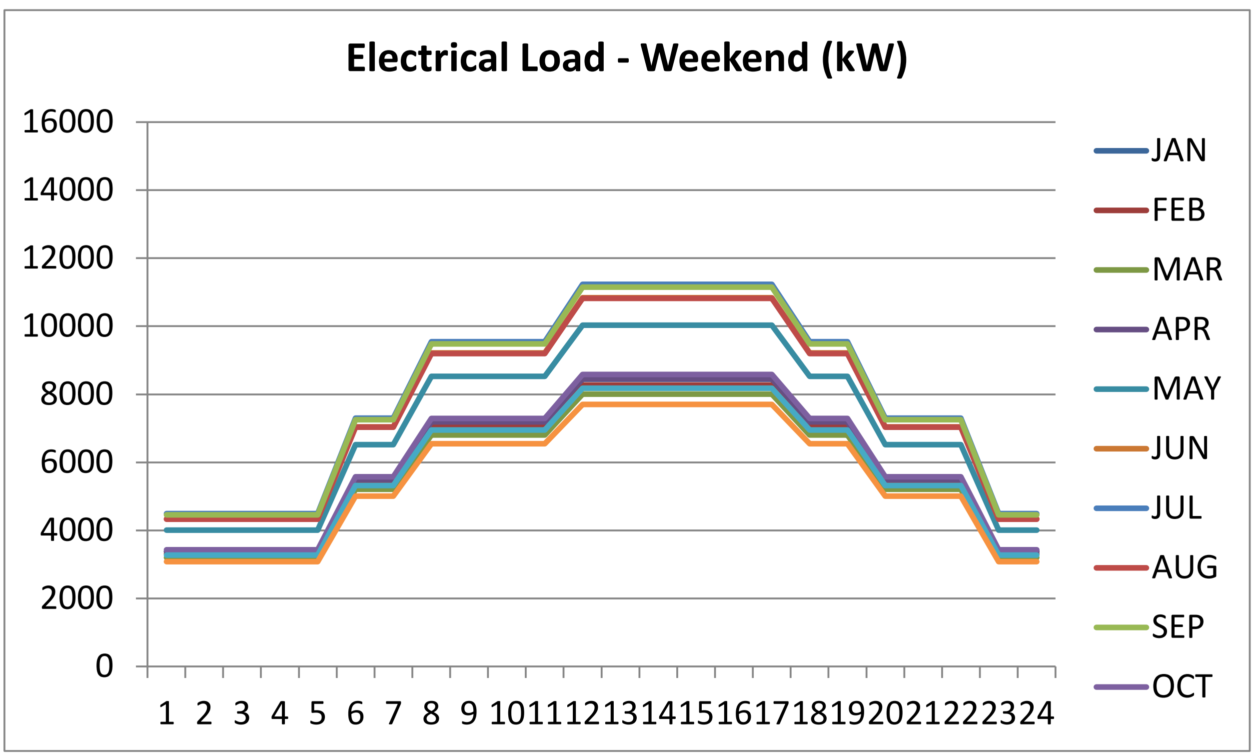

Figure 2-4: Microgrid Weekend Electrical Load Profile (kW)

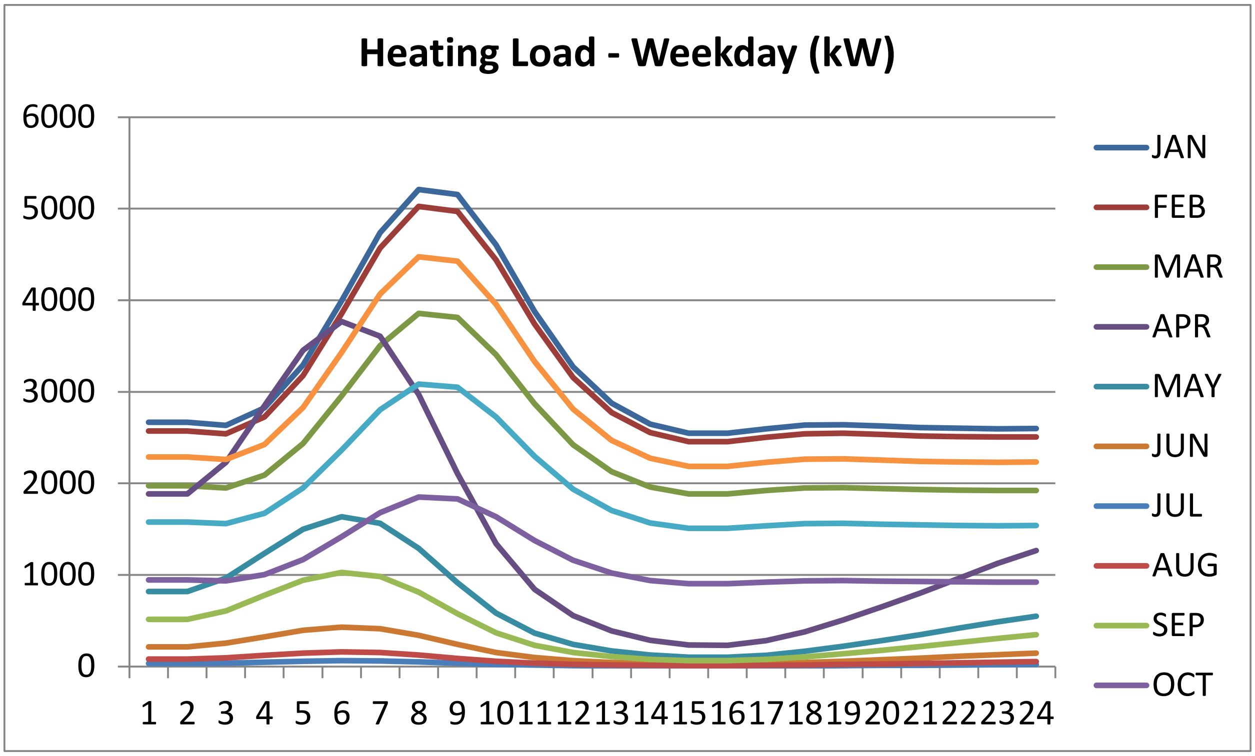

Figure 2-5: Microgrid (Hospital Only) Weekday Heating Load Profile (kW)

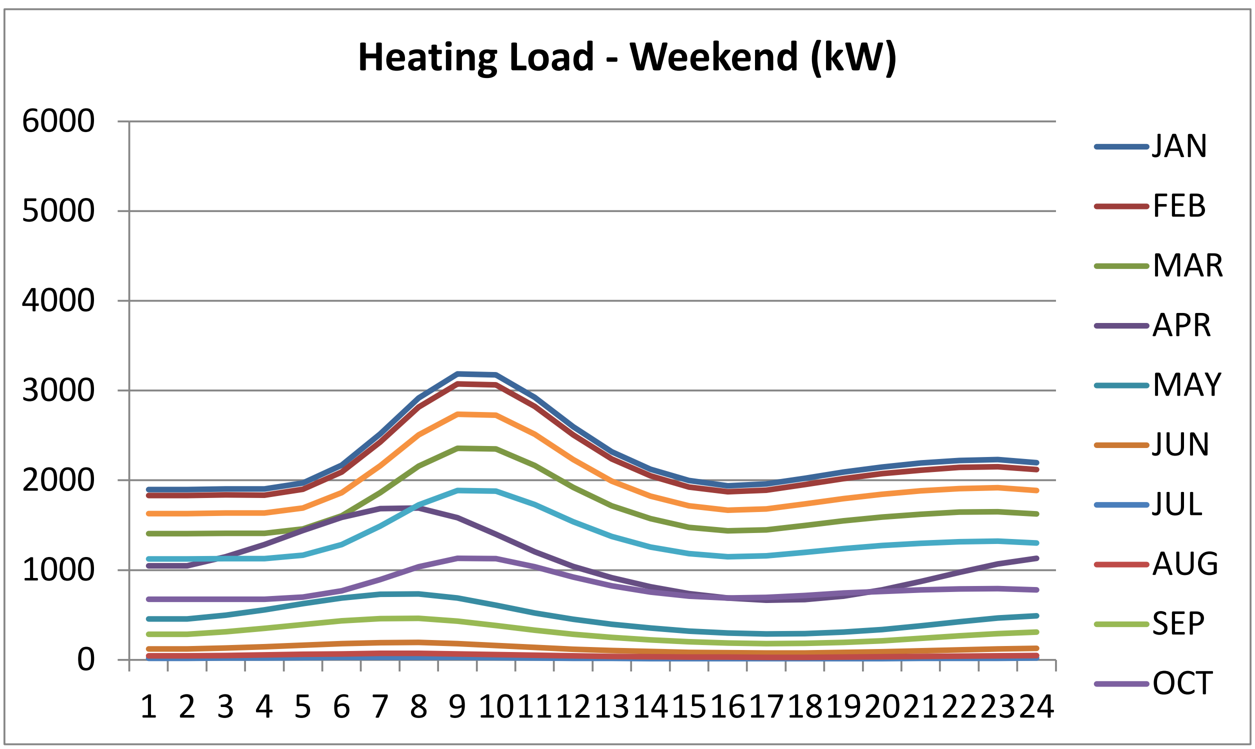

Figure 2-6: Microgrid (Hospital Only) Weekend Heating Load Profile (kW)

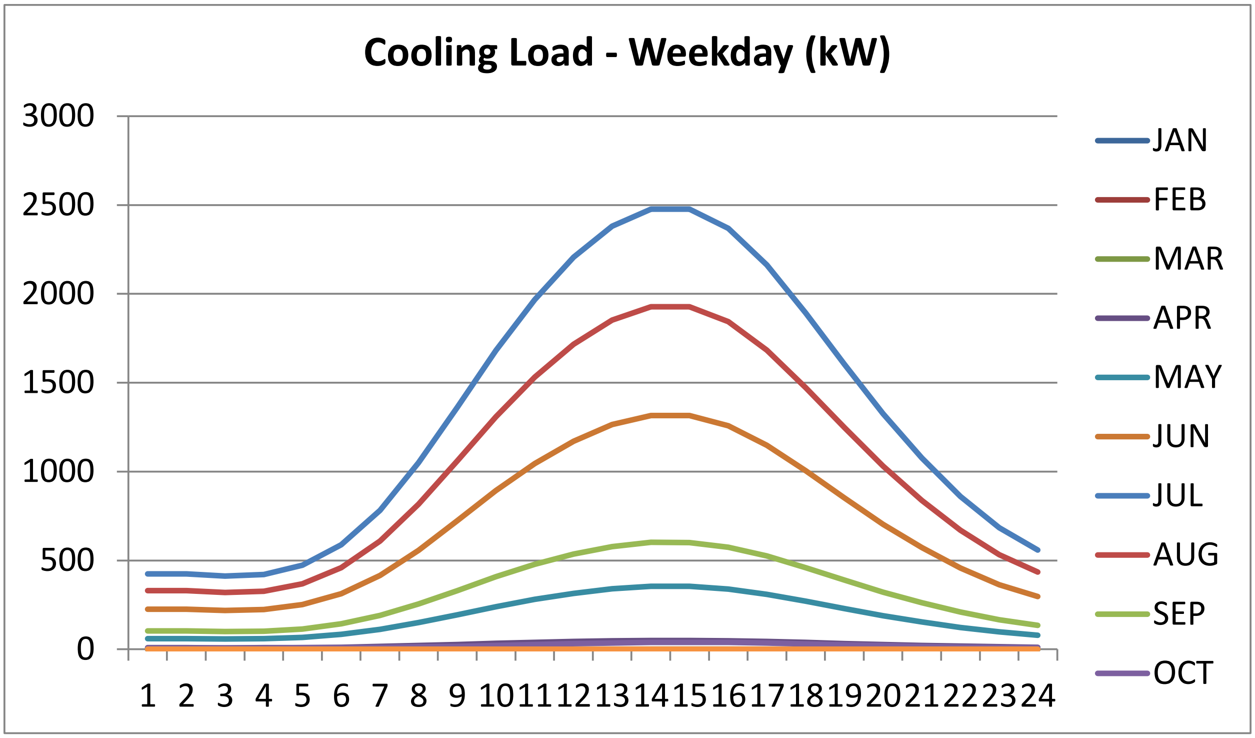

Figure 2-7: Microgrid (Hospital Only) Weekday Cooling Load Profile (kW)

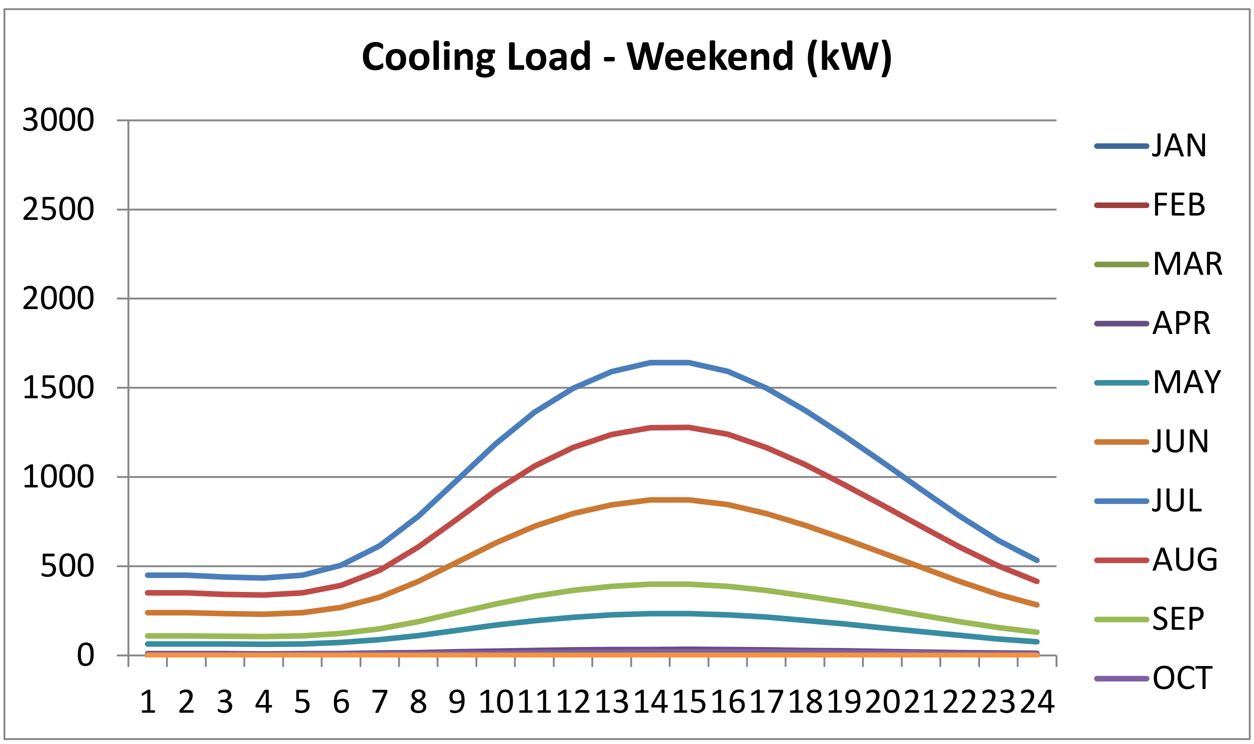

Figure 2-8: Microgrid (Hospital Only) Weekend Cooling Load Profile (kW)

2.2.3 Description of Loads

The microgrid total load is based on the entire load of a full feeder and partial loads on two other feeders that host critical facilities. The following table lists the original critical facilities identified early in the project for which more accurate load data was collected. It was decided later that it would be less costly to include other loads hosted on the same feeders as the original critical loads than incurring the additional expense of switching them off during the emergency periods. In addition, providing additional power to those additional facilities was assumed to be additional societal benefit, particularly since it was determined that the OCRRA facility had sufficient capacity and fuel storage to be able to cover the additional load in the system.

Table 2-2 below lists both the original critical facilities selected for inclusion in the microgrid and also a listing of additional facilities located on the same feeders as the original loads. Complete information on the electrical energy and demand data for the additional feeder loads was not available, but the team was able to use the difference between the total feeder loads (provided by National Grid) and the original critical facility loads to estimate the "Extra Feeder Load".

Although not needed during the seven-day emergency period, the proposed microgrid includes about 673 kW of available load curtailment, equal to about 10% of peak loads of the three largest facilities. The microgrid functional design includes the control and communications elements needed to dispatch/shed selective loads at the three sites. These selected demand-side resources can also be offered as demand response during normal blue sky days.

The total seven-day emergency electrical energy requirement of the microgrid is about 1,798 MWh, with a peak load of 14.973 kW (annual energy requirement of 72,270 MWh). As discussed earlier, OCRRA has the ability to store enough trash for three days of continuous operation at peak capacity (39.6 MW). This is equivalent to 3-days x 24-hours x 39.6 MW = 2,851 MWh of energy, which is more than sufficient to cover the one-week energy need of the microgrid (1,798 MWh). Furthermore, OCRRA's full capacity is able to meet the peak load for the microgrid during the emergency.

Hence, OCRAA's generation together with the new 2-MW CCHP at UUHCC should be more than enough to meet the microgrid electrical load during emergencies. Furthermore, the CCHP will be able to provide the majority of the heating and cooling needs for the hospital with capacity for future expansion.

It should be noted that there are additional backup diesel generators at a number of facilities within the microgrid. However, the units will not be needed for any prolonged operation, either in islanded mode during emergency, or in grid connected mode during normal conditions.

Table 2-3 lists the only facility thermal loads included in the microgrid. For comparison, the electrical load with the same equivalent units is also included.

Table 2-2: Summary of Microgrid Electrical Load

Facility Name	Facility/Customer Description (Specify Number of Customers if More Than One)	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)
USPS	Federal. Mail	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Onondaga Community College	Community College	12,254	3.153
Upstate University Hospital - Community	Hospital	11,263	2.557
Van Duyn Center for Rehab and Nursing	Nursing home	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Valley Vista Apt	Senior Housing	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Mobile Gas Station	Fuel, food, ATM	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Loretto Campus	Senior Housing	10,448	2.019
Faith Heritage School	School / Place of Refuge	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Syracuse Community Police Department	Police Department, Tops Market, Family Dollar store	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Onondaga Hill Fire Department	Fire Department	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Betts Branch Onondaga Public Library	Library / Place of Refuge	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Brighton Towers	Apartments	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Nob Hill Apartments	Apartment	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Kinney Drugs	Drug Store, Food,	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Onondaga Middle School	School / Place of Refuge	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Onondaga County 911 Center	911 Dispatch	(Included in Total Feeder Load)	(Included in Total Feeder Load)
St. Michaels Church	Place of worship / Place of Refuge	(Included in Total Feeder Load)	(Included in Total Feeder Load)
Extra Feeder Load	Mixed Residential + Commercial	31,740	7.244
TOTAL Microgrid Load	**Mixed**	**72,270**	**14.973**

Table 2-3: Microgrid Heating and Cooling Load

Facility	Electrical Load		Heating Load		Cooling Load	
	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)	Energy (kWh)	Peak (kW)
Upstate University Hospital -Community Campus (UUHCC)	14,400,033	2,557	11,403,162	5,210	2,464,644	2,477

2.3 Distributed Energy Resources Characterization

2.3.1 DER and Thermal Generation Resources

The following table lists the existing and proposed (in **bold**) generation resources in the microgrid.

Table 2-4 Microgrid Generation Resources

Facility Name	Energy Source	Nameplate (MW)
OCRRA	*Waste-to-Energy/Natural Gas*	39.6/9.0 MW
Proposed UUHCC CCHP	***Natural Gas***	**2.000**
Existing UUHCC Gen 1	*Diesel*	0.650
Existing UUHCC Gen 2	*Diesel*	0.600
Existing UUHCC Gen 3	*Diesel*	0.300
Existing Loretto Gen 1	*Diesel*	0.350
Existing Loretto Gen 2	*Diesel*	0.250
Existing Loretto Gen 3	*Natural Gas*	0.150
Existing Loretto Gen 4	*Diesel*	0.250
Existing Loretto Gen 4	*Diesel*	0.350
Existing OCC Gen 1	*Diesel*	0.50
Existing OCC Gen 2	*Diesel*	1.500
Existing OCC PV	*Solar*	0.075

In the summer the heat output from the CCHP is run through an indirect fired absorption chiller; inputting 190-degree hot water and producing 40-degree Fahrenheit chilled water for space cooling. Waste heat is rejected to the atmosphere via cooling tower. On average the CCHP plants will supply a large portion of the hospital's yearly thermal needs. During the hotter and colder days of the year the CCHP plant will be backed thermally by the existing boiler and cooling plants within the facility. The existing diesel units are not expected to run for any significant amount of time in either of those periods, since they will not be needed to meet the load in islanded mode, and they will be too costly to run during grid connected mode.

2.3.2 New DER and Thermal Generation Resources

The principal generation resource of the microgrid during emergency periods is the existing WTE generation of the OCRRA facility. This proposed microgrid takes advantage of this existing resources and provides emergency power for a large number of critical and non-critical facilities during a widespread grid outage. The additional new generation resource and its location are shown in **bold** font in Table 2-4 above: 2 MW of CCHP proposed at the Upstate Medical Hospital Facility.

2.3.3 Adequacy of DERs and Thermal Generation Resources

The DER-CAM model takes into consideration the 12-month x 24-hour daily electrical load of the aggregate microgrid, and the thermal (heating and cooling) load of the hospital. The solar energy (based on the solar irradiance profile in Syracuse, NY) is available during the on-peak hours.

Figure 2-9 provides a view of the "theoretical" load and supply balance over a weekday of operation on a normal day in July (which is the peak electrical load month based on the assumed load shapes). The DER-CAM model dispatches all the generation resources based on the comparative economics of on-site generation versus purchase from the utility. As can be seen, power is purchased from the utility during off-peak hours (there is a demand charge during on-peak hours). However, we have imposed a requirement that the CCHP run as baseload during all hours of the year to meet current and future thermal loads of the hospital. On the other hand, the OCRRA facility is assumed to be free to operate as it wishes during normal blue sky days by providing power to the larger grid and participating in the available electricity markets.

Therefore, the figures that follow will show all on-site generation (OCRRA + CCHP) during the emergency periods and only CCHP generation plus power purchase from utility (or larger grid) during normal periods.

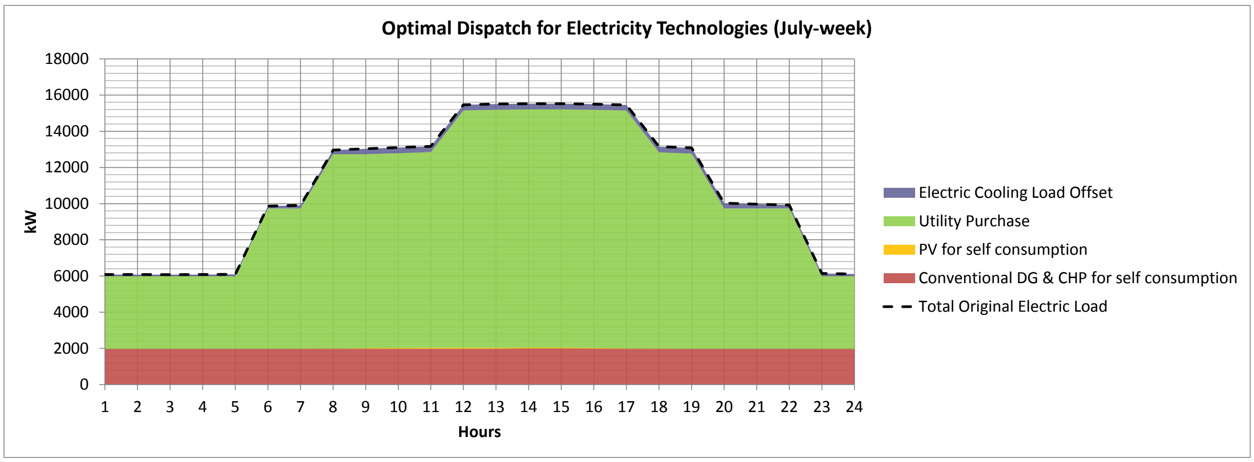

Figure 2-9 Microgrid Dispatch to Meet Electrical Load – July Normal Weekday

In the above figure, the dotted line represents the total original electrical load. The burgundy colored area represents the available on-site generation in the microgrid during normal days (CCHP, but not OCRRAA which runs independently from the microgrid load). The yellow colored area (very small and hence not visible) is the solar production from the existing 75 kW PV. The green colored area is the additional electric energy purchased from the utility. The very thin purple colored area above the green area is the reduction in the original electric load due to use of absorption chillers, which replaces the electric usage by central chillers.

Figure 2-10 shows the microgrid operation during an emergency weekday in July (the month with the highest microgrid load based on the assumed load shape. As can be observed, there is no utility purchase, and all microgrid load is met by on-site generation, including solar PV (again, very small, and hence not visible). It is interesting to note that the combination of on-site generation and electric load reduction due to absorption chillers is actually sufficient to meet the entire microgrid electric load, even though the model "dispatches" some of the curtailable load.

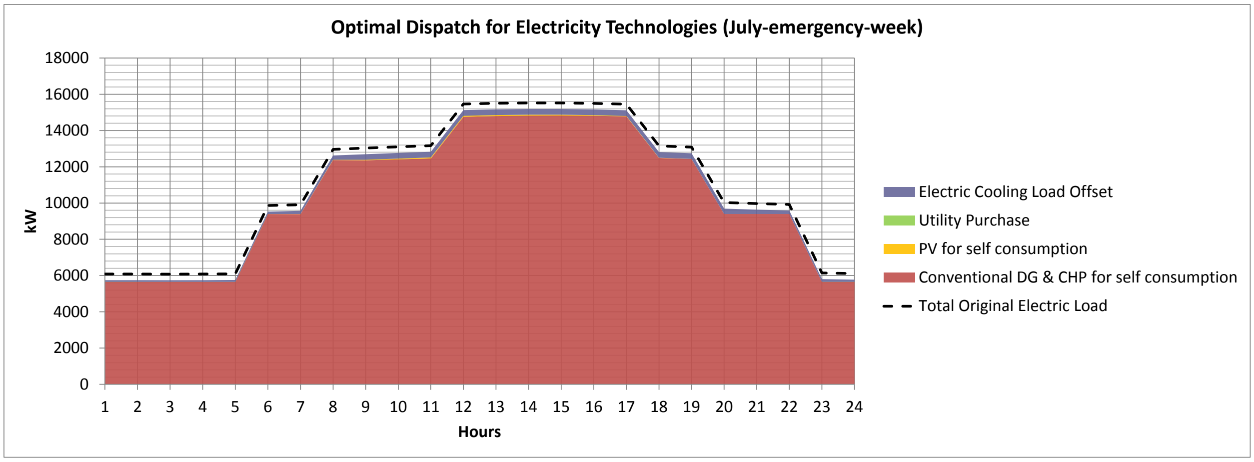

Figure 2-10 Microgrid Dispatch to Meet Electrical Load – July Emergency Weekday

Figure 2-11 shows thermal dispatch for heating load during a normal weekday in January (a high heating load month). The dotted line is the microgrid original total heat load. The burgundy colored area is the heating load being met by the recovered heat of the CCHP. The gray colored area is the additional heating load being met by boiler thermal energy.

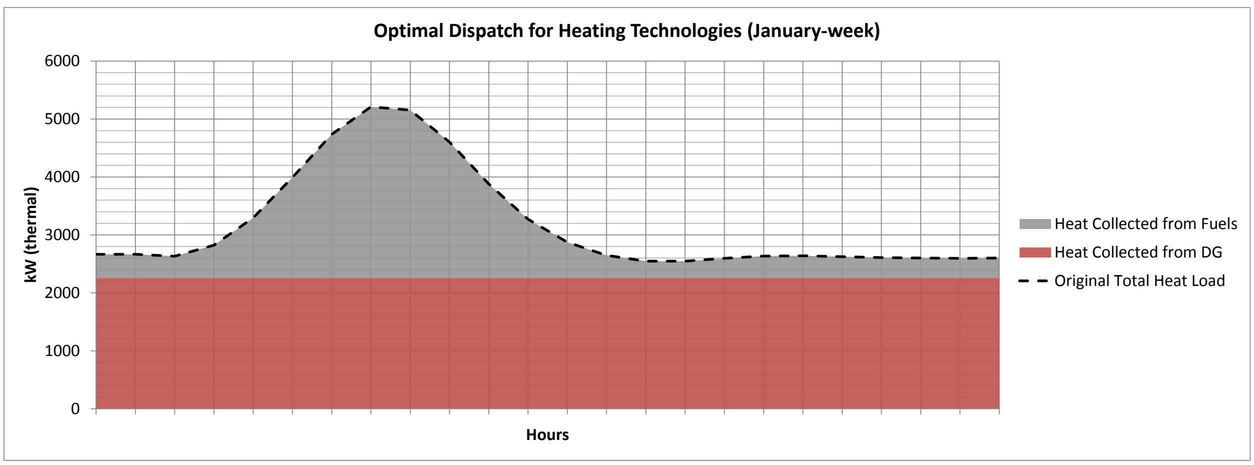

Figure 2-11 Microgrid Dispatch to Meet the Heating Load – January Normal Weekday

Figure 2-12 shows thermal dispatch for heating load during a normal weekday in July. The dotted line almost sitting on the x-axis is the microgrid original total heating load. The burgundy colored area is the heating load being met by the recovered heat of the CCHP. The additional thermal generation going above and beyond the heat load is actually the portion of the CCHP thermal energy that is used to run the absorption chiller, shown in the next figure.

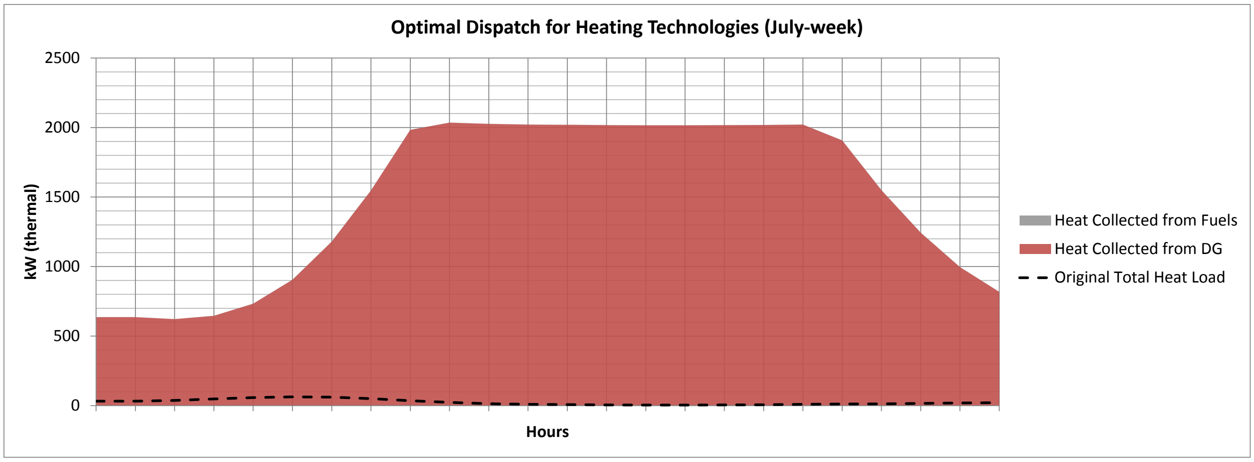

Figure 2-12 Microgrid Dispatch to Meet the Heating Load – August Normal Weekday

Figure 2-13 shows thermal dispatch for cooling load during a normal weekday in July. The dotted line is the microgrid original total cooling load. Note that in DER-CAM, the cooling load size is not based on the final cooling energy output. It is actually based on the equivalent electric input of central dispatch that will provide that amount of thermal energy, and hence reflects the assumed Coefficient of Performance (COP), which we have assumed to be 4.5.

The burgundy colored area is the cooling load that is provided by the absorption chiller. As shown, there is a need for additional supply to meet the total cooling load - provided by the central chiller (blue colored area).

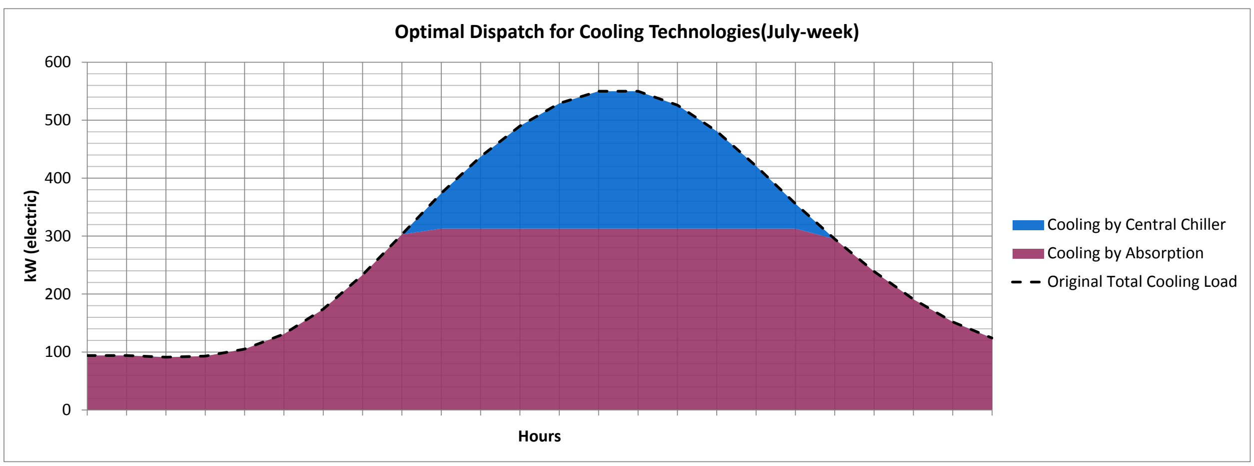

Figure 2-13 Microgrid Dispatch to Meet the Cooling Load – August Normal Weekday

2.3.4 Resiliency of DERs and Thermal Generation Resources

OCRRA's power plant is in an enclosed facility and is connected to the Rock Cut substation via a 115-kV line that is constructed to higher standards than typical distribution lines, with a right-of-way clear of trees and vegetation. The plant has four boilers which are maintained regularly, and has not had a forced outage in recent memory. Based on discussions with OCRRA, the main interruption during long-term emergency periods could be due to disruption in waste delivery. However, during a seven-day emergency period OCRRA is not expected to run at full capacity all the time, and it is estimated that the three-day waste storage capacity will more than meet the fuel requirements for OCRRA to run at part load during that period. In addition, history has shown that during major events trash delivery to OCRRA has continued uninterrupted. As a last resort, OCRRA's boilers can be operated on natural gas at 9 MW peak operating capacity.

The new CCHP unit will be storm hardened against weather events as it will be installed elevated above the flood plain at the hospital. According to the EPA Catalog of CHP technologies,[7] natural gas engine CHP units have an availability of about 1% for units sized 800-9000 kW, a forced outage rate of less than 1%, and a scheduled outage rate of about 2.5%. The CCHP unit, along with the emergency backup generation at the various sites results in a collective power system with very high reliability that is insulated from the forces of nature. The expected forced-outage rate of the entire power plant will be analyzed in Stage 2.

According to National Grid, the natural gas supply has proven to be extremely resilient during past major events. Therefore supply to the CCHP unit is not expected to be interrupted in most emergencies (barring seismic activity or sabotage). The possibility of these events is remote enough to preclude consideration of propane tanks, CNG, or LNG.

2.3.5 Fuel Sources for DERs

In this project, waste and natural gas are the primary fuel sources for generation. The OCRRA facility has sufficient storage to run at full capacity (39.6 MW) for three days by burning waste. When the supply of waste is exhausted, the boilers can be fired on natural gas to provide up to 9 MW of power in that mode. DER CAM analysis has shown that based on microgrid load profile during an extended outage, OCRRA will have sufficient waste storage to provide energy for seven days, and will not actually need to switch to natural gas. In addition, history has shown that trash delivery is likely to continue during an emergency.

The microgrid project also includes a 2 MW natural-gas CCHP unit at UUHCC. This generation will be combined with OCRRA's output to produce a reliable power supply during a grid outage.

Additionally, several diesel standby units are located on the microgrid. OCC has 2 MW of diesel standby generation, UUHCC has 1.55 MW of diesel standby, and the Loretto facilities have 1.2 MW of diesel standby. While these units may not be needed for continual operation during islanded operation, they could be used for black-start and microgrid formation, and can also provide peak load support and frequency regulation when needed.

2.3.6 Capability of DERs

In connected mode (parallel to the grid), microgrid generation resources would not be required to regulate frequency, and would likely have a small role if any in voltage regulation. These services are provided by the bulk power system and the surrounding distribution system. However, in islanded mode, microgrid resources will need to provide for power balance/frequency control and reactive power balance/voltage control.

New York State and National Grid interconnection requirements with respect to voltage and frequency response will apply to the microgrid generation when it is in grid-connected mode. Whenever voltage or frequency at the POI are outside the allowable bands, the microgrid controller should initiate a disconnect sequence. However, the microgrid generation and control system have the ability to ride-through grid events

[7] http://www.epa.gov/sites/production/files/2015-07/documents/catalog_of_chp_technologies.pdf

and regulate voltage and frequency at the POI to help in fault recovery. This action can be coordinated with the utility operations center if needed.

The standby diesel generators located at various microgrid facilities (Upstate Hospital, Loretto, and Onondaga Community College) are capable of operating without the presence of the distribution system which makes them ideal for black start application. As such, these generators have the ability to maintain real and reactive power balance and can maintain frequency and voltage. Most have the capacity for partial load operation within a range (minimum/maximum capacity ratings). However, upgrades to control and protection equipment may be necessary to allow the generators to feed the larger grid.

Some types of generators are more capable of providing frequency control than others. For the Syracuse microgrid, some assets will provide baseload power while other assets would switch to frequency control mode. Both the CCHP unit and the OCRRA plant tend to be better suited to baseload operation than frequency control. That means the majority of fast frequency regulation would come from the standby generation. However, the CCHP units could also provide frequency regulation when operated at part-load. To augment this fast frequency regulation, load may need to be controlled. Additionally, it may be necessary for solar production to be curtailed. The specific demands for power matching/frequency regulation will be determined through study, and the microgrid controller will manage assets in response to changing conditions.

Unlike power matching/frequency regulation where some generators are better suited to respond quickly to changes in real power, most generators are capable providing VARs and reacting quickly to changes in voltage. Traditionally, a few types of generator controls are available: voltage control, VAR control and power factor control. For the Syracuse microgrid, some combination of these modes will be employed depending on the asset type. For example, the OCRRA plant will likely be in voltage control mode to provide fast voltage regulation/reactive power balance and to support voltage during a fault to allow the protection system to operate correctly. The CCHP unit may be used in VAR control mode to supply a reactive power base, and the PV inverters may be in power factor control to smooth voltage variations due to intermittent power output. As with the power balance/frequency control, the specific roles of the different generation assets will be determined through study, and the microgrid controller will manage these assets in response to changing conditions.

2.4 Electrical and Thermal Infrastructure Characterization

2.4.1 Electrical and Thermal Infrastructure

Due to the large generation capacity available from the OCRRA plant and the CCHP unit, the incumbent electrical infrastructure serving the local area will be utilized without disconnecting most of the additional customers on feeder sections that are needed to power the critical facilities. To facilitate formation of the microgrid, three existing switches will be upgraded to allow remote/automated operation, and four new automated switches will be added to sectionalize non-critical portions of the circuit.

Within the facilities, to match cadence with the grid and prevent damage to equipment, each DER system comes complete with a utility interconnection relay system that monitors the electrical mains with four CTs and a PT/VT set to track phase angle, voltage, and frequency of the grid. When the grid moves, the CCHP system will match within a certain tolerance. When the limits are reached the CCHP islanding breaker will open and the system will separate from the grid until at which time the grid parameters are back within those limits.

The CCHP system contributes to the thermal needs of the hospital by supplying hot water to the manifold of the existing heating plant, and basically replacing those boilers. For cooling loads the CCHP plant sends 190-degree hot water through 3 way valves to absorption chillers which then feed chilled water to the cooling manifold.

2.4.2 Resiliency of Electrical and Thermal Infrastructure

The proposed microgrid consists largely of overhead distribution lines. While the area is generally free of trees and other obstructions that typically cause distribution line outages, some particularly susceptible portions of the circuit may need to be hardened to ensure reliability. This could include measures such as aggressive tree-trimming, removal of danger and hazard trees, use of upgraded poles and cross arms, use of tree wire, compact construction or space cable. Since the circuit is being largely fed in an “as-designed” configuration when in islanded mode, the circuit can be reconfigured to isolate faulted/damaged portions of the circuit.

The 115-kV line connecting OCRRA to Rock Cut substation is relatively clear of vegetation and is constructed to more robust design standards than typical distribution circuits. The highest risk is from vehicular accidents, but the lines are sufficiently far away from major roadways to minimize this risk.

The electrical system is backed by the existing back-up generators. The thermal system in the hospital is backed up by the existing boiler and cooling machines. These systems are located above the flood plains.

2.4.3 Microgrid Interconnection to the Grid

Figure 2-14 shows the points of interconnection with the larger system. When in islanded mode, the microgrid will be connected to OCRRA through the Rock Cut substation. The microgrid will power the majority of a feeder and portions of two other feeders as shown in Figure 2-2. However, the microgrid will shed some laterals and portions of the feeders that are not feeding critical loads.

Because the microgrid sources are primarily rotating machines, traditional protection schemes based on high fault currents will likely be applicable when in islanded mode. While fuses are a low cost option for overcurrent protection, coordination of the protection schemes between grid-connected and islanded mode may require relays capable of being remotely switched between multiple modes or set-points.

In addition to Instantaneous/Timed Overcurrent protection (Functions 50P/50G/51P/51G), the microgrid protection scheme will employ some combination of the following:

1. Over/Under Voltage (Functions 27/59)
2. Over/Under Frequency (Functions 81O/81U)
3. Reverse Power (Function 32)
4. Transfer Trip
5. Anti-islanding

2.5 Microgrid Controls Characterization

2.5.1 System Control Architecture

The proposed microgrid control architecture consists of four control device types:

1. **Microgrid Energy Management System** (MG EMS) (1 per microgrid)

The MG EMS orchestrates all control actions as well as provides the utility interface. It serves as a main microgrid configuration and dashboard station. For instance, a station operator is able to provide scheduling policies through its web interface. The data historian and possibly other data bases are stored at MG EMS which also provides analytics applications.

2. **Microgrid Master Control Station** (1 per microgrid)

   Master Control Station is a hardened computer that hosts critical real-time monitoring and control services. It performs forecasting, optimization and dispatch functions.

3. **Microgrid Facility Control Node** (1 per facility)

   Facility Control Node coordinates control across multiple buildings composing a specific facility. This controller abstraction is utilized also for any building in the microgrid with local control functions, i.e. a building that hosts a generation unit or building management system (BEMS). Most facility control nodes would also be hardened industrial computers.

4. **Microgrid Edge Control Node** (1 per facility)

   Edge Control Node is an automation controller or a feeder management relay with a direct switching interface to loads in a building. This is typically a multifunction controller/IED providing automation and physical interface to switchgear and sensors.

Figure 2-14 shows control devices for the proposed Syracuse microgrid as an overlay on the electrical one-line diagram.

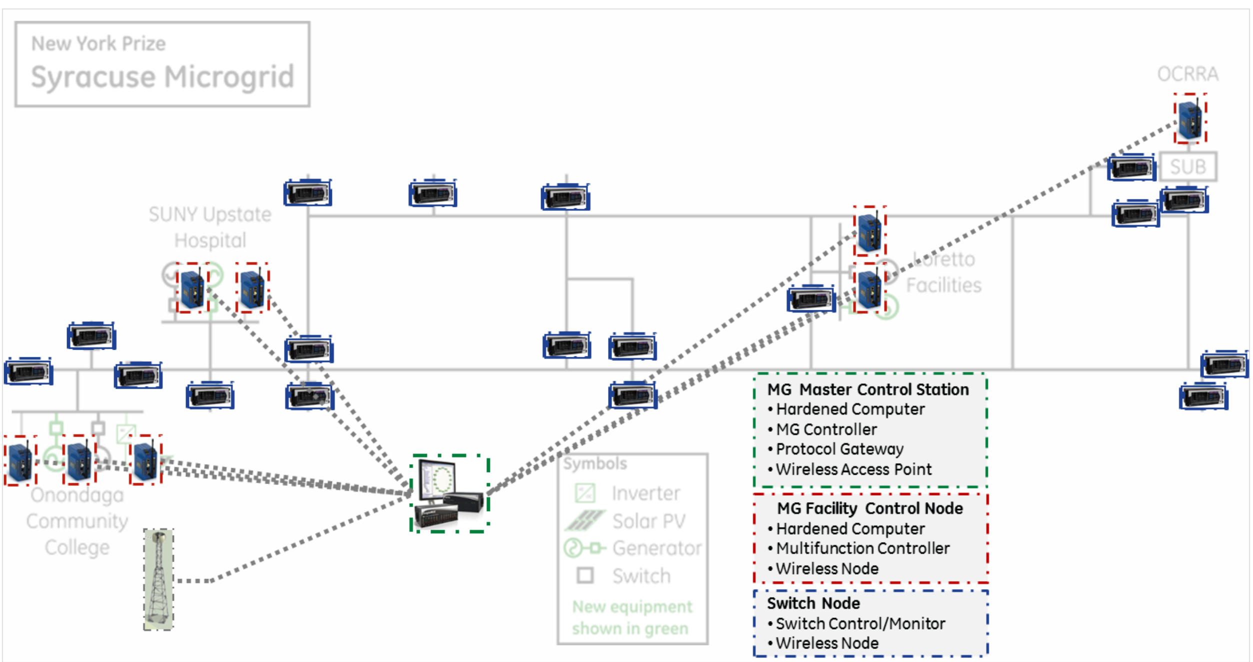

Figure 2-14: Syracuse Microgrid Electrical One-Line Diagram with Control and Communications Overlay

Both old and new generation units are expected to be equipped with microprocessor-based controllers that can regulate either the natural-gas engines or the inverter-based power conditioning systems. During a typical operation, while a unit is in standby or parallel modes, the controller issues power set-points, while continuously adjusting the engine speed to optimize efficiency.

The local controller devices can interface with the hierarchical control system via Modbus communications. This interface would be used to communicate necessary information between a microgrid facility control node and the local controller of the generation unit located in that facility. The facility control node would act as Modbus master, and the local controller would act as the Modbus slave, sometimes called a remote transmitter unit. The master device initiates all communication, sending commands or requests for information. The local controller would relay all of the AC power related information back to the facility control node including the voltage, current, frequency, and power factor. Thus, this interface will allow the microgrid control system to individually start, stop, and change the set-point of any microgrid generation unit, as well as read all of its inputs and outputs.

The microgrid master controller will likely include load management in the economic optimization of microgrid assets. In such cases, it will communicate with building energy management systems to determine and set load set points. At this point it is not clear which facilities have energy management systems and which will be included in microgrid optimization. In terms of peak demand, primary candidates are Upstate University Hospital and Onondaga Community College. We recommend that the microgrid control architecture be built on one of the open software control platforms such as Tridium JACE (Java Application Control Engine). Such a platform can be used to control a variety of BEMS systems, HVAC and DDC devices. This platform supports most of the open protocols for building automation systems sector such as LonWorks, BACnet, and Modbus.

2.5.2 Services Provided by Microgrid

Automatically connecting to and disconnecting from the grid

At all times in grid connected mode, the microgrid control scheme must maintain enough generation, to supply the critical microgrid loads. When an event occurs, the microgrid control system would initiate a sequence of operations to transition from grid-connected to islanded mode. This was described earlier in Section 2.1.2. Seamless transition during an unplanned event is not foreseen due to current interconnection rules governing DER operation. However, it is conceivable that a planned seamless transition can be achieved.

The formation of a microgrid generally proceeds as follows:

- Detect abnormal conditions
- Isolate microgrid from utility system
- Isolate uninterruptable microgrid from rest of microgrid
- Stabilize generation and uninterruptable loads
- Add loads and generation to core microgrid

Note: some steps may be performed in parallel.

The steps listed above are a combination of predetermined operating procedures and automated control actions. For example, during the planning stages, the load and generation that makes up the core or uninterruptable microgrid will be determined and the sectionalizing scheme that isolates the core microgrid will be established. When an abnormal condition is detected (or and isolation signal is given), relay operations will then automatically perform the topology reconfiguration. At the same time, generation controls must be sufficiently flexible to survive a disturbance that may be associated with the abnormal grid condition that requires the microgrid to go into islanded mode. Actions such as the addition of loads and generation to the core microgrid may be manual.

Automatic disconnection: At the points of interconnection, the microgrid will sense abnormal grid conditions such as loss of voltage (on all feeds) and automatically isolate from the grid. The OCRRA facility and relevant transmission assets will be configured such that the OCRRA plant feeds only the critical feeder out of the Rock Cut substation. The configuration may be a combination of manual an automated steps. The microgrid will then form in the manner described above and earlier in Section 2.1.2.

Automatic connection: The microgrid will also be capable of automatically reconnecting to the grid if desired. However, since the microgrid will be reconnecting into a network, the microgrid may be required to power down before reconnection. If automatic reconnection is desired, when the microgrid senses that the utility feed has returned to normal (generally for a period of time), the microgrid will sense the phase and magnitude of the voltage at the utility interconnection point. Using either active or passive synchronization, the microgrid controller may close the breaker that ties the microgrid to the utility system.

At the time of reconnection, the net load to the system from the microgrid will be minimal. The microgrid can coordinate the return of the additional microgrid loads to normal status with the utility to avoid undue stress on the recovering grid. Depending on the final design of the microgrid, this return to normal may be a combination of automatic and manual operations.

Load shedding schemes

Load management is also integral in islanded mode and in the transition to islanded mode. During microgrid formation, load will likely be shed to allow seamless transition for the uninterruptable loads on the microgrid. Once the microgrid is established, controllable loads may be used in much the same was spinning reserve generation. The three largest facilities are slated for 10% load curtailment capability.

Black start and load addition

During an unplanned event, the microgrid must be capable of black starting or energizing without an existing power system. Many grid-forming generators can be used for blackstarting. Once the generator has been started and the core microgrid formed, the formation of the microgrid may proceed normally.

Any of the diesel generators located at SUNY Upstate Hospital, Loretto or Onondaga Community College are good candidates for black start. As standby units, these generators are generally capable of operating without a grid connection (maintaining voltage and frequency); however, some upgrades to protection / control equipment may be necessary to allow connection to the larger grid. Once black start power is provided via the standby generators, CCHP units and the OCRRA can come online and provide power to the larger microgrid. CCHP can black start with their on board 24VDC battery systems and "starters".

Performing economic dispatch and load following

The Syracuse microgrid will provide load following during emergency periods utilizing the new CCHP reciprocating engine and existing backup generation if needed. The economic dispatch of the microgrid plant during emergency periods will be performed by the microgrid controller and energy management system, based on the amount of generation needed to balance the time varying net load (i.e., load minus solar generation), and the microgrid generation unit efficiencies and constraints, fuel prices, and variable operations and maintenance (VOM) costs.

During normal/blue sky days, the microgrid dispatch will be based on the thermal load needs, although the DER-CAM modeling does not currently have the flexibility of forcing CCHP dispatch based on thermal needs (it is based on economic considerations). It is plausible to assume that at some future point in time, a more complex decision process will determine the microgrid resource dispatch during normal days, more likely based on the relative economic costs of on-site generation versus purchase from the utility or even sales to the larger grid or NYISO, subject to applicable future REV framework. The trade-off between on-site generation and utility purchase is demonstrated in the DER-CAM modeling (illustrated earlier). Although simplified compared to actual operations, the DER-CAM model illustrates how utility purchases vary with time, and shows their dependency on relative energy costs of on-site generation versus utility purchases, and the influence of utility monthly and daily on-peak demand charges.

Demand response

The same load resources that are available for load curtailment are also available for demand response. The initial plan is to have at least 10% of the microgrid peak load be curtailable during a long-term emergency when the microgrid goes into islanded mode. However, the same load resources can be used as demand response during normal/blue sky days. The 10% of peak load of the combined facilities is about 673 kW, and should be available as demand response during normal days. The demand response resources can be utilized in various utility price-based or event-based demand response programs in the future, such as critical peak pricing (CPP) or critical peak rebates (CPR), or even as part of a portfolio of aggregated demand response resources under management of third party demand response providers who participate in the NYISO demand response and load management programs.

Storage optimization

The microgrid does not currently incorporate energy storage because the business case is not strong. If seamless transition from grid-connected mode during an emergency is a critical requirement, then storage may be option. At this stage of the project, the benefit-cost analysis is not definitive enough for the stakeholders to request that this feature be incorporated into the microgrid.

National Grid has not placed a definitive value on storage at this location. As the project moves forward, the team will continue to look at options for storage to provide services to the grid and the microgrid. If storage proves economical, storage will be optimized based on the application.

Maintaining frequency and voltage

When in grid-connected mode, the primary focus of the microgrid control systems will be to maintain system voltage within the acceptable range. This range is generally specified in ANSI C84.1 but may also be coordinated with utility conservation voltage reduction schemes.

For the Syracuse microgrid, a large portion of the flexible generation will be the 2 MW CCHP. This CCHP generation will act as base-load generation with a reserve margin. The CCHP reciprocating engines are also capable of load-following and regulation at part-load operation. Faster acting generators such as the backup units at various microgrid facilities can be used to manage fluctuations in load as well as variation in power output caused by solar – although amount of solar compared to the overall microgrid load is negligible. For reactive power/voltage control, CCHP and standby generators may be used. The microgrid controller will determine the appropriate control modes (voltage, pf control, VAR control, etc.) and set-points for the various microgrid assets.

Coordination of protection settings

When the microgrid is in islanded mode, some key protection functions will be under the purview of the microgrid controller. Where fault current is insufficient to ensure that secure, safe, dependable, reliable operation of protection systems (such as fuses), the Team may consider another layer of protection that predicated on transfer trip signals from the controller.

Because the microgrid sources are primarily rotating machines, traditional protection schemes based on high fault currents will likely be appropriate when in islanded mode. While fuses are a low cost option for overcurrent protection, coordination the protection schemes between grid-connected and islanded mode may require relays capable of being switched between multiple modes or set-points. In addition to Instantaneous/Timed Overcurrent protection (Functions 50P/50G/51P/51G), the microgrid protection scheme will employ some combination of the following:

- Over/Under Voltage (Functions 27/59)
- Over/Under Frequency (Functions 81O/81U)
- Reverse Power (Function 32)
- Transfer Trip
- Anti-islanding

Selling energy and ancillary services

Subject to evolving NY REV framework, the NY PSC market rules applicable to microgrids and distributed generation, and enabling technology (to allow back-feeding in the network), it is expected that OCRRA can sell energy into the larger grid though the Distribution System Platform model being developed within REV, and account for direct energy sales to customers connected to the system. Remote net metering will be utilized to account for individual consumption and billing will occur via typical PPA agreements.

Data logging features

According to the control architecture presented above, data logging is both local (at microgrid facility control nodes) and global (at microgrid master control station). These controllers, typically industrial PCs, record system data at regular intervals of time. A Human Machine Interface client for accessing data through a web interface exists at least at the master control station.

The data is stored in a round robin database that overwrites oldest values. The standard storage solutions (e.g., 1TB) are sufficient to store data for at least a full year. Depending on the devices that a facility control node regulates, such a node may be equipped with an event recorder that captures asynchronous events with high time resolution. This allows for fast, sub-second, data collecting and analysis. The DERs will automatically send daily reports (in 15 minute intervals of data) to NYSERDA and host site technicians.

2.5.3 Resiliency of Microgrid and Building Controls

The standard industrial-grade control and communication devices can withstand extreme operational temperature range of -40^0 C to +70^0 C. In addition, they are often enclosed in rugged aluminum chassis tested for shock and vibration according to military standards. Control boxes will also be elevated for flood avoidance.

2.6 Information Technology (IT)/Telecommunications Infrastructure Characterization

2.6.1 Information Technology

Due to the lack of existing dedicated communication infrastructure (e.g. fiber optic network), for the microgrid communications backbone we are proposing a wireless field network as shown in Figure 2-14. The Microgrid Master Control Station is a hardened computer hosting monitoring, optimization and control services. It communicates to the utility wide area network through 3G/4G, WiMax, or 900 MHz communication links.

In addition, each microgrid facility is equipped with a Control Node, a hardened computer hosting local control applications with or without BEMS integration. At least the control node at the Upstate University Hospital will integrate with the existing building management system. Communication with the master control station is achieved through 900 MHz or WiMax field network. The wireless communication links to the switchgear devices are not shown in the figure.

The communications network will provide at least 100 Mbit/s Ethernet which is expected to be sufficient for all monitoring and control applications and for the network of this size. The application-layer protocols will be selected among DNP3, Modbus TCP/IP, Modbus Serial, IEC61850, Ethernet depending on MG deployed devices (e.g. IED’s, PLC, switchgear, relay, sensors, meters, etc.).

2.6.2 Communications

When the lack of communication signals from the utility is set as an abnormal condition, the microgrid can isolate from the utility and thus operate when there is a loss in communications with the utility. From that moment the local generation and load devices are under the control of the microgrid controller.

If the utility communications network is considered external to the microgrid communications network, an interposing server will be utilized to provide for controlled information flow. Firewalls will be utilized between the microgrid network and the interposing server and between the external link and the interposing server to provide enhanced cyber security for this link.

The suggested communication infrastructure design assumes industrial-grade, long range, point-to-multipoint wireless communication with MIMO (Multiple-In, Multiple-Out) antennas that provide robust communications.

3 ASSESSMENT OF MICROGRID'S COMMERCIAL AND FINANCIAL FEASIBILITY

3.1 Commercial Viability - Customers

3.1.1 Individuals Affected

The proposed Syracuse microgrid will serve a mixed group of customers, including both small and large commercial/industrial customers (both public and private) as well as residential customers, many of which may experience some loss of power outage without the proposed microgrid.

During a grid outage, the microgrid will power virtually an entire feeder and parts of 2 others with a total load demand of about 14 MW. This encompasses an area of about two square miles with about 5,000 residents. Also on these feeders are Upstate University Hospital, Onondaga Community College, and Loretto Nursing Home, which collectively have 3.4 MW of backup generation. Another 2.0. MW of CCHP generation is planned, to supplement OCRRA generation and the backup generation. The CCHP system will have indirect fired absorption chillers to allow for thermal usage (hot to chilled) in the summer for year round performance. The savings from the CCHP as well as possible participation in the ISO/capacity markets will enhance the microgrid economics. The Team explored the possibility of installing roof-top PV on some of the buildings that comprise the microgrid facilities and available ground level areas, but decision was made that to keep the investment costs at a minimum, additional solar power will not be needed (however, the Team will be open to consider special deals by developers that may be of mutual benefit to the microgrid and the developers). The amount of existing PV will is very small and is not expected to impact the system reliability or stability. Any future additions will be expected to still be less than 10% of the microgrid peak demand and an even less percentage of the energy.

3.1.2 Microgrid's Expected Customers

The microgrid will be powering an entire feeder and part of two additional feeders which service approximately 600 commercial customers, several critical facilities, and around 1,700 residential homes.

3.1.3 Other Affected Microgrid Stakeholders

The proposed microgrid is expected to eliminate the prolonged outage periods of the microgrid critical facilities and minimize the short-term interruptions. Hence, the experience of microgrid facilities will be improved significantly, not only during the extended outage periods caused by natural or man-made disasters, but possibly also during normal operating times when the larger grid experiences shorter interruptions due to extreme weather or equipment failure.

3.1.4 Relationship between Microgrid Owner and Customers

The microgrid operator will be a Special Purpose Vehicle (SPV) created to operate the T&D assets that comprise the microgrid. Ownership of the T&D assets will remain with National Grid, ownership of the main DER will remain with OCCRA, and microgrid controls will be owned and operated by the SPV. Power purchasers outside of the utility and DER will not have ownership of T&D or DER assets, but could become contributors or participants in the SPV given opportunities to add additional DERs.

The proposed microgrid will be designed to operate immediately based on a command from the microgrid controller to transfer from grid-connected to microgrid operation. Other on-site power systems will have the ability to start and operate using battery power and UPS devices and controls to start from a state of zero power to a state of sustained power production as matched to the microgrid load. In addition to providing black start capability, the proposed microgrid will also provide voltage or reactive power support as well as frequency or real power support, which may be eligible to participate in NYISO markets under certain conditions.

3.1.5 Customers during Normal Operations vs. Island Operations

The inclusion of OCRRA's 39.6 MW Waste-To-Energy (WTE) Plant currently serves as a contributor to the overall energy supply for distribution throughout the National Grid distribution system.

During normal operations microgrid participants will be supported by the normal operating grid delivery system with billing for consumption potentially occurring through the supply side of their bills via a PPA. Delivery will be associated with normal delivery billing arrangements specific to a customer's service class.

During islanded operation, the WTE plant and potential future microgrid generation sources will be providing electricity service to the microgrid customers. Facilities served by the microgrid during grid disruptions supply side resiliency reserve charges will be associated with supply charges and potential delivery surcharges which will provide specific cost recovery avenues for maintenance and operation of the microgrid. Contracts may be required to ensure compliance with applicable consumer protection laws, including the New York State Home Energy Fair Practices Act.

Furthermore, the resiliency reserve mechanism used to recover the capital costs of the microgrid could also be reduced to a standard contract agreement for ensuring the generators and microgrid SPV receive just and reasonable compensation for providing power during grid outages.

3.1.6 Contractual Agreements and Customer Solicitation and Registration

Several scenarios have been explored regarding participation in the Microgrid. Tis project is very unique in that it serves a large number of customers (over 2000) and it proves service to a broad range of service classes ranging from residential to large commercial.

Certain changes to existing relationships including OCCRAs agreements with National Grid, as well as recent changes to net metering laws could provide avenues for unique customer and service provider arrangements.

One potential scenario involves OCCRA serving as an ESCO and entering into PPA arrangements with all of the microgrid participants. Detail related to agreements with this many customers may require an "opt-out" provision currently in place for CCA arrangements. Participants would then receive "credit" for OCCRA supplied power during normal operations without directly receiving OCCRA supplied power at a rate to be determined. During island mode, the relationship would remain the same, but supplied and delivered power will be directly provided by OCCRA and delivered by the isolated microgrid delivery system.

Critical facilities served by the microgrid during grid disruptions would likely be asked to sign standard service agreements related to billing and terms of service. In addition, to the extent that the microgrid provides electric service to residential customers, contracts may be required to ensure compliance with applicable consumer protection laws, including the New York State Home Energy Fair Practices Act.

Furthermore, the resiliency reserve mechanism used to recover the capital costs of the microgrid could also be reduced to a standard contract agreement for ensuring the generators and microgrid SPV receive just and reasonable compensation for providing power during grid outages.

Outside of these substantial changes to existing utility/customer arrangements the microgrid will still have the ability to serve the identified customer base via typical supply-delivery services. Billing and accounting related to resiliency benefits could be accounted for via delivery surcharges via utility billing or creation of a special service class, all subject to PSC approval.

3.1.7 Other Energy Commodities

In addition to electricity, the microgrid would facilitate the provision of thermal energy for heating and cooling loads. The microgrid would create a thermal and electrical connection between Upstate Medical and Van Duyn Nursing Care Facility. This is innovative and beneficial for a few reasons.

1) Upstate University Hospital's Community Campus is fed in 2 directions, the other being Harris Hill, thus allowing the further expansion of the microgrid in the future to pick up all those feeder loads (~5 MW).
2) Having the thermal loads at Van Duyn and SUNY Upstate allows the sizing of the CCHP at Upstate to be sized top accommodate for space heating thermal loads at the Hospital and Nursing Home facilities.
3) Upstate Medical would like to execute a 90,000 square foot addition adjacent to its existing building. National Grid does not have enough power available on that circuit to allow this. It would cost prohibitive to the utility to bring a higher voltage circuit over from a few thousand feet. The CCHP plant can accommodate this new load.
4) The CCHP system thermal output can be used not only for space heating on these sites but also for sterilization, laundry, dishes, domestic hot water and showers. The chilled water can be used to power the refrigerators in both facilities.

Additionally, inclusion of the CCHP system provides for load following of the microgrid in island mode. Financing of the CCHP system may be able to be removed from the capitalization of the microgrid given the current market performance contracting and opportunities for utilization during normal grid operation.

3.2 Commercial Viability – Value Proposition

3.2.1 Community Benefits and Costs

This project will benefit the microgrid participants as well as the community at large in several ways. Direct benefits include added reliability, resiliency, and a reduction in energy costs for microgrid participants. Additionally, the Hospital will have the ability to provide peak load support and enable participation in a demand response program. Utility direct benefits include the potential to extend the life of the Rock Cut Road substation by reducing the load on the substation and associated feeders, as well as favorable impact on National Grid's SAIFI, SAIDI, CAIDI metrics. The additional automation/switching assets will enable system to reconfigure more rapidly in response to disruptions. The microgrid will also give the local utility greater flexibility within the distribution systems and will provide an opportunity to demonstrate new technologies regarding grid control and utility infrastructure management.

More broad community benefits include the provision of a significant number of facilities of refuge including the OCC campus, which could house as many as 200-300 individuals in the instance of a long term outage providing amenities including heated and cooled sleeping facilities, bathrooms, and access to electricity. Additional benefits include added resiliency at UUHCC and Van Duyn eliminating the need to consider relocation of patients during severe weather events and anticipated outages. The microgrids also provides energy to other community facilities including the consolidated County 911 call center (a critical service in emergency situations), and ~2000 residential and small commercial customers. The residential customers continued connection to electricity supplies will allow them to host neighbors and local relatives who are not connected to the microgrid providing additional opportunities to house those experiencing longer term outages.

The microgrid will provide for additional opportunities to spur economic development in the area through opportunities to participate in the microgrid and the provision of low cost, reliable power. Companies directly impacted through power disruption may find this service beneficial. Finally, the microgrid will provide opportunities for additional DERs as well as developing technologies to both grow the microgrid and provide a part of the system with unique controls and monitoring systems to evaluate the impact of additional technologies in the future.

3.2.2 Proposed Business Model

Several business models have been evaluated as part of this feasibility study. The first business model envisions a vertically-integrated utility microgrid financed through a public capital vehicle based on the most mature revenue streams currently available for microgrid. In the first business model, the local distribution utility would continue to be the owner of the microgrid's T&D assets. As illustrated in the decision tree included below, this ownership arrangement could be described as a vertically-integrated utility microgrid. This ownership structure significantly reduces the complexity of establishing and managing the microgrid, and places operation responsibility mainly on the utility company, not including the design of generation facilities and any behind-the-meter modifications for load management. The microgrid owner is also responsible for design, construction, operation, and maintenance of the electrical distribution system that connects the generating assets to the facilities, as well as all points of interconnection with its own distribution system.

The main DER (the WTE facility) asset would continue to be owned and operated by OCCRA. The additional CCHP would be located at the hospital and would be an off balance sheet microgrid asset, financed through a third party mechanism, but available to the microgrid for island mode operation.

A vertically-integrated microgrid could raise capital through public markets by pooling the microgrid's assets and payment streams under a single investment umbrella. Public capital vehicles can secure funds on more favorable terms than would otherwise be available from private investors. The result is that investments in energy projects funded with capital raised on public markets has the potential to provide greater cost savings to customers than would otherwise be possible. The potential public capital vehicles available for financing the microgrid include asset-backed securities (ABSs), master limited partnerships (MLPs) and real estate investment trusts (REITs).

The microgrid operating participants would be organized as a special purpose vehicle (the Microgrid SPV) for designing, building, owning, operating and transferring (DBOOT) the microgrid assets for microgrid customers. The Microgrid SPV would be a Master Limited Partnership (MLP) to secure the debt and equity financing needed to finance the microgrid. Microgrid customers with sufficient tax appetite could be given an option of investing in the Microgrid SVP as limited partners to earn federal tax credits and take advantage of the bonus depreciation rules for renewable energy. Either the local distribution utility or a third-party energy services company could act as the General Partner of the Microgrid SVP, which would also need to provide financing for the design phase. Under this DBOOT model, microgrid customers would sign a long-term (20 years) "Energy Services Agreement" (ESA) with the Microgrid SPV to pay charges for electric, heating and cooling services. The ESA would ensure that investors recovered their capital costs and expenditures relating to the construction of the microgrid. At the end of the ESA, ownership of the microgrid assets would transfer and vest to the customers.

A second potential business model envisions the microgrid owner serving as a "network coordinator" or "microgrid coordinator" that incentivizes customers to provide the highest value energy supply, load management, or ancillary services to the microgrid system by providing differentiated price signals. The Microgrid Coordinator's role would be more like that of a wholesale grid operator and would provide highly differentiated price signals to direct investments by other service providers. The Microgrid Coordinator would focus on operating the grid, interconnecting customers and managing complex transactions among growing number of actors.

In the second business model, the ownership arrangements would fall into the "unbundled utility microgrid" category. As illustrated in the decision tree included above, this ownership arrangement could be characterized as an "unbundled utility microgrid." In particular, the local distribution utility would own a majority stake in the SPV created to own and operate the microgrid system. The SPV would be used to ring fence the microgrid assets to insulate ratepayers not served by the microgrid from potential operating risks.

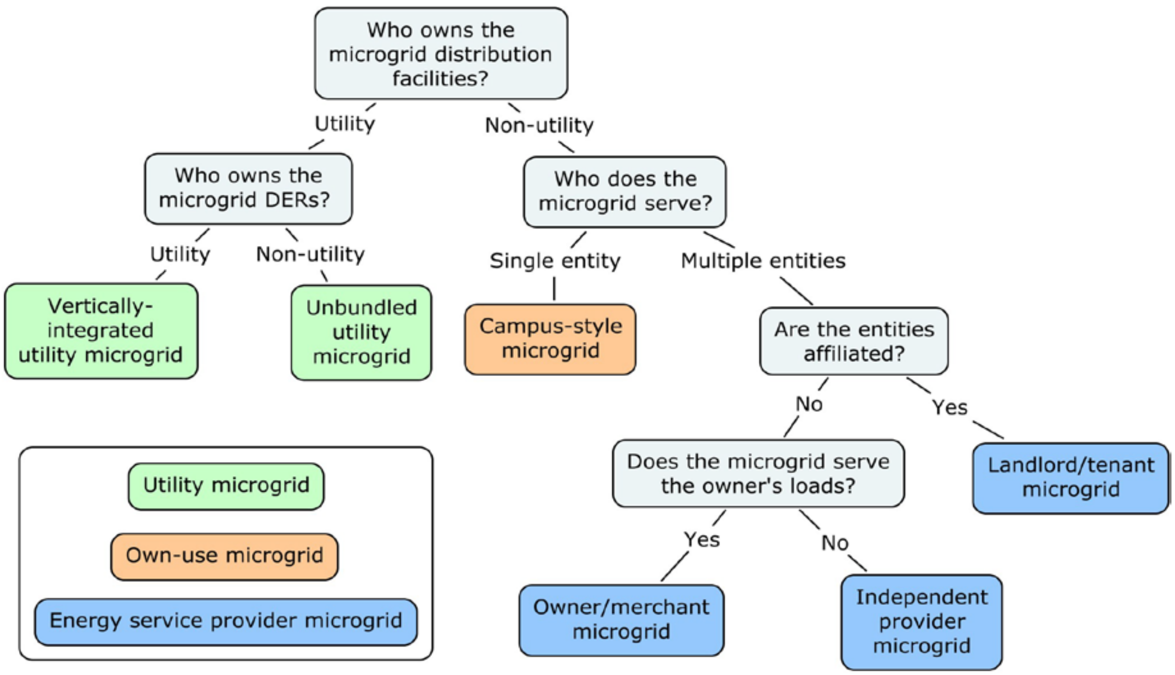

Figure 3-1 Ownership Model Typology

In the unbundled utility microgrid, the distribution utility would own the T&D infrastructure but would not own the distributed generation and other demand side resources located behind the customer meter.

Financing Structure for T&D: Ring-Fenced Special Purpose Vehicle

The SPV would finance the incremental investment in infrastructure with a combination of equity and debt. Given the novelty of the project, a greater share of equity would likely be required before debt finance became available on reasonable terms. Even with a higher level of equity, the debt service coverage ratio would likely remain elevated, which would limit the project's leverage. A credit enhancement would likely be required to attract equity investors and secure debt on non-usurious terms.

Strengths

- Microgrid customers pay no capital costs for developing the microgrid.
- The Microgrid SPV can earn significant tax credits not available to public sector entities with no tax liability.
- ESA contracts could be structured to ensure that microgrid customers paid lower rates than they would have paid if they had not become a microgrid customer.
- Any additional savings that may arise during the tenure of the ESA could be shared between the Microgrid SPV and the microgrid customers to augment the customers' cash flow savings or accelerate transfer of the microgrid assets to customers.

Weaknesses

- General Partner may not be as effective as energy service companies at developing DERs on the customer's side of the meter.
- Centralizing ownership of DER assets may limit flexibility of financing options.

Table 3-1: Microgrid SWOT

Strengths	Opportunities
Modular design	Carbon regulation
Resilience during grid outages	Self-balancing for prosumers
Accommodates multiple ownership models	Heterogeneous power quality
Diverse applications	Declining DER cost curves
Flexible architecture	Improvements in inverter and storage technologies
Weaknesses	**Threats**
Incentives diffuse	Political power of incumbents
Unclear road map	Lack of established standards
Fragmented regulation	Competing business models
Utility safety concerns	Risk of stranded assets
Complexity of allocating costs equitably	Lack of interoperability

3.2.3 Unique Site Characteristics

An important unique feature of the proposed Syracuse Community Microgrid is that the main source of power generation, OCRRA's Waste-To-Energy (WTE) Plant, is already in operation and therefore the investment, installation, and commissioning cost of new major baseload generation for the microgrid is avoided. Furthermore, the WTE Plant has already established a history of continuous operations during normal days as a renewable generation resource, with minimal variable operating costs and zero - or even negative - fuel costs, since OCRRA is actually gets paid to take in municipal waste. Additionally, this project involves utilization of existing T&D assets with investments mainly involving grid controls and operational improvements.

The other unique, and perhaps most unique, aspect of this project is the customer base it will serve. Our project involves over 2,000 participants, creating a “resiliency district” where a diverse portion of customers have access to the microgrid benefits.

The microgrid will also incorporate monitoring and control technology to allow incorporation of additional DERs including solar PV to supply additional loads or customers who may join the network due to resiliency of financial benefits. The addition of DERs is not only practical but could be expected given the dedicated customer base identified for participation. This pre-identified customer base removes a significant amount of uncertainty for DER developers and could significantly impact the soft costs of project development, which can reach as high as 50% of the overall costs.

3.2.4 Replicability/Scalability

The microgrid project is designed to exploit specific local opportunities that may not exist elsewhere, but is in itself replicable. The microgrid encompasses a wide geographic area and thousands of customers served by a complete National Grid feeder and portions of two adjacent feeders. The primary source of generation on the microgrid is the OCRRA waste-to-energy plant, the largest such facility in the region, and a truly unique aspect of the project. Areas experience landfill closings or limits on municipal solid waste should could explore a WTE facility and if located in an appropriate area, could replicate the scale and deployment of this type of system. While there is a limited number of these facilities in the state, particularly of this size (~40 MW), the concepts developed for this project can be replicated wherever there is a significant generation source feeding the grid that would otherwise be stranded during a wide-scale outage. The business model used to capture this opportunity is replicable and could be used effectively to capture opportunities in other circumstances. There are also opportunities to increase the scale of the microgrid given the partial connection to additional feeders, allowing not only for the addition of customers, but the incorporation of additional DER assets.

3.2.5 Purpose and Need for Project

Central New York is not susceptible to severe weather events as much other areas of the county or state may be, however, weather related events and utility disruptions do occur and can cause significant issues for critical facilities on the microgrid including UUHCC an, Loretto, and Van Duyn. These disruptions can cause significant operating issues, but also put the health, safety, and welfare of those being served by these facilities. The microgrids provision of resilient service can significantly alleviate concerns related to longer term outages and the need to relocate those being served at these facilities. Additionally, these facilities could likely expect and uptick in the need for services, in particular the hospital, in the case of a severe weather event due to an increase in injuries. Additional critical facilities located on the microgrid include the 911 call center, which handles all 911 calls in Onondaga County, and OCC also provide essential services that could be severely impacted during a long term outage with detrimental impact on the community. OCC will serve as a significant facility of refuge with the ability to serve over 200 residents providing critical services for daily life including showers and a warm place to sleep. The 911 call center received and dispatches services across the county and could have serious issues if they experienced a serve weather related outage.

Additional benefits include a revitalized business model for the WTE facility, which alleviated the need for a new landfill, a significantly contentions topic. Maintaining operation of the facility provides a critical service to the community above and beyond its provision of electricity.

Finally, This project provides a fertile testing ground for new technologies related to gird operation, and could defer a significant investment from the utility (which in turn is passed on to rate payers in the form of higher rates) to increase service in a very constrained part of the utility T&D system.

3.2.6 Value Propositions

The microgrid is purpose-built to enhance the resilience of the power supply in the Syracuse area at minimal cost.

The proposed microgrid is expected to provide peak load support and enable participation in a demand response program. In addition, the proposed microgrid may provide National Grid with greater flexibility in managing the cost of making future reliability upgrades or mitigating the impact of potential changes in market conditions for ratepayers. While these potential future benefits for the utility grid are by no means certain to materialize, they should not be dismissed as irrelevant or ignored. For example, the proposed microgrid has the potential to extend the life of the Rock Cut Road substation by reducing the load on the substation and associated feeders. As supply and demand patterns shift in New York State, utilities are likely to adjust the distribution planning practices, which may provide opportunities to take advantage of the microgrid for the benefit of ratepayers.

Loretto, OCC, SUNY Medical, and Van Duyn Nursing Care Facility will experience the benefits of CCHP as aforementioned. The tag line of going green is good for morale, marketing opportunities, often recruitment and tax advantages. It may also be possible to negotiate a reduction in insurance premiums for microgrid customers, especially customers that are covered for losses under business interruption policies.[8]

Finally, the microgrid will increase the reliability levels of electric service for about 1,700 small commercial and residential customers. Over the long term, the microgrid will enhance economic development in the region by improving the reliability of the local power grid. Other regions affected with semi-frequent power disruptions have struggled to attract new businesses to locate facilities due to concerns about the ability to expand at a later date.[9]

3.2.7 Added Revenue Streams, Savings and Costs

The proposed microgrid will provide a revised business model for OCCRA, with a dedicated customer base and an increase in revenues. The Community will realize and increase in overall property values given the increase in resiliency, opening the door for an increase in economic activity and businesses desire to locate in the area, in particular if their business is susceptible to power outages and disruptions.

The microgrid could also provide a platform for participating in demand response, ancillary services and peak load support.

Customers participating on the microgrid can take advantage of a lower costs for supply of electricity due to the decrease rate provided by OCCRA (estimated to be around 3-4 cents) when compared to the average utility rates. Additionally OCCRA will benefit significantly from the increase in revenue from the direct sale of electricity to customers (similar to and ESCO relationship). OCRA currently sells power to the utility at a 30% market discount. The delta between current rates and the new rates available from the dedicated

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[8] Failure Analysis of First Omaha Sure Power System available at http://www.mtechnology.net/Long-term%20Availability%20of%20the%20Sure%20Power%20System%20for%20FNBO%20Exec%20Summary%20Aug%201998.pdf

[9] See Progress Report on CHP Development in Stamford, U.S. Environmental Protection Agency, 2009.

customer base will provide a long term revenue source for OCCRA, as well as an income stream for a part of the debt associated with capitalization of the project.

3.2.8 Promotion of State Policy Objectives

The project will advance several New York State policy objectives. In particular, the project will enhance the resiliency of New York's power supply during natural emergencies. It will also reduce greenhouse-gas emissions, and promote economic development, and serve as a model for other communities to replicate. The project area will also be fertile ground for demonstration of additional DERs including new technologies given the additional gird monitoring, load following, and monitoring and control technologies associated with the microgrid. Our project will in fact not only create a microgrid, but a smart gird with real time monitoring and the ability to reconfigure the system, or react to changes instantaneously. All of these points trike at the heart of REV's goal by building a clean, resilient and affordable energy system. It also advance economic development agendas, including the CNY REDC focus on development of emerging technologies, and the CNY Center of Excellence goals of developing companies with expertise in environmental and energy systems. This area will serve as a prime area for development and location of these companies due to the advanced T&D system available to demonstrate technology benefits.

3.2.9 Promotion of New Technology

As stated above, promotion of new energy related technologies is a key focal point of the Center of Excellence (CoE) located in Syracuse. The microgrid provides an opportunity to demonstrate developing technologies and DER resources including small wind, and behind the meter efficiency improvements being developed in the CoE including indoor air quality technology, domestic hot water improvements, and data center energy management. Air quality has a significant impact on hospital and elderly carte facilities and technologies being developed at the CoE could have a significant impact on the microgrid participants. Demonstration of the efficiency benefits of these new technologies could be precisely measured given the control and monitoring capabilities of the microgrid. The microgrid will also provide an opportunity to demonstrate in front of the meter grid controls not currently incorporated into the existing T&D system operated by the utility. Demonstration opportunities for these technologies will provide a critical path for advancing the REV framework and redevelopment of the utility business model across New York State.

3.3 Commercial Viability – Project Team

3.3.1 Current Status and Securing Support

OCRRA and National Grid has been involved and supported project team since the project's inception. Additional support, discussion, site visits, and facility specific information have been part of the project with partners including Onondaga Community College, Loretto, and UUHCC.

Key engagement strategies the Project Team employed include:

- One on one discussions with critical facility managers' related to facility load information, and the availability of particular services as a facility of refuge.
- Sharing of critical information as we reached critical milestones including development of load profiles, business model development and projected revenue streams, and completion of the cost benefit analysis.
- Citizen task force and CNY RPDB board member presentations including description of the overall approach and benefits.

3.3.2 Team Members Roles

National Grid and OCCRA have been critical team members outside of our consultant team for the duration of the project. National Grid provided load profiles and usage information for several critical facilities, as well as distribution system diagrams and feeder load profiles. OCCRA has shared operation information including variability and current business constraints. Other team members including critical faculties allowed for site visits, identification of opportunities for location of DER resources (mainly the hospital campus) and current constrains on the existing T& D System.

3.3.3 Public/Private Partnerships

A public/private partnership is possible for this microgrid project, assuming the entity financing the assets owned by the SPV is a public entity. OCCRA is an animal of Onondaga County, and their participation could be perceived as a public side of this partnership. National Grid is a privately owned investor utility company. Several other facilities could be perceived as public, including OCC and the 9611 call center.

3.3.4 Applicants Financial Strength

National Grid is an investor owned utility with significant financial strength. Given the broad spectrum and significant number of microgrid participants, the identified customer base provides significant reliability in the ability of this project to provide cash flow income opportunities to cover debt associated with capitalization. The underwriting associated with the project would be similar to a PPA structure where contractual obligations for participation can justify long term investments.

3.3.5 Qualification and Performance Record

The Central New York Regional Planning and Development Board (CNY RPDB) is a public agency that was established in 1966 under the provisions of Article 12B of the New York State General Municipal Law. The CNY RPDB has more than four decades of experience in comprehensive and coordinated planning in the areas of housing, transportation, community development, economic development, environment, water infrastructure, and energy. Significant project related to energy management include completion of a five-county regional sustainability plan, aggregation project involving over 40MW of solar for municipal operations, and public infrastructure funding from various state and federal resources.

GE Energy Consulting (www.geenergyconsulting.com) is a core group of leading GE technical and business experts that has focused its collective energies on solving the electric power industry's most pressing challenges with a goal to "pursue and execute engagements that expand the study portfolio and help define the energy industry of the future". The foundational strength of GE Energy Consulting lies in the experience and expertise of its employees, a total staff of approximately 100, with most having advanced degrees in engineering disciplines, including more than 25 with doctoral degrees. GE Energy Consulting is distinguished by having six engineers on staff who have been elevated to the esteemed status of IEEE Fellow, the highest honor bestowed by IEEE. Cumulatively, GE Energy Consulting engineers have published hundreds of technical papers and authored or co-authored many textbooks. Our engineers on the team play an important role in the power industry by leading and participating in a number of industry organizations, including 30 IEEE Committees, Subcommittees and Working Groups, and 5 CIGRE Working Groups as well as international standards committees, such as IEC.

GE Energy Consulting has decades of experience conducting detailed engineering assessments in New York State, the Northeast and across the country. The recent interest in microgrids, driven by storm impacts in the Northeast, has resulted in a number of working opportunities with the states of New York, New Jersey, Pennsylvania, Connecticut, and Massachusetts, individual utilities in the Northeast, and various end-customers and communities. As a precursor and enabler to NY Prize, Energy Consulting was retained by NYSERDA to perform microgrid feasibility studies and develop the technical microgrid functional designs for five designated sites in New York State. The results of this work are found in the NYSERDA final report entitled Microgrids for Critical Facility Resiliency in New York State, December 2014.

3.3.6 Contractors and Suppliers

Incorporation of the microgrid controller and other technology into the existing utility system will follow the utility procurement guidelines to ensure compliance with regulatory policies and technology compatibility. A partner for the next phase of NY Prize has been identified through an RFQ process completed by the CNY RPDB.

3.3.7 Project Financers or Investors

As illustrated in the diagram below, Social Impact Bonds seem to be a compelling financing vehicle for the microgrid project. Other bond opportunities may be available, including CREBS, provided by New York State.

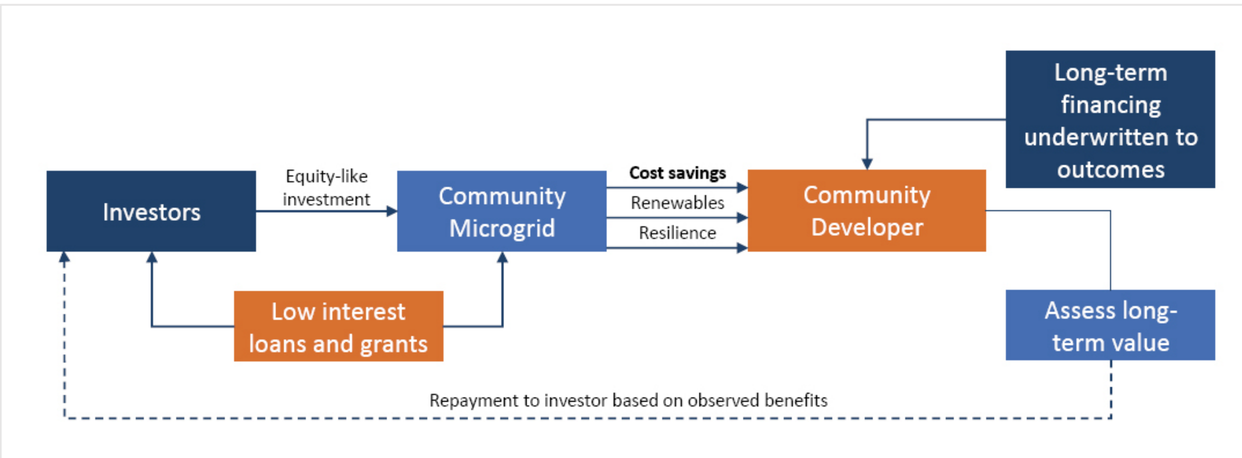

Figure 3-2 Illustration of Social Impact Bonds seem as a financing vehicle

Outside of a municipal bond investment, a potentially significant revenue stream is available through the operation of this project and the revenue generated from the sale of electricity to microgrid customers providing an opportunity for two additional capital finance strategies including a rate payer, investor utility project capitalization where the Utility and OCCRA cover the cost of construction of the microgrid and cover the debt through the increased revenue. This revenue stream could also attract outside private capital partners including ESCOs like Siemens and Honeywell. This relationship could also provide opportunities for scale energy efficiency improvements paid for with additional operations savings.

3.3.8 Legal and Regulatory Advisors

Legal and regulatory assistance has been provide by the project consultant team, as well as the Utility and OCCRA who have a significant amount of experience in regulatory and market constraints to wholesale or direct dale of electricity and utilization of T&D distribution systems. Moving forward there will be considerable questions related to the existing regulatory policy and the operation of the microgrid, but subtle changes to the remote net metering laws could alleviate a significant amount of regulatory hurdles. The main hurdle being the qualified DER resources approved for remote net metering in NY and the capacity limits on those systems.

3.4 Commercial Viability – Creating and Delivering Value

3.4.1 Microgrid Technologies Selection

The OCRRA WTE plant is existing, and can serve the entire base load of the proposed microgrid. Combined Cooling Heat and Power (CCHP) generation technology was selected based on the microgrid needs during a long term outage and normal operation, and sized to meet assist in meeting the total electrical load on the feeder.

The CCHP system was located at the hospital due to its potential to provide significant positive impacts on hospital operations during normal grid operation. CCHP is an approach that can help address these energy, environmental, and fiscal issues in hospitals. Onsite generation of electricity and steam can provide low cost, reliable on site generation, is extremely efficient in its energy conversion (as high as 85%)[10], and can serve as backup generation in the case of larger utility outages. Today, CCHP is installed in only approximately 4% of the active stock of U.S. hospitals.

Solar PV was considered for any site with sufficient available area and location that could be used for installation of solar PV panels. However, with the abundant generation from OCRRA, additional solar PV was not justified, but could be considering potential economic growth in the area. Electric battery storage was evaluated but found to not economical given access to the larger grid during normal operations.

These technologies were included in the DER-CAM model with assumed installed costs, annual fixed operations & maintenance costs, and variable operations & maintenance costs, and industry average efficiencies for each technology types and at different discrete capacity sizes. The DER-CAM model in general appeared to select reciprocating/internal combustion engines for the CCHP option. To the extent possible, existing backup generation resources were considered for inclusion in the microgrid, if they were of sufficiently larger size and if it was determined that they had existing automatic control options and could be integrated to the electrical and also control and communication network without substantial investments. However, with the OCRRA generation some of these generation resources may only be required for regulation services in islanded mode, if at all.

3.4.2 Applicant or Microgrid Owner Assets

This project provides for little change to the ownership of existing assets, with OCCRA maintaining ownership of the major DER resource, National Grid maintaining ownership of the existing T&D infrastructure, with joint management of the system facilitated by the creation of the SPV.

3.4.3 Load-Generation Balance

Some types of generators are more capable of providing frequency control than others. For the Syracuse microgrid, some assets will provide baseload power while other assets would switch to frequency control mode. Both the CCHP unit and the OCRRA plant tend to be better suited to baseload operation than frequency control. That means the majority of fast frequency regulation would come from the standby generation. However, the CCHP units could also provide frequency regulation when operated at part-load. To augment this fast frequency regulation, load may need to be controlled. Additionally, it may be necessary for solar production to be curtailed. The specific demands for power matching/frequency regulation will be determined through study, and the microgrid controller will manage assets in response to changing conditions.

[10] Combined Heat & Power (CHP) Resource Guide for Hospital Applications- 2007 Midwest CHP Application Center

Unlike power matching/frequency regulation where some generators are better suited to respond quickly to changes in real power, most generators are capable providing VARs and reacting quickly to changes in voltage. For the Syracuse microgrid, some combination of these modes will be employed depending on the asset type. For example, the OCRRA plant will likely be in voltage control mode to provide fast voltage regulation/reactive power balance and to support voltage during a fault to allow the protection system to operate correctly. The CCHP unit may be used in VAR control mode to supply a reactive power base, and the PV inverters may be in power factor control to smooth voltage variations due to intermittent power output. As with the power balance/frequency control, the specific roles of the different generation assets will be determined through study, and the microgrid controller will manage these assets in response to changing conditions.

3.4.4 Permits/Permissions

There are no special permits required to complete this project. In order to operate the OCRRA facility on natural gas in the event of a long term outage there would need to be a modification to the facility's Title V permit and potentially apply for additional operating permits in New York State. Changes to the DER definitions and capacity caps, or special permissions, at the state level will also be necessary for the PPA customer model suggested for microgrid participants.

3.4.5 Project Development, Construction and Operations

The microgrid would be organized as a SPV for designing, building, owning, operating and transferring (DBOOT) the microgrid assets, allowing for coordination of particular details and project financing to be handled under on coordinated effort. Individual generating projects can be added outside of the SPV if associated with particular facilities. If there is a desire to add additional DERs the SPV can facilitate evaluation of the value proposition and customer participation. While the mechanism for participation is still under consideration, the two scenarios considered include all customers signing a long-term (20 years) "Energy Services Agreement" (ESA) with the SPV to pay charges for electric supply services. The other scenario, not currently available, involves an opt-out provision where all customers are opted into participation (similar to CCA models currently allowed in NYS). The ESA would ensure that investors recovered their capital costs and expenditures relating to the construction of the generating projects.

3.4.6 Benefits Passed to Community

This project will have numerous community benefits, starting with facilitation of the long-term viability of OCRRA. As the primary entity handling waste and recycling service for all 33 of the communities within Onondaga County, the financial stability of OCRRA has a substantial impact on the sustainability of all of those communities. In 2015, the Facility processed 322,072 tons of non-hazardous, non-recyclable waste (enough to overfill the Syracuse Carrier Dome) and, in doing so, generated 220,908 megawatt hours of electricity. OCRRA's success allows for a cost effective solution for waste and recycling, and the avoidance of creation of a new landfill. Had the 315,638 tons of waste processed at the Facility in 2013 been landfilled, it would have utilized more than half of a million cubic yards of landfill space. To put this into perspective, if the waste was compacted to a 20-foot height, the landfilled waste would consume nearly 17 acres of land. In addition to the other environmental benefits of the Facility, it's important to note that the Facility is a zero discharge plant relative to process wastewater; meaning that only sanitary sewage is discharged off-site. All process water generated by the Facility is treated and reused on-site, thereby requiring less potable water.

Additional benefits include the facilities of refuge including OCC which could be a significant community resource in the case of a long term outage providing a place for shelter for as many as 200-300 people. Low cost energy for participants also allows for more business stability as well as opportunities to grow the local economy along the T&D microgrid infrastructure. The project also allows for additional DERs which contribute to a lower carbon footprint as a reduction in GHG emissions.

3.4.7 Utility Requirements

The distribution utility or a subsidiary of the utility company will hold title to and maintain operating control over the microgrid's T&D assets. The majority of improvements associated with the project involve improvements to the T&D system and will require significant participation of the utility company, including design and procurement. Billing of participants and design of the rate class, if necessary, will also require significant participation from the utility.

3.4.8 Demonstrated Technologies

The Microgrid Control design may incorporate GE's proven U90Plus Microgrid Cost Minimizer to dispatch the DERs, and the D400 RTU/Controller to implement various operational control strategies. GE is currently developing a DoE funded eMCS controller that expands upon the algorithms implemented in the U90Plus and incorporates many of the control functions that now reside in the D400. The eMCS will be tested at NREL in early 2016 and will be applied at a microgrid site on Potsdam, NY. The U90Plus algorithm is being incorporated into the D400 controller, and this solution will be deployed in mid-2016 on a Microgrid at the University of Ontario in Toronto.

Another proven solution that could be utilized is GE's proven C90Plus Fast Load Shed Controller. The C90Plus provides adaptive load shedding for loss of generation and/or a utility tie to trip non-critical load. The IEDs/relays communicate real-time load and generation values as well as status to the C90Plus via IEC 61850 GOOSE messaging. The C90Plus evaluates this information and will issue a fast trip GOOSE message to the IEDs/relays to trip non-critical loads to assure a generation-load balance. The tripping of the load breakers is initiated in less than 20ms from detection of the triggering event. This compares to 200ms to 400ms for conventional load shedding schemes. This solution was recently successfully deployed and demonstrated at the Portsmouth Naval Shipyard under a DoD Environmental Security Technology Certification Program (ESTCP) contract.

3.4.9 Operational Scheme

The microgrid will be organized as a SPV for designing, building, owning, operating and transferring the microgrid assets for microgrid customers. Depending on future regulatory changes, OCRRA may have opportunities to sell power directly to microgrid customers and other end users at competitive rates. As in a typical distribution system operation, National Grid will be responsible for maintenance of T&D assets and will bill customers for supply and delivery. OCRRA will maintain responsibility of operation of the major DER resource (their facility). Maintenance of the system will be the joint responsibility of OCRRA and the Utility through the SPV. Allocation of funding for this will be facilitated by a billing mechanism described earlier, with actual details TBD. A partition surcharge, special billing mechanism, or a more direct ESCO/SPV contractual relationship are all possibilities. The final financial operational billing/customer mechanism will be determined in Stage II.

3.4.10 Customer Metering and Charges

The metering and billing will rely on existing customer equipment. The microgrid will not require any major investments in supplemental telemetry infrastructure, however, utilization of smart meters (which are expected to be installed at every customer location over the coming years under REV) will allow for potential benefits including demand response and other potential customer/ distribution system/ DER relationships.

3.4.11 Replication Plans

The proposed microgrid project's business model is sufficiently flexible to accommodate a wide range of technical microgrid configurations and institutional settings. In particular, the ability to integrate multiple asset owners and diverse generating resources makes the business model broadly applicable.

3.4.12 Barriers to Market Entry/ Overcoming Barriers

Initial capitalization and other existing regulatory constraints are existing barriers to incorporation of the microgrid into the larger T&D infrastructure.

The key to overcoming the financial barrier will require a combination of public and private resources. There are significant public resources including bond mechanisms to provide for or reduce the cost of capital. The anticipated project revenues provide for significant cash flow to cover debt providing the opportunity to attract private capital, the operation of microgrids is still a new market and the ability to alleviate the risk associated with this will be a key to implementation.

Additional hurdles include creation of the OCCRA/Utility SPV and regulatory hurdles in billing and operation of the DER resources. The SPV model is not new as an operational model, but will take some discussion and revision to fit the utility and DER operational model. Other regulatory hurdles can be overcome through larger REV discussion including definition of DER resources and increases in generation caps, which can advance REV goals as well as facilitate the developing business model for the microgrid operation.

3.5 Financial Viability

3.5.1 Categories of Revenue Streams

Revenue from operation of the microgrid is anticipated to be in the form of increased revenue from the sale of electricity from OCRRA, as well as resiliency benefits from major facilities incorporated into the system. How these benefits are billed and collected could take several forms. Given certain regulatory changes as discussed earlier, direct sale of OCRRA generated electricity could be possible for all ~2,000 microgrid participants. Given existing rates OCRRA charges National Grid (30% below market rate) the difference between current rates and market rates would provide enough revenue to support operation and maintenance of the system, as well as provide an increase in revenue to OCRRA.

Annually OCRRA produces approximately 180,000- 220,000 MWh of electricity[11], dependent on trash delivery volume of ~300,000 tons of municipal solid waste. Total (gross) electricity generated for 2013 was 216,401 megawatt-hours (MWh). Of this amount, 188,529 MWh, or 87%, was sold to National Grid (net electricity). The balance, or 13%, was used for the Facility's electrical needs. The Facility had a net electricity production of 597 kilowatt-hours per ton of refuse processed (kWh/ton).

For 2013 (most recent full year with completed financials) the total amount of electricity sold was 188,529 MWh. The annual average electricity rate (including the capacity factor) was 4.3¢ per kWh. In 2013, total energy revenues were $8,154,000, with OCRRA's share generating $7,339,000 in revenue, with a total effective rate per kWh of $0.038/kWh. Current supply rates in Upstate NY range from $0.053- $0.081per

[11] OCRRA Annual WTE Reports https://ocrra.org/about-us/information/reports-and-policies/

kWh[12]. If OCRRA has the ability to directly sell electricity to microgrid customers at competitive rates, it could provide for $0.015 per kWh in increase revenue totaling $2,827,935 in additional revenue. This delta will provide enough additional income to increase revenues at OCCRA, as well as cover debt associated with project capitalization and operation and maintenance.

Also explored was an increase in revenue at the utility through the additional of surcharges for particular customers for resiliency benefits. This increase in revenue was not included in the financial analysis due to the uncertainty of the financial value of the increase in service to these facilities, as well as the uncertainty that the revenue may not be necessary given the increased revenues at OCRRA. The full analysis will be completed in Phase II.

3.5.2 Other Incentives

There are a number of project subsidies that could be utilized for this project. Implementation and initial capitalization is anticipated to involve some form of public financing due to the uniqueness of the market mechanisms. Initial economic evaluation has illustrated the potential ability to stand on its own, without subsidy given the appropriate legal and regulatory framework and an investor with an understanding of asset performance and anticipated returns.

3.5.3 Capital and Operating Costs

The present value of the project's capital costs is estimated at approximately $6.18 million, including costs associated with the new 2 MW CHP system and absorption chiller; utility interconnection; upgrades to the distribution circuit; and other system software and controls. The new CHP generator will also require the installation of emissions control equipment. The project team's best estimate of capital costs for emissions control is approximately $1,500 per year for the replacement of catalytic converters. The present value of these emissions control costs is approximately $17,000. The present value of the microgrid'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 approximately $1.7 million, or $150,000 annually.

3.5.4 Business Model Profitability

As stated above in section 3.5.1 the business model has the ability to generate $2,827,935 in additional revenue through the sale of OCCRA power. Annual operating expenses for the microgrid are estimated at $1,700,000 providing for operating income of ~$1,100,000. Annual debt service on the estimated $6.18 estimated to capitalize the project utilizing CREB's (whose current rates are 3.91% for 10 years[13]) would be $747,660 with a total net positive income of $352,340.

3.5.5 Financing Structure

The business model described above provides significant revenue to attract permanent capital investment as well as revenue to cover municipal bond capitalization. Design and other soft costs can be completed under the scope of work as details in NY Prize Stage II. Completion of construction including financing could be completed through several avenues including short term debt issued by the utility, or other forms of standard construction financing for utility improvements provided by the utility.

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[12]https://www.chooseenergy.com/shop/residential/electricity/NY/13202/national-grid-ny-electricity/?contractLength=%5B12,36%5D

[13] https://www.treasurydirect.gov/GA-SL/SLGS/selectCREBDate.htm

3.5.6 Proposed Project Ownership

Ownership of the system will involve joint control over certain elements between the utility and OCCRA including the microgrid controller and other communication devices. Outside of these elements, ownership of other system component, mainly the DER and T&D system, will remain with their current owners; OCRRA and the utility respectively.

3.5.7 Project Owner Identification

Owners of the microgrid assets will be as follows:

System Component	Owner
Transmission and Distribution System	National Grid (Utility)
Main Distributed Energy Resource	Onondaga County Resource Recovery Agency (OCRRA)
2 MW CCHP System	Hospital/ 3rd Party ESCO
Microgrid Controller	SPV

3.5.8 Site Ownership

All required sites are under control and owners are cooperating.

3.5.9 Privacy Rights of Customers

No privacy concerns have arisen as a result of this feasibility study. Since we are powering an entire feeder, individual account information is not necessary outside of the operational information necessary to operate the microgrid in the instance of a sustained outage. Cybersecurity will be incorporated into the microgrid controller including the proposed microgrid control and communications architecture and the multifunction controller/IEDs that provide automation and physical interface to switchgear and sensors and existing generation.

3.5.10 Regulatory Hurdles

The overall regulatory framework for the operation of our microgrid exists today. Based on the desired business model, several changes may be necessary for operation as proposed including:

- Waste-to Energy facilities are not currently included in the list of DERs and not eligible to contribute to the states CO2 goals as defined by the new CES. Considerations have been made recently to allow for Nuclear power to be included and a similar consideration could be given to WTE.

- There is a current remote net metering cap of 2MW. We are proposing a remote net metering scenario well above that threshold. Changes, or specific consideration will need to be made to accommodate our current business model.
- Customer aggregation for DER project does not currently follow an opt-out methodology, however Community Choice Aggregation (CCA) does. The definition of an entity allowed to initiate a CCA would need to be made to facilitate the customer model we have proposed.

It is important to note that none of these regulatory hurdles are insurmountable, with current regulations only requiring slight modifications or acceptations. The raising of net metering caps and DERs allowed, inclusion of WTE plants as DER resources, and CCA customer aggregation as an allowed acquisition model are all low to no impact actions with no anticipated negative externalities.

4 INFORMATION FOR BENEFIT COST ANALYSIS

The purpose of this task was to provide input to Industrial Economics, Inc. (IEc) to allow them to conduct a screening-level analysis of the project's potential costs and benefits. To facilitate data collection, two questionnaires were provided to aggregate pertinent data for the benefit-cost analysis (BCA). The sections below discuss how the data and information were obtained and developed for the questionnaires and summarizes of the input provided to IEc and the results of IEc's analysis.

4.1 Facility and Customer Description

The microgrid is designed to supply all loads, critical and otherwise, on a feeder and a portion of the load on two adjacent feeders that serve critical facilities. As such, the microgrid includes several thousand individual facilities comprised mostly of residential homes and apartments, some small commercial establishments and several large institutional loads. Table 4-1 below summarizes the facilities and shows their rate class and economic sector. The table also shows the average annual consumption, peak demand, percentage of facilities' average demand that the microgrid would support during a major power outage, and the hours per day, on average, that facilities would require electricity from the microgrid the outage.

As the table shows, individual energy use data was available for the three anchor facilities (OCC, SUNY-UUHCC, and Loretto) and usage for the other facilities is included in the "Extra Feeder Load" in the second to last row.

Table 4-1 Background Information on the Facilities

Facility Name	Rate Class	Usage/Description	Economic Sector Code	Annual Energy (MWh)	Peak Demand (MW)	During Major Outage	
						% Use Supported	Hours of Elect/dy
Onondaga Community College	Large Commercial/Industrial (>50 annual MWh)	Community College	*All other industries*	12,254	3.153	*100%*	24
SUNY Upstate University Hospital - Community	Large Commercial/Industrial (>50 annual MWh)	Hospital	*All other industries*	11,263	2.557	*100%*	24
Loretto Campus	Large Commercial/Industrial (>50 annual MWh)	Senior Housing	*All other industries*	10,448	2.019	*100%*	24
USPS	Small Commercial/Industrial (<50 annual MWh)	Federal. Mail	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	18
Van Duyn Center for Rehab and Nursing	Large Commercial/Industrial (>50 annual MWh)	Nursing home				*100%*	24
Valley Vista Apt	Large Commercial/Industrial (>50 annual MWh)	Senior Housing				*100%*	24

Facility Name	Rate Class	Usage/Description	Economic Sector Code	Annual Energy (MWh)	Peak Demand (MW)	During Major Outage	
						% Use Supported	Hours of Elect/dy
Mobile Gas Station	Small Commercial/Industrial (<50 annual MWh	Fuel, food, ATM	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Faith Heritage School	Small Commercial/Industrial (<50 annual MWh)	School, Place of Refuge				*100%*	18
Syracuse Community Police Department	Small Commercial/Industrial (<50 annual MWh)	Police Dept, Tops Market, Family Dollar store				*100%*	24
Onondaga Hill Fire Department	Small Commercial/Industrial (<50 annual MWh)	Fire Dept				*100%*	24
Betts Branch Onondaga Public Library	Small Commercial/Industrial (<50 annual MWh)	Library, Place of Refuge				*100%*	24
Brighton Towers	Large Commercial/Industrial (>50 annual MWh)	Apartments				*100%*	24
Nob Hill Apartments	Large Commercial/Industrial (>50 annual MWh)	Apartment				*100%*	24
Kinney Drugs	Small Commercial/Industrial (<50 annual MWh)	Drug Store, Food				*100%*	18
Onondaga Middle School	Small Commercial/Industrial (<50 annual MWh)	School, Place of Refuge				*100%*	18
Onondaga County 911 Center	Small Commercial/Industrial (<50 annual MWh)	911 Dispatch				*100%*	24
St. Michaels Church	Small Commercial/Industrial (<50 annual MWh)	Place of worship, Place of Refuge				*100%*	12
Extra Feeder Load	**Mixed Residential + Commercial**	**Mixed Res + Comm**	***All***	**31,740**	**7.244**	**100%**	**24**
TOTAL Microgrid Load	**Mixed**	**Mixed**	***All***	**72,270**	**14.973**	**100%**	**24**

4.2 Characterization of Distributed Energy Resources

As discussed in Chapter 2, the principal generation resource of the microgrid during emergency periods is the existing WTE generation of the OCRRA facility. The WTE plant has sufficient trash storage to run at full capacity (39.6 MW) for three days. When the supply of waste is exhausted, the boilers can be fired on natural gas to provide up to 9 MW of power in that mode. The microgrid project also includes a 2 MW natural-gas CCHP unit at SUNY-UUHCC plus over 3 MW of existing standby diesel generation collectively at several facilities. Table 4-2 below summarizes the distributed energy resources (DER) the microgrid would incorporate, including the energy/fuel source, nameplate capacity, estimated average annual production (MWh) under normal operating conditions, average daily production (MWh/day) in the event of a major power outage, fuel consumed per MWh generated. Based on the energy consumption and peak loading in Table 4-1, it is clear that OCRRA has enough capacity to serve the entire microgrid load in trash-burning mode.

Table 4-2 Summary of DER Resources

DER Name	Facility	Energy Source	Name plate Capacity (MW)	Avg. Annual Production - Normal Conditions (MWh)	Avg. Daily Production - Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
OCRRA WTE Plant	OCRRA	*Waste to Energy*	39.6	346,896	202.284	0.8	Tons of trash
CHP	SUNY-UUHCC	*Natural Gas*	2.0	17,397	48.000	8.530	MMBtu/MWh
Solar PV	OCC	*Solar*	.075	124.102	0.452	N/A	N/A

4.3 Capacity Impacts and Ancillary Services

The main generation resource for the microgrid is an existing WTE plant that currently sends power to the National Grid T&D system via a 115 kV transmission line into the Rock Cut Substation. This resource currently provides peak load support and ancillary services to the bulk grid. However, the additional 2 MW of CHP generation proposed at SUNY-UUHCC and the 3.5 MW of existing standby generation that will be incorporated into the microgrid control system will be available to provide peak load support to the Rock Cut Substation service area. Therefore, the project team estimates the capacity available for the provision of peak load support to be approximately 5.5 MW per year.

In addition, integration of the anchor facilities' building energy management systems into the microgrid control system will facilitate approximately 670 kW of fast-load shed demand response that will be available to the market. The projected load curtailment by facility is: 256 kW at SUNY-UUHCC, 102 kW at Loretto and 315 kW at OCC.

In 2014, SUNY Upstate Hospital experienced ten (10) outages combined for the two utility feeds serving the campus. There were six (6) outages in 2013 and five (5) in 2012. There have been two (2) instances in 50 years when both National Grid feeders have gone out at the same time leaving the hospital on 100% backup power, leading to a reduction in services of approximately 50%. Based on preliminary discussions with National Grid, the Team understands that facility expansion projects under consideration by the hospital may further strain the hospital's electric service. While it is difficult to quantify differed or avoided distribution capacity upgrades, the 2 MW CHP proposed at the hospital is aligned with the utility expansion plans and will help meet the projected load growth for the area.

The project team has indicated that the proposed microgrid 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 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 these services

Presently, SUNY Upstate Hospital does not have a CHP system; the facility is primarily heated by a conventional gas-burning boiler system and cooled via an electric chiller. The new CCHP at UUHCC will supply baseload thermal loads at the campus while meeting a large portion of the hospital's electrical load. This will lower the overall cost of energy and is expected to pay for itself in seven years. The CCHP can be connected to the nearby Van Duyn Nursing Care Facility to supply its thermal loads, allowing for even more efficient operation of the CHP plant. The Team projects that the facilities can save over $55,000 annually on fuel costs from operation of the CHP system at SUNY-UUHCC.

Based on the DER CAM simulation of the microgrid operation during islanded mode, incremental emissions (above and beyond what is established for OCRRA) are:

- CO_2: 0.50300 Metric Tons/MWh
- NO_X: 0.00023 Metric Tons/MWh

Emission rates for SO_2 and Particulate Matter are negligible.

4.4 Project Costs

The total capital cost for the microgrid is estimated at over $6.3M. The highest capital outlay, as expected, is the installed cost of the 2 MW of CHP at SUNY Upstate Hospital, which accounts for over two-thirds of the capital outlay. However, as pointed out earlier, the CHP system should generate sufficient savings to pay for itself in seven years. The next most costly items are the absorption chiller that will be part of the CHP system and the microgrid control system, including the Energy Management System, Edge Control Nodes, and integration software. Table 4-3 below summarizes the installed costs of all capital equipment planned in the microgrid. All components are assumed to have a 20-year useful life.

Initial planning and design costs for the project are estimated at $670,000. This includes the cost for detailed analysis of steady–state, dynamic and transient interactions, engineering design and equipment specifications, engineering drawings and blueprints, energy modeling and simulation, heating, cooling and plumbing site studies, regulatory, policy and legal issues, financial modeling, cost estimations, interconnection applications and other permitting issues, project management, contract administration, governance, and other project administrative components.

Fixed operations and maintenance (O&M) costs are estimated at $150,000 per year. These costs typically include computer and software licenses, insurance, contract updates, contract reviews, training, leased equipment, technical support, equipment maintenance contracts, taxes and fees.

Table 4-3 Summary of Project Capital Costs

Capital Component	Installed Cost ($)	Description of Component
General Management and stake holder management	105,000	Managing mostly outside project team players, municipalities, regulatory, community, code
Contract admin, legal and paperwork	40,000	Typical contract admin, legal work
Interconnect	15,000	Utility Interconnection for sites
Permitting	25,000	Apply for permit and manage inspectors
Indirect fired absorption chiller 400T at SUNY Upstate	500,000	Uses CHP heat to produce chilled water allowing for summertime use of CHP heat
motorized breakers x 2	110,000	A breaker for each CHP to achieve island mode
Transfer Switchgear x 3	45,000	Automatic transfer switch for each facility
Microgrid control and communications system	350,000	Controller, node, instrumentation, radios, switches, integration/configuration,
Software	10,000	Misc. billing, control, modeling, etc. software as needed to include internet website.
2 megawatt CHP at SUNY Upstate Community Hospital	4,260,000	CHP producing baseload thermal and electrical as throttled given thermal needs
Evaluate and repair the existing subterranean pipes between SUNY and Van Duyn	100,000	Thermally connecting allows for greater electricity availability to operate in ISO market and pay for microgrid
Building Heating Distribution	150,000	Heat exchanges, pumps, bypass valves
Electrical work on buildings	150,000	Sensors on electrical mains, equipment panels, outdoor disconnects, etc.
Natural Gas work on buildings	35,000	Getting 2 psi gas to CHP. New meters for new service class
Misc. allotment	250,000	Misc. expense allotment, contingency
Distribution circuit upgrades	200,000	15-kV class isolation switches, protection and monitoring equipment

Variable O&M costs, (excluding fuel costs) for the microgrid generation resources are shown in Table 4-4 below. These costs include part replacements, upgrades, inspections and overhauls, labor, and rentals, cost of waste disposal, pollution control costs, and utilities.

Table 4-4 Non-Fuel Variable O&M Costs

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
20.00	$/MWh	OCRRA VOM
17.00	$/MWh	UUHCC CHP VOM

As discussed earlier, OCRRA typically has enough trash stored to run at full capacity for three days if trash delivery is interrupted (which is unlikely). After that, the boilers can be fired on natural gas with 9 MW of capacity. Based on the average load profiles of the feeders, OCRRA will have sufficient waste storage to provide energy for seven (7) days during an extended outage, and will not actually need to switch to natural gas. However, even on natural gas, the microgrid has sufficient capacity between OCRRA the SUNY-UUHCC natural gas-fired CHP, and demand response to supply all the critical facilities for as long as natural gas supply lasts. Table 4-5 below shows the amount of fuel that would consumed by each DER resource during a prolonged (seven-day) outage.

Table 4-5 Fuel Consumed During a Prolonged Outage

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
OCRRA in trash-burning mode	OCRRA	7	1.132.8	Other – Tons of trash
SUNY-UUHCC CHP	Upstate Medical Hospital	7	4,094.6	MMBtu

4.5 Costs to Maintain Service during a Power Outage

In aggregate, the Team has identified over 3 MW of diesel and natural backup generation, ranging from 650 kW to 150 kW at various facilities within the microgrid. None of these existing units will be run for any significant amount of time during islanded emergency periods, due to the availability of OCRRA generation to cover the microgrid load. During grid connected blue sky days, the existing backup units are too expensive to run as baseload generation and so will not typically operate. However, they are available for peak load support and can be part of a demand response program, given teh right market signals. For each of these backup units, Table 4-6 below summarizes the fuel/energy source, nameplate capacity, percentage of nameplate capacity during an extended power outage, average daily electricity production during a major outage, associated fuel consumption, one-time costs for connection/startup, and ongoing (non-fuel) costs for operation.

During a widespread power outage (i.e., a total loss of power in the surrounding area), each of the three anchor critical facilities has emergency measures for maintaining operations, preserving property, and/or protecting the health and safety of workers, residents, or the general public. The first line of defense involves connecting and powering up the backup generation resources identified in Table 4-6 below. For some, like SUNY Upstate Hospital, there is a code requirement for emergency power to come on to supply critical loads within ten seconds. These systems are on automatic transfer switches with a control system that senses loss of voltage, transitions critical circuits to the emergency backup system and starts up the machines. For some other facilities, startup of emergency backup might be a manual process. On loss of power, there are procedures that each facility would follow to notify personnel, check on the welfare of affected persons, and evacuate certain areas if necessary. As the emergency persists, facilities might incur additional costs to maintain backup power, including equipment rental, remedial measures, administrative costs, maintenance, fuel costs, permits and fees for extended operation.

Table 4-7 below summarizes the one-time and ongoing costs for the three anchor facilities in the Syracuse project when the facilities are operating on backup power. Table 4-8 summarizes the costs for the three anchor facilities when backup power is not available.

Table 4-6 Summary of Backup Generation Resources

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
SUNY-UUHCC	UUHCC-G01	Diesel	.650	100	15.6	1,200	Gal/day	200	20
SUNY-UUHCC	UUHCC-G02	Diesel	.600	100	14.4	1,027	Gal/day	200	20
SUNY-UUHCC	UUHCC-G03	Diesel	.300	100	7.2	504	Gal/day	200	20
Loretto	LOR-G01	*Diesel*	.350	100	8.4	630	Gal/day	200	20
Loretto	LOR-G02	*Diesel*	.250	100	6.0	432	Gal/day	200	20
Loretto	LOR-G03	*Natural Gas*	.150	100	3.6	33.12	MMBtu/ day	200	20
Loretto	LOR-G04	*Diesel*	.250	100	6.0	432	Gal/day	200	20
Loretto	LOR-G05	*Diesel*	.350	100	8.4	630	Gal/day	200	20
OCC	OCC-G01-11	*Diesel*	.500	100	12.0	840	Gal/day	200	20

Table 4-7 Cost of Maintaining Service while Operating on Backup Power

Facility Name	Type of Measure (One-Time or Ongoing)	Costs	Units	When would these measures be required?
OCC	1 time	3000	$	Upon loss of power
SUNY	1 time	3000	$	Upon loss of power
Loretto Campus	1 time	3000	$	Upon loss of power
OCC	Daily	7,000	$/day	Daily while no power
SUNY	Daily	8,000	$/day	Daily while no power
Loretto Campus	daily	4,000	$/day	Daily while no power
Other buildings and residences	Daily	150,000	$/day	Daily while no power

Table 4-8 Cost of Maintaining Service while Backup Power is Not Available

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
SUNY Upstate Community Hospital	One time	Rapid evacuation of 140-160 inpatients to other hospital, long term care and psychiatric facilities. Prepare and transport patients,	200,000	$	During a power outage. First day
SUNY Upstate Community Hospital	Ongoing	Lost net revenue $435,000/day incurring expenses of $345,000/day. Perishable blood products, food and supplies would be lost.	850,000	$/day	Having no power at the hospital campus
Loretto Nursing Home	One time	Relocate people and operations	85,000	$	Power out for more than 6 hours
Loretto Nursing Home	Ongoing	Serves over 7000 people in Onondaga and Cayuga County; over 850 daily on the campus. They operate a cooked/chilled food service program on the campus that the microgrid would serve. This produces meal production of 40,000 per week.	90,000	$/day	When they need to relocate facilities. More than a 6 hour power outage
OCC	Ongoing	12,000 students without classes. Make up time, logistics, overtime.	600,000	$/day	Daily During Outage
Residential - 1,666 households, ~ 5000 people	Ongoing	Loss of home office use, inconvenience, spoilage, remedial measures, purchase, inconvenience	65/person x 5,000 = 325,000	$/day	Daily During Outage
Small Commercial/mixed - 600 other buildings	Onetime and Ongoing	Computer crashes, point of sale impact, lost production	250,000	$/day	Daily During Outage

Based on the data above, during power outage while operating on backup power, SUNY Upstate Hospital would experience a 60% loss in services, Loretto would experience 70% loss of services and OCC would experience 95% loss on services. The impact on residential and small commercial establishments varies, but should average between 10% and 30% loss in services.

If backup generation is not available, all three anchor facilities would experience 100% loss in services and residential and small commercial establishments would experience 50% to 70% loss in services.

4.6 Services Supported by the Microgrid

The microgrid includes facilities that provide fire, emergency medical, hospital, and police services. Fire services are provided by the Onondaga Hill Fire Department which serves a surrounding population of 33,000. The nearest backup fire station is three miles away. The microgrid would provide resilience to the fire district resulting in 50% increase in response time.

Emergency Medical Services (EMS) are provided by the Onondaga County 911 Center. Since Cayuga, Madison, and Owego counties tie into Onondaga County's 911 radio system, the total population served is almost half-a-million, mostly in an urban area. The nearest alternative dispatch center is 5 miles away. The dispatch center has backup generation for routine outages. However during a prolonged outage the dispatch system would be available they would rely on cell phones, which can be unreliable during times of congestion. The microgrid would increase response time dramatically during a prolonged outage.

Hospital services are provided by SUNY Upstate Hospital which serves a population of over 660,000. The nearest alternative hospital is 3.1 miles away and serves a population of 500,000.

Police services are provided by a Syracuse Community Police Department station in the microgrid area. The station serves a population of 22,000. During normal conditions 16 officers would be working at the station, and during a power outage this doubles to 32. There is presumably a 50% reduction in service effectiveness during a power outage. The resiliency provided by the microgrid would mitigate this impact.

The microgrid serves an entire distribution feeder plus portions of two adjacent feeders. The estimated population of residential customers within the five square miles of service area is 5,000. Most of these are single family homes, but there are several apartment buildings, student housing, and two large nursing homes in the area. During a major outage, most of the 5,000 residents would be affected, as described in Table 4-8.

4.7 Benefit-Cost Analysis Results

To assist with the completion of the project's NY Prize Stage 1 feasibility study, Industrial Economics, Inc. (IEc) conducted a screening-level analysis of its potential costs and benefits based on the inputs described above. IEc typically considers two scenarios for the benefit cost analysis. The first scenario assumes a 20-year operation periods with no major power outages (i.e., normal operating conditions only). The second scenario calculates the average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under the first scenario.

Results of IEc's analysis (included in Appendix) indicate that even if there are no major power outages over the 20-year period analyzed, the project's benefits would exceed its cost by a factor of more than two. This result was based on the first of two scenarios that IEc considers for the analysis. As a result, IEc decided not to consider the second scenario, since any length of major outage will simply increase the project's considerably positive benefit-cost ratio.

As can be seen, the major cost component is the fuel costs of the microgrid generation resources (other than the OCRRA WTE Plant) during grid connected operations (for example, the CCHP running during normal days), and the cost associated with the corresponding environmental emissions. The capital costs are actually a smaller portion of the total cost. The major benefit component is the power quality improvements during grid connected operations. IEc notes that even if this benefit is excluded from the analysis, the overall results will not change, i.e., the project's benefits will still outweigh its costs. The other significant benefits are based on reduction in generation costs, fuel savings from CHP, generation capacity cost savings, reliability improvements, and the avoided emissions damages.

It is important to note that even without any major power outages over the 20-year period analyzed, the project has a benefit-cost ratio of 2.6, and an internal rate of return of 222%. Table 4-1 below summarizes the detailed results of the Scenario 1 benefit cost analysis.

Table 4-9: 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	$840,000	$74,100
Capital Investments	$6,180,000	$545,000
Fixed O&M	$1,700,000	$150,000
Variable O&M (Grid-Connected Mode)	$3,350,000	$296,000
Fuel (Grid-Connected Mode)	$11,500,000	$1,010,000
Emission Control	$17,000	$1,500
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$8,880,000	$579,000
Total Costs	**$32,500,000**	
Benefits		
Reduction in Generating Costs	$10,700,000	$948,000
Fuel Savings from CHP	$4,310,000	$380,000
Generation Capacity Cost Savings	$5,160,000	$456,000
Distribution Capacity Cost Savings	$828,000	$73,000
Reliability Improvements	$9,980,000	$881,000
Power Quality Improvements	$42,200,000	$3,720,000
Avoided Emissions Allowance Costs	$5,900	$521
Avoided Emissions Damages	$12,400,000	$808,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$85,600,000**	
Net Benefits	**$53,200,000**	
Benefit/Cost Ratio	**2.6**	
Internal Rate of Return	**222%**	

APPENDIX A – FULL BCA REPORT

Site 74 – City of Syracuse
BENEFIT-COST ANALYSIS SUMMARY REPORT

4.7.1 Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the City of Syracuse has proposed development of a microgrid that would that would enhance the resiliency of electric service for nearly 2,300 residential, commercial, and industrial customers in Onondaga County. These customers include:

- The State University of New York (SUNY) Upstate University Hospital;
- Onondaga Community College;
- The Onondaga Community 911 Dispatch Center;
- The Syracuse Community Police Department;
- Onondaga Hill Fire Department;
- Several nursing homes and senior housing facilities;
- Four facilities (two schools, a library, and a church) that can be used as emergency shelters in the event of a widespread power outage;
- Approximately 600 other commercial and industrial facilities; and
- Approximately 1,700 residential households.

The microgrid would be powered by a new 2 MW natural gas-fired combined heat and power (CHP) generator, which would be located at the SUNY Upstate University Hospital; an existing 75 kW solar photovoltaic array, located at Onondaga Community College; and the community's largest distributed generation resource, an existing 40 MW waste-to-energy plant owned by the Onondaga County Resource Recovery Agency (OCRRA).[14] Each of these resources would produce electricity for the grid during periods of normal operation, as well as in islanded mode during power outages. In addition, the microgrid will incorporate nine existing natural gas and diesel backup generators (combined capacity: 3.4 MW) that will not operate except when called upon to provide peak load support. The system as designed would have sufficient generating capacity to meet average demand for electricity from all included facilities during a major outage. The project's consultants also indicate that the system would be capable of providing ancillary services, in the form of frequency regulation, reactive power support, and black start support, to the grid.

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

[14] Because the waste-to-energy plant and solar array are already installed and operating, the energy they generate and the capacity they provide are not treated as benefits of the microgrid.

4.7.2 Methodology and Assumptions

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

- Costs represent the value of resources consumed (or benefits forgone) in the production of a good or service.
- *Benefits* are impacts that have value to a firm, a household, or society in general.
- *Net benefits* are the difference between a project's benefits and costs.
- Both costs and benefits must be measured relative to a common baseline - for a microgrid, the "without project" scenario - that describes the conditions that would prevail absent a project's development. The BCA considers only those costs and benefits that are incremental to the baseline.

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

The BCA model is structured to analyze a project's costs and benefits over a 20-year operating period. The model applies conventional discounting techniques to calculate the present value of costs and benefits, employing an annual discount rate that the user specifies – in this case, seven percent.[15] 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

[15] 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.]

a choice among investments in multiple projects, the "societal cost test" guides the decision toward the investment that produces the greatest net benefit.

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[16]

4.7.3 Results

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that even if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's benefits would exceed its costs by a factor of more than two. As a result, the analysis does not evaluate Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio.

The discussion that follows provides additional detail on these findings.

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

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$53,200,000	Not Evaluated
Benefit-Cost Ratio	2.6	Not Evaluated
Internal Rate of Return	222%	Not Evaluated

4.7.4 Scenario 1

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

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

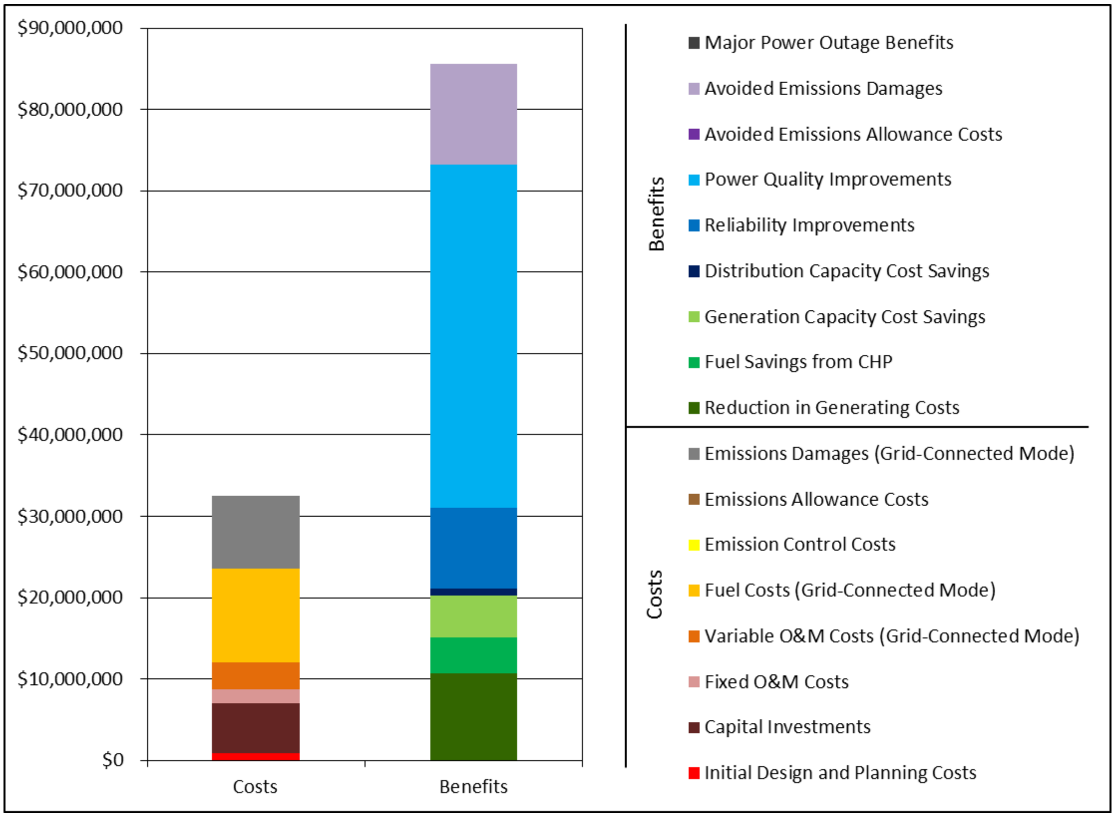

Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$840,000	$74,100
Capital Investments	$6,180,000	$545,000
Fixed O&M	$1,700,000	$150,000
Variable O&M (Grid-Connected Mode)	$3,350,000	$296,000
Fuel (Grid-Connected Mode)	$11,500,000	$1,010,000
Emission Control	$17,000	$1,500
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$8,880,000	$579,000
Total Costs	**$32,500,000**	
Benefits		
Reduction in Generating Costs	$10,700,000	$948,000
Fuel Savings from CHP	$4,310,000	$380,000
Generation Capacity Cost Savings	$5,160,000	$456,000
Distribution Capacity Cost Savings	$828,000	$73,000
Reliability Improvements	$9,980,000	$881,000
Power Quality Improvements	$42,200,000	$3,720,000
Avoided Emissions Allowance Costs	$5,900	$521
Avoided Emissions Damages	$12,400,000	$808,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$85,600,000**	
Net Benefits	**$53,200,000**	
Benefit/Cost Ratio	**2.6**	
Internal Rate of Return	**222%**	

4.7.4.1 Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $840,000. The present value of the project's capital costs is estimated at approximately $6.18 million, including costs associated with the new 2 MW CHP system and absorption chiller; utility interconnection; upgrades to the distribution circuit; and other system software and controls. The new CHP generator will also require the installation of emissions control equipment. The project team's best estimate of capital costs for emissions control is approximately $1,500 per year for the replacement of catalytic converters. The present value of these emissions control costs is approximately $17,000. The present value of the microgrid'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 approximately $1.7 million, or $150,000 annually.

4.7.4.2 Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's CHP generator. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.[17] The BCA does not estimate any incremental cost associated with fueling the existing waste-to-energy generator. The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $11.5 million.

The BCA also considers the project team's best estimate of the microgrid's variable 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 approximately $3.35 million, or $17 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 microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid are estimated at approximately $579,000 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 $8.88 million.

4.7.4.3 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 $10.7 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. Additional benefits would result from fuel savings due to the new CHP system; the BCA estimates the present value of these fuel savings over the 20-year operating period to be approximately $4.31 million. The reduction in demand for electricity from bulk energy suppliers and for 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 $5,900 and avoided emissions damages with a present value of approximately $12.4 million.[18]

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution

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[17] 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.

[18] 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.

capacity.[19] The project team estimates the capacity available for the provision of peak load support to be approximately 5.4 MW per year, based on estimates of the new CHP system's and existing backup generators' output during system peak. The project team also expects development of the microgrid to reduce the conventional grid's demand for generating capacity by an additional 670 kW each month as a result of new demand response capabilities. The BCA estimates the present value of the project's generating capacity benefits to be approximately $5.16 million over a 20-year operating period. The present value of the project's potential distribution capacity benefits is estimated to be approximately $828,000.

The project team has indicated that the proposed microgrid 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 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 these services.

4.7.4.4 Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $881,000 per year, with a present value of $9.98 million over a 20-year operating period. This estimate is developed using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[20]

- System Average Interruption Frequency Index (SAIFI) – 0.96 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 116.4 minutes.[21]

The estimate takes into account the number of small and large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[22] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

It is important to note that the analysis of reliability benefits assumes that development of a microgrid would insulate the facilities the project would serve from outages of the type captured in SAIFI and CAIDI values. The distribution network within the microgrid is unlikely to be wholly invulnerable to such interruptions in

[19] 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.

[20] www.icecalculator.com.

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

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

service. All else equal, this assumption will lead the BCA to overstate the reliability benefits the project would provide.

4.7.4.5 Power Quality Benefits

The power quality benefits of a microgrid 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 microgrid would avoid each year. The Syracuse team estimates that the facilities served by the microgrid would avoid an average of approximately seven such events annually. The model estimates the present value of avoiding these events to be approximately $42.2 million over a 20-year operating period.[23] In reality, some customers for whom power quality is important (e.g., the hospital) may already have systems in place to protect against voltage sags, swells, and momentary outages. If this is the case, the BCA may overstate the power quality benefits the project would provide. Of note, however, the reduction or exclusion of power quality benefits would not change the overall result of this analysis; i.e., that the project's benefits outweigh its costs.

4.7.4.6 Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 2.6; i.e., the estimate of project benefits is more than twice that of project costs. Accordingly, the analysis does not consider the potential of the microgrid to mitigate the impact of major power outages in Scenario 2. Consideration of such benefits would further increase the net benefits of the project's development.

[23] 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, which may not reflect the characteristics of the proposed microgrid. For example, if the proposed microgrid does not serve customers in the construction, manufacturing, or financial/insurance/real estate sectors, which typically have the highest costs per power quality event, the estimate presented here may overstate benefits. [See: Sullivan, Michael J. *et al*. Estimated Value of Service Reliability for Electric Utility Customers in the United States. LBNL-2132E: June 2009.]

APPENDIX B - FACILITY AND MICROGRID QUESTIONNAIRES

NY Prize Benefit-Cost Analysis: Facility Questionnaire

This questionnaire requests information needed to estimate the impact that a microgrid might have in protecting the facilities it serves from the effects of a major power outage (i.e., an outage lasting at least 24 hours). The information in this questionnaire will be used to develop a preliminary benefit-cost analysis of the community microgrid you are proposing for the NY Prize competition. Please provide as much detail as possible.

For each facility that will be served by the microgrid, we are interested in information on:

1. Current backup generation capabilities.
2. The costs that would be incurred to maintain service during a power outage, both when operating on its backup power system (if any) and when backup power is down or not available.
3. The types of services the facility provides.

If you have any questions regarding the information requested, please contact Industrial Economics, Incorporated, either by email (NYPrize@indecon.com) or phone (929-445-7641).

Microgrid site: 74. City of Syracuse

Point of contact for this questionnaire:

Name: Herbert Dwyer
Address: 950 Danby Road Suite 100F Ithaca, NY. 14850
Telephone: 607-330-1203
Email: Herbert.dwyer@asienergy.com

Backup Generation Capabilities

1. Do any of the facilities that would be served by the microgrid currently have backup generation capabilities?
    1. ☐ No - proceed to Question 4
    2. ☒ Yes - proceed to Question 2

2. For each facility that is equipped with a backup generator, please complete the table below, following the example provided. Please include the following information:
    1. **Facility name:** For example, "Main Street Apartments."
    2. **Identity of backup generator:** For example, "Unit 1."
    3. **Energy source:** Select the fuel/energy source used by each backup generator from the dropdown list. If you select "other," please type in the energy source used.

4. **Nameplate capacity:** Specify the nameplate capacity (in MW) of each backup generator.
5. **Standard operating capacity:** Specify the percentage of nameplate capacity at which the backup generator is likely to operate during an extended power outage.
6. **Average electricity production per day in the event of a major power outage**: Estimate the average daily electricity production (MWh per day) for the generator in the event of a major power outage. In developing the estimate, please consider the unit's capacity, the daily demand at the facility it serves, and the hours of service the facility requires.
7. **Fuel consumption per day:** Estimate the amount of fuel required per day (e.g., MMBtu per day) to generate the amount of electricity specified above. This question does not apply to renewable energy resources, such as wind and solar.
8. **One-time operating costs:** Please identify any one-time costs (e.g., labor or contract service costs) associated with connecting and starting the backup generator.
9. **Ongoing operating costs:** Estimate the costs ($/day) (e.g., maintenance costs) associated with operating the backup generator, excluding fuel costs.

Note that backup generators may also serve as distributed energy resources in the microgrid. Therefore, there may be some overlap between the information provided in the table below and the information provided for the distributed energy resource table (Question 2) in the general Microgrid Data Collection Questionnaire.

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
SUNY Community Medical Hospital	UUHCC-G01	Diesel	.650	100	15.6	1,200	Gal/day	200	20
SUNY Community Medical Hospital	UUHCC-G02	*Diesel*	.600	100	14.4	1,027	Gal/day	200	20
SUNY Community Medical Hospital	UUHCC-G03	*Diesel*	.300	100	7.2	504	Gal/day	200	20

Please Note: These existing units will not run after the Microgrid development has been completed. These units will NOT operate in either islanded (emergency) mode or grid connected (normal and blue sky days) mode. However, they are available for Peak Load Support. Therefore, the information in this table only applies to the current "pre-microgrid" situation.

Costs of Emergency Measures Necessary to Maintain Service

We understand that facilities may have to take emergency measures during a power outage in order to maintain operations, preserve property, and/or protect the health and safety of workers, residents, or the general public. These measures may impose extraordinary costs, including both one-time expenditures (e.g., the cost of evacuating and relocating residents) and ongoing costs (e.g., the daily expense of renting a portable generator). The questions below address these costs. We begin by requesting information on the costs facilities would be likely to incur when operating on backup power. We then request information on the costs facilities would be likely to incur when backup power is not available.

A. **Cost of Maintaining Service while Operating on Backup Power**

3. Please provide information in the table below for each facility the microgrid would serve which is currently equipped with some form of backup power (e.g., an emergency generator). For each facility, please describe the costs of any emergency measures that would be necessary in the event of a widespread power outage (i.e., a total loss of power in the area surrounding the facility lasting at least 24 hours). In completing the table, please assume that the facility's backup power system is fully operational. In your response, please describe and estimate the costs for:

1. One-time emergency measures (total costs)
2. Ongoing emergency measures (costs per day)

Note that these measures do not include the costs associated with running the facility's existing backup power system, as estimated in the previous question.

In addition, for each emergency measure, please provide additional information related to when the measure would be required. For example, measures undertaken for heating purposes may only be required during winter months. As another example, some commercial facilities may undertake emergency measures during the work week only.

As a guide, see the examples the table provides.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
OCC	*1 time*	*Turn on and check backup power. Notify of issue, send many people home*	*3000*	*$*	*Upon loss of power*
SUNY	*1 time*	*Turn on and check backup power. Notify of issue, send many people home*	*3000*	*$*	*Upon loss of power*
Loretto Campus	1 time	*Turn on and check backup power. Notify of issue, send many people home*	3000	$	Upon loss of power
OCC	Daily	Price for diesel to power facility	7,000	$/day	Daily while no power
SUNY	Daily	Price for diesel to power facility	8,000	$/day	Daily while no power
Loretto Campus	daily	Price for diesel to power facility	4,000	$/day	Daily while no power
Other buildings and residences	Daily	Back up generation per building x 2,200 buildings	150,000	$/day	Daily while no power

B. Cost of Maintaining Service while Backup Power is Not Available

4. Please provide information in the table below for each facility the microgrid would serve. For each facility, please describe the costs of any emergency measures that would be necessary in the event of a widespread power outage (i.e., a total loss of power in the area surrounding the facility lasting at least 24 hours). In completing the table, please assume that service from any backup generators currently on-site is not available. In your response, please describe and estimate the costs for:

   1. One-time emergency measures (total costs)
   2. Ongoing emergency measures (costs per day)

   In addition, for each emergency measure, please provide additional information related to when the measure would be required. For example, measures undertaken for heating purposes may only be required during winter months. As another example, some commercial facilities may undertake emergency measures during the work week only.

   As a guide, see the examples the table provides.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
1,666 residential households	*Daily Alter their lifestyle*	*Misc.*	*$65/person x 5,000 people is 325,000*	*$/day*	*Some missing work, some buying batteries and heat fuel, etc.*
600 other buildings making due	*Daily*	*Make due*	*240,000*	*$/day*	*Alter business to cope*
SUNY Upstate Community Medical	*One time*	Rapid evacuation of 140-160 inpatients to other hospital, long term care and psychiatric facilities. Prepare and transport patients,	*200,000*	*1 time*	*During a power outage. First day*
SUNY Upstate Community Medical	*Daily*	Lost net revenue $435,000/day incurring expenses of $345,000/day. Perishable blood products, food and supplies would be lost.	*850,000*	*$/day*	Having no power at the hospital campus
Loretto	*Daily*	*Relocate people and operations*	85,000	*$/day*	Power out for more than 6 hours

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Loretto	*Daily*	*Serves over 7000 people in Onondaga and Cayuga County . over 850 daily on the campus. we operate a cook chill food service program on the campus that the micro grid would serve . This produces meal production of 40,000 per week*	90,000	*$/day*	When they need to relocate facilities. More than a 6 hour power outage
OCC	*Close the campus*	*12,000 students don't have class. Lost revenue*	$600,000	*$/day*	During blackout
OCC	*Close the campus*	Start backup generators, communications	$10,000	1 time	During blackout
All other commercial buildings	*Close business for the day*	Loss of revenue given 5,000 people in the affected area	$250,000	*$/day*	Each day during blackout
Residential	*Backup lighting and other measures.*	5,000 people live in this area	395,000	*$/day*	First and each subsequent day there is no power

Services Provided

We are interested in the types of services provided by the facilities the microgrid would serve, as well as the potential impact of a major power outage on these services. As specified below, the information of interest includes some general information on all facilities, as well as more detailed information on residential facilities and critical service providers (i.e., facilities that provide fire, police, hospital, water, wastewater treatment, or emergency medical services (EMS)).

A. Questions for: All Facilities

3. During a power outage, is each facility able to provide the same level of service when using backup generation as under normal operations? If not, please estimate the percent loss in the services for each facility (e.g., 20% loss in services provided during outage while on backup power). As a guide, see the example the table provides.

Facility Name	Percent Loss in Services When Using Backup Gen.
SUNY Upstate Community Hospital	60%
OCC	95%
Loretto	70%
1,666 households	10%
600 other buildings	30%

4. During a power outage, if backup generation is not available, is each facility able to provide the same level of service as under normal operations? If not, please estimate the percent loss in the services for each facility (e.g., 40% loss in services provided during outage when backup power is not available). As a guide, see the example the table provides.

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
OCC	*100%*
SUNY Upstate Community Hospital	100%
Loretto	100%
1,666 households	50%
600 other buildings	70%

B. Questions for facilities that provide: Fire Services

5. What is the total population served by the facility?

33,000

6. Please estimate the percent increase in average response time for this facility during a power outage:

50

7. What is the distance (in miles) to the nearest backup fire station or alternative fire service provider?

3

C. **Questions for facilities that provide: Emergency Medical Services (EMS)**

8. What is the total population served by the facility?

467,000 also Cayuga, Madison, and Owego ty into this radio system

Carl Loerzel provided info from 911 Center

9. Is the area served by the facility primarily (check one):

☒ Urban

☐ Suburban

☐ Rural

☐ Wilderness

10. Please estimate the percent increase in average response time for this facility during a power outage:

With their generator back up there I none. Without that they are using cell phones therefore 200%

11. What is the distance (in miles) to the next nearest alternative EMS provider?

5 miles

D. **Questions for facilities that provide: Hospital Services**

12. What is the total population served by the facility?

662,000

13. What is the distance (in miles) to the nearest alternative hospital?

3.1

14. What is the population served by the nearest alternative hospital?

500,000

E. Questions for facilities that provide: Police Services

15. What is the total population served by the facility?

22,000

16. Is the facility located in a (check one):

☐ Metropolitan Statistical Area

☒ Non-Metropolitan City

☐ Non-Metropolitan County

17. Please estimate:

1. The number of police officers working at the station under normal operations.

16

2. The number of police officers working at the station during a power outage.

32

3. The percent reduction in service effectiveness during an outage.

50

F. Questions for facilities that provide: Wastewater Services

18. What is the total population served by the facility?

Click here to enter text.

19. Does the facility support (check one):

☐ Residential customers

☐ Businesses

☐ Both

G. Questions for facilities that provide: Water Services

20. What is the total population served by the facility?

Click here to enter text.

21. Does the facility support (check one):

☐ Residential customers

☐ Businesses

☐ Both

H. Questions for: Residential Facilities

22. What types of housing does the facility provide (e.g., group housing, apartments, nursing homes, assisted living facilities, etc.)?

Every demographic is represented in this microgrid, including an estimated 5,000 residential customers.

23. Please estimate the number of residents that would be left without power during a complete loss of power (i.e., when backup generators fail or are otherwise not available).

5,000. THAT EXPANSE OF THIS MICROGRID IS 5 SQUARE MILES OF THE PART OF SYRACUSE KNOWN AS THE VALLEY. NEIGHBORHOOD

4.8 NY Prize Benefit-Cost Analysis: Microgrid Questionnaire

This questionnaire solicits information on the community microgrid you are proposing for the NY Prize competition. The information in this questionnaire will be used to develop a preliminary benefit-cost analysis of the proposed microgrid. Please provide as much detail as possible. The questionnaire is organized into the following sections:

If you have any questions regarding the information requested, please contact Industrial Economics, Incorporated, either by email (NYPrize@indecon.com) or phone (929-445-7641).

Microgrid site: 74. City of Syracuse

Point of contact for this questionnaire:

Name: Herbert Dwyer
Address: 950 Danby Road Ithaca NY 14850
Telephone: 607-330-1203
Email: Herbert.dwyer@asienergy.com

A. Project Overview, Energy Production, and Fuel Use

1. The table below is designed to gather background information on the facilities your microgrid would serve. It includes two examples: one for Main Street Apartments, a residential facility with multiple utility customers; and another for Main Street Grocery, a commercial facility. Please follow these examples in providing the information specified for each facility. Additional guidance is provided below.

   - **Facility name:** Please enter the name of each facility the microgrid would serve. Note that a single **facility** may include multiple **customers** (e.g., individually-metered apartments within a multi-family apartment building). When this is the case, you do not need to list each customer individually; simply identify the facility as a whole (see Table 1, "Main Street Apartments," for an example).
   - **Rate class:** Select the appropriate rate class for the facility from the dropdown list. Rate class options are residential, small commercial/industrial (defined as a facility using less than 50 MWh of electricity per year), or large

commercial/industrial (defined as a facility using 50 or more MWh of electricity per year).

- **Facility/customer description:** Provide a brief description of the facility, including the number of individual customers at the facility if it includes more than one (e.g., individually-metered apartments within a multi-family apartment building). For commercial and industrial facilities, please describe the type of commercial/industrial activity conducted at the facility.
- **Economic sector:** Select the appropriate economic sector for the facility from the dropdown list.
- **Average annual usage:** Specify the average annual electricity usage (in MWh) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from average annual usage for the facility as a whole.
- **Peak demand:** Specify the peak electricity demand (in MW) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from peak demand for the facility as a whole.
- **Percent of average usage the microgrid could support in the event of a major power outage:** Specify the percent of each facility's typical usage that the microgrid would be designed to support in the event of a major power outage (i.e., an outage lasting at least 24 hours that necessitates that the microgrid operate in islanded mode). In many cases, this will be 100%. In some cases, however, the microgrid may be designed to provide only enough energy to support critical services (e.g., elevators but not lighting). In these cases, the value you report should be less than 100%.
- **Hours of electricity supply required per day in the event of a major power outage:** Please indicate the number of hours per day that service to each facility would be maintained by the microgrid in the event of a major outage. Note that this value may be less than 24 hours for some facilities; for example, some commercial facilities may only require electricity during business hours.

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
USPS	Small Commercial/Industrial (<50 annual MWh)	Federal. Mail	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	18
Onondaga Community College	Large Commercial/Industrial (>50 annual MWh)	Community College	*All other industries*	12,254	3.153	*100%*	24
SUNY Upstate University Hospital - Community	Large Commercial/Industrial (>50 annual MWh)	Hospital	*All other industries*	11,263	2.557	*100%*	24
Van Duyn Center for Rehab and Nursing	Large Commercial/Industrial (>50 annual MWh)	Nursing home	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Valley Vista Apt	Large Commercial/Industrial (>50 annual MWh)	Senior Housing	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Mobile Gas Station	Small Commercial/Industrial (<50 annual MWh	Fuel, food, ATM	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Loretto Campus	Large Commercial/Industrial (>50 annual MWh)	Senior Housing	*All other industries*	10,448	2.019	*100%*	24
Faith Heritage School	Small Commercial/Industrial (<50 annual MWh)	School / Place of Refuge	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	18
Syracuse Community Police Department	Small Commercial/Industrial (<50 annual MWh)	Police Department, Tops Market, Family Dollar store	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Onondaga Hill Fire Department	Small Commercial/Industrial (<50 annual MWh)	Fire Department	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Betts Branch Onondaga Public Library	Small Commercial/Industrial (<50 annual MWh)	Library /Place of Refuge	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Brighton Towers	Large Commercial/Industrial (>50 annual MWh)	Apartments	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Nob Hill Apartments	Large Commercial/Industrial (>50 annual MWh)	Apartment	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
Kinney Drugs	Small Commercial/Industrial (<50 annual MWh)	Drug Store, Food	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	18
Onondaga Middle School	Small Commercial/Industrial (<50 annual MWh)	School / Place of Refuge	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	18
Onondaga County 911 Center	Small Commercial/Industrial (<50 annual MWh)	911 Dispatch	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	24
St. Michaels Church	Small Commercial/Industrial (<50 annual MWh)	Place of worship / Place of Refuge	*All other industries*	No Data (See Extra Feeder Load)	No Data (See Extra Feeder Load)	*100%*	12
Extra Feeder Load	**Mixed Residential + Commercial**	**Mixed Residential + Commercial**	***All***	**31,740**	**7.244**	**100%**	**24**

Facility Name	Rate Class	Facility / Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
TOTAL Microgrid Load	**Mixed**	**Mixed**	***All***	**72,270**	**14.973**	**100%**	**24**

Please Note: We have included energy and peak demand information only for those facilities that provide data that enabled us to directly calculate their energy use. We were not able to collect direct information on energy use from other facilities on the distribution feeders which are part of the Microgrid, However, we had information on the Total Microgrid Feeders based on information from National Grid that enabled us to estimate the total Feeder Loads and after subtracting the energy and peaks of the critical facilities with actual data, we were able to estimate the remaining load (i.e., the Extra Feeder Load). Hence, the total Microgrid Annual Energy Requirement is 72,270 MWh with a Peak Demand of 14,973 MW, and a Load Factor of about 55%.

2. In the table below, please provide information on the distributed energy resources the microgrid will incorporate. Use the two examples included in the table as a guide.

- **Distributed energy resource name:** Please identify each distributed energy resource with a brief description. In the event that a single facility has multiple distributed energy resources of the same type (e.g., two diesel generators), please use numbers to uniquely identify each (e.g., “Diesel generator 1” and “Diesel generator 2”).
- **Facility name:** Please specify the facility at which each distributed energy resource is or would be based.
- **Energy source:** Select the fuel/energy source used by each distributed energy resource from the dropdown list. If you select “other,” please type in the energy source used.
- **Nameplate capacity:** Specify the total nameplate capacity (in MW) of each distributed energy resource included in the microgrid.
- **Average annual production:** Please estimate the amount of electricity (in MWh) that each distributed energy resource is likely to produce each year, on average, **under normal operating conditions.** The benefit-cost analysis will separately estimate production in islanded mode in the event of an extended power outage. **If the distributed energy resource will operate only in the event of an outage, please enter zero.**
- **Average daily production in the event of a major power outage:** Please estimate the amount of electricity (in MWh per day) that each distributed energy resource is likely to produce, on average, **in the event of a major power outage.** In developing your estimate for each distributed energy resource, you should consider the electricity requirements of the facilities the microgrid would serve, as specified in your response to Question 1.
- **Fuel consumption per MWh:** For each distributed energy resource, please estimate the amount of fuel required to generate one MWh of energy. This question does not apply to renewable energy resources, such as wind and solar.

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
Waste to Energy Mode: OCRRA will have sufficient Trash Storage, and therefore, is not expected to require running on Natural Gas Mode, even though it has the capability of doing so. During the islanded emergency mode, OCRRA is not expected to run at full load since the Microgrid Peak Load is less than the full capacity of OCRRA. This is an EXISTING power source, but will be the principal power source for the Microgrid during emergency periods.	OCRRA Onondaga County Resource Recovery Agency	*Other - please specify waste to energy*	39.6	346,896	202.284	.8	Tons of trash
Proposed UUHCC RICE CHP	Upstate Medical Hospital	*Natural Gas*	2	-17,397	48.000	8.530	MMBTU
Solar PV	OCC	*Solar*	.075	124.102	0.452	NA	other
Existing UUHCC-G01	SUNY Communicate Medical Hospital	*Diesel*	.65	0	0	59	Gallons
Existing UUHCC-G02	SUNY Communicate	*Diesel*	.6	0	0	60	Gallons

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
	Medical Hospital						
Existing UUHCC-G03	SUNY Communicate Medical Hospital	*Diesel*	.3	0	0	66	Gallons
Existing LOR-G01	Loretto	*Diesel*	.35	0	0	75	Gallons
Existing LOR-G02	Loretto	*Diesel*	.25	0	0	72	Gallons
Existing LOR-G03	Loretto	*Natural Gas*	.15	0	0	9000	CF
Existing LOR-G04	Loretto	*Diesel*	.25	0	00	72	Gallons
Existing LOR-G05	Loretto	*Diesel*	.35	0	0	75	Gallons
Existing OCC-G01-11	OCC	*Diesel*	.5	0	0	70	Gallons

Please Note: None of the Existing Units will run during islanded emergency periods, due to the availability of OCRRA generation. During grid connected normal blue sky days, the existing units are too expensive to run and will not operate, But they are available for Peak Load Support.

OCRRA plus the 2000 kW CHP and the Load Curtailment together are more than sufficient to meet the Microgrid load during the emergency period.

B. Capacity Impacts

3. Is development of the microgrid expected to reduce the need for bulk energy suppliers to expand generating capacity, either by directly providing peak load support or by enabling the microgrid's customers to participate in a demand response program?

☐ No – proceed to Question 6

☒ Yes, both by providing peak load support and by enabling participation in a demand response program – proceed to Question 4

☐ Yes, by providing peak load support only – proceed to Question 4

☐ Yes, by enabling participation in a demand response program only – proceed to Question 5

Provision of Peak Load Support

4. Please provide the following information for all distributed energy resources that would be available to provide peak load support:

- **Available capacity:** Please indicate the capacity of each distributed energy resource that would be available to provide peak load support (in MW/year).
- **Current provision of peak load support, if any:** Please indicate whether the distributed energy resource currently provides peak load support.

Please use the same distributed energy resource and facility names from Question 2.

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does distributed energy resource currently provide peak load support?
Waste to energy mode	OCRRA Onondaga County Resource Recovery Agency	39.6	☒ Yes
UUHCC 2MW (RICE) CCHP	Upstate Medical Hospital	2.0	☐ Yes
			☐ Yes
			☐ Yes
Existing Generation	UUHCC + Loretto + OCC	3.475	☐ Yes
Solar PV (iCAP 23.5% of 0.075 MW – 23.5% is the Annual Capacity Factor – which is close to PV Capacity Value)	OCC	0.018	☐ Yes
			☐ Yes

If development of the microgrid is also expected to enable the microgrid's customers to participate in a demand response program, please proceed to Question 5. Otherwise, please proceed to Question 6.

Participation in a Demand Response Program

5. Please provide the following information for each facility that is likely to participate in a demand response program following development of the microgrid:

- **Available capacity:** Please estimate the capacity that would be available to participate in a demand response program (in MW/year) following development of the microgrid.
- **Capacity currently participating in a demand response program, if any:** Please indicate the capacity (in MW/year), if any, that currently participates in a demand response program.

Facility Name	Capacity Participating in Demand Response Program (MW) peak	
	Following Development of Microgrid	Currently
Upstate Medical Hospital	0.256	Yes
Loretto	0.102	No
OCC	0.315	No
The values are Demand-Side Demand Response / Load Curtailment based on reduction of Load – they are not Supply Side Generation and are ADDITIVE to the Peak Load Support resources.		

6. Is development of the microgrid expected to enable utilities to avoid or defer expansion of their transmission or distribution networks?

☒ Yes – proceed to Question 7

☐ No – proceed to Section C

7. Please estimate the impact of the microgrid on utilities' **transmission** capacity requirements. The following question will ask about the impact on distribution capacity.

Impact of Microgrid on Utility Transmission Capacity	Unit
14,500 OPTION TO DEFER	MW/year

8. Please estimate the impact of the microgrid on utilities' **distribution** capacity requirements.

Impact of Microgrid on Utility Distribution Capacity	Unit
14,500	MW/year

C. Project Costs

We are interested in developing a year-by-year profile of project costs over a 20-year operating period. The following questions ask for information on specific categories of costs.

Capital Costs

9. In the table below, please estimate the fully installed cost and lifespan of all equipment associated with the microgrid, including equipment or infrastructure associated with power generation (including combined heat and power systems), energy storage, energy distribution, and interconnection with the local utility.

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
General Management and stake holder management	105,000	20	Managing mostly outside project team players, municipalities, regulatory, community, code
Contract admin, legal and paperwork	40,000	20	Typical contract admin, legal work
Interconnect	15,000	20	Utility Interconnection for sites
Permitting	25,000	20	Apply for permit and manage inspectors
Indirect fired absorption chiller 400T at SUNY Upstate	500,000	20	Uses CHP heat to produce chilled water allowing for summertime use of CHP heat
motorized breakers x 2	110,000	20	A breaker for each CHP to achieve island mode
ATS x 3	45,000	20	Automatic transfer switch for each facility
Microgrid control and communications system	350,000	20	Controller, node, instrumentation, radios, switches, integration/configuration,
Software	10,000	20	Misc. billing, control, modeling, etc. software as needed to include internet website.
2 megawatt CHP at SUNY Upstate Community Hospital	4,260,000	20	CHP producing baseload thermal and electrical as throttled given thermal needs
Evaluate and repair the existing subterranean pipes between SUNY and Van Duyn	100,000	20	Thermally connecting allows for greater electricity availability to operate in ISO market and pay for microgrid
Building Heating Distribution	150,000	20	Heat exchanges, pumps, bypass valves
Electrical work on buildings	150,000	20	Sensors on electrical mains, equipment panels, outdoor disconnects, etc.
Natural Gas work on buildings	35,000	20	Getting 2 psi gas to CHP. New meters for new service class

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
Misc. allotment	250,000	20	Misc. expense allotment, contingency
Distribution circuit upgrades	200,000	20	15-kV class isolation switches, protection and monitoring equipment

Initial Planning and Design Costs

10. Please estimate initial planning and design costs. These costs should include costs associated with project design, building and development permits, efforts to secure financing, marketing the project, and negotiating contracts. Include only upfront costs. Do not include costs associated with operation of the microgrid.

Initial Planning and Design Costs ($)	What cost components are included in this figure?
$670,000	Energy analysis, engineering design, energy modeling, BIM, AutoCad, electrical and plumbing site investigative study existing conditions, project management, contract admin, financial modeling, draft RFPs, conduct submittals, estimate costs, print blueprints, set up project steering committee, kick off meeting, design review meeting, final design meetings, set up studies office, hire and implement outside subject matter experts as needed, conduct DFMEA, apply for building permit and see what issues come back from the city, also apply for interconnection and see what issues come up from the utility.

Fixed O&M Costs

11. Fixed O&M costs are costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces each year (e.g., software licenses, technical support). Will there be any year-to-year variation in these costs for other reasons (e.g., due to maintenance cycles)?

☒ No – proceed to Question 12

☐ Yes – proceed to Question 13

12. Please estimate any costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces each year.

Fixed O&M Costs ($/year)	What cost components are included in this figure?
150K	Billing software, manager, assistant manager, computer infrastructure and software, insurances, contract updates, contract reviews, customer service

	department training, phone, office, brick and mortar, absorption chillers and cooling tower maintenance

Please proceed to Question 14.

13. For each year over an assumed 20-year operating life, please estimate any costs associated with operating and maintaining the microgrid that are unlikely to vary with the amount of energy the system produces.

Year	Fixed O&M Cost ($)	What cost components are included in this figure?
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Variable O&M Costs (Excluding Fuel Costs)

14. Please estimate any costs associated with operating and maintaining the microgrid (excluding fuel costs) that are likely to vary with the amount of energy the system produces each year. Please estimate these costs per unit of energy produced (e.g., $/MWh).

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
20.00	$/MWh	**OCRRA VOM**
17.00	$/MWh	UUHCC CHP VOM
	Choose an item.	

Fuel Costs

15. In the table below, please provide information on the fuel use for each distributed energy resource the microgrid will incorporate. Please use the same distributed energy resource and facility names from Question 2.

- **Duration of design event:** For each distributed energy resource, please indicate the maximum period of time in days that the distributed energy resource would be able to operate in islanded mode without replenishing its fuel supply (i.e., the duration of the maximum power outage event for which the system is designed). **For renewable energy resources, your answer may be "indefinitely."**
- **Fuel consumption:** For each distributed energy resource that requires fuel, please specify the quantity of fuel the resource would consume if operated in islanded mode for the assumed duration of the design event.

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
Waste to Energy mode (DER-CAM Results)	OCRRA	7	1.132.8	Other –Tons of waste to burn
UUHCC CHP RICE	Upstate Medical 2 meg CHP	7	4,094.6	MMBtu

16. Will the project include development of a combined heat and power (CHP) system?

☒ Yes – proceed to Question 17

☐ No – proceed to Question 18

17. If the microgrid will include development of a CHP system, please indicate the type of fuel that will be offset by use of the new CHP system and the annual energy savings (relative to the current heating system) that the new system is expected to provide.

Type of Fuel Offset by New CHP System	Annual Energy Savings Relative to Current Heating System	Unit
Natural gas	55,639	MMBtu
Choose an item.		Choose an item.
Choose an item.		Choose an item.
Choose an item.		Choose an item.
Choose an item.		Choose an item.

Emissions Control Costs

18. We anticipate that the costs of installing and operating emissions control equipment will be incorporated into the capital and O&M cost estimates you provided in response to the questions above. If this is not the case, please estimate these costs, noting what cost components are included in these estimates. For capital costs, please also estimate the engineering lifespan of each component.

Cost Category	Costs ($)	Description of Component(s)	Component Lifespan(s) (round to nearest year)
Capital Costs ($)	$1,500	Catalytic convertors swapped out in each CHP unit	1
Annual O&M Costs ($/MWh)	$1,500	Annual catalytic convertor swap	
Other Annual Costs ($/Year)			

19. Will environmental regulations mandate the purchase of emissions allowances for the microgrid (for example, due to system size thresholds)?

☐ Yes

☒ No

D. *Environmental Impacts*

20. For each pollutant listed below, what is the estimated emissions rate (e.g., tons/MWh) for the microgrid?

Emissions Type	Emissions per MWh	Unit
CO_2	0.503	Metric Tons/MWh
SO_2	0.0000	Metric Tons/MWh
NO_x	0.00023	Metric Tons/MWh
PM	0.0000	Metric Tons/MWh

E. Ancillary Services

21. Will the microgrid be designed to provide any of the following ancillary services? If so, we may contact you for additional information.

Ancillary Service	Yes	No
Frequency or Real Power Support	☒	☐
Voltage or Reactive Power Support	☒	☐
Black Start or System Restoration Support	☒	☐

F. Power Quality and Reliability

22. Will the microgrid improve power quality for the facilities it serves?

☒ Yes – proceed to Question 23

☐ No – proceed to Question 24

23. If the microgrid will result in power quality improvements, how many power quality events (e.g., voltage sags, swells, momentary outages) will the microgrid avoid each year, on average? Please also indicate which facilities will experience these improvements.

Number of Power Quality Events Avoided Each Year	Which facilities will experience these improvements?
~7	All on the microgrid about 2,200+ buildings

Estimated SAIFI	Estimated CAIDI
1.17	2.87

SAIFI and CAIDI Values for 2014, as reported by DPS

Utility	SAIFI (events per year per customer)	CAIDI (hours per event per customer)
Central Hudson Gas & Electric	1.62	3.74
Con Edison	0.11	3.09
PSEG Long Island	0.76	1.42
National Grid	1.17	2.87
New York State Electric & Gas	1.34	2.97
Orange & Rockland	1.19	2.4
Rochester Gas & Electric	0.85	2.32
Statewide	*0.68*	*2.7*
Source: New York State Department of Public Service, Electric Distribution Systems Office of Electric, Gas, and Water. June 2015. 2014 Electric Reliability Performance Report, accessed at: http://www3.dps.ny.gov/W/PSCWeb.nsf/All/D82A200687D96D3985257687006F39CA?OpenDocument.		

G. *Other Information*

24. If you would like to include any other information on the proposed microgrid, please provide it here.

A. The hospital wants to execute a 100K square foot addition project. National Grid is running out of power in the area for this to occur. This microgrid and its CHP assets would negate the distribution impact allowing the utility to offset expenses. This growth scenario and the future existence of the microgrid will allow for utility cost outlay deferral opportunities.

B. OCRRA is a unique facility and it would be a stranded asset without this microgrid, if there was ever an event where as natural gas utility was lost OCRRA could be brought up to generate 39 megawatts feeding ~30% of Syracuse with power by itself. This is a unique asset not included in most other grids. The ability to use waste to energy as prime mover fuel. We could possibly install a 2 MW solar PV array at OCC as a community solar project. And use all that power during microgrid mode to support the microgrid's loads.

C. OCC has a large campus and offers great space to install solar PV and future CHP units. This offer an opportunity for the knowledge transfer and project-educational component that many public funding opportunities seek.