

51 - City of Troy (RPI Samaritan)

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NY PRIZE STAGE 1 FEASIBILITY ASSESSMENT

FINAL REPORT



CITY OF TROY

NYSERDA AGREEMENT NO. 64607

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SUBMITTED BY COGEN POWER TECHNOLOGIES

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EXECUTIVE SUMMARY

PROPOSED MICROGRID CONFIGURATION

The microgrid to serve downtown Troy could include the following facilities: Rensselaer Polytechnic Institute (RPI), Samaritan Hospital, the Troy Housing Authority, Kennedy Towers, and City of Troy Fire Station #5. This location was highlighted in the Opportunity Zones map provided by NYSERDA on the NY Prize website.¹ A third party financing entity or Cogen Power Technologies (CPT) will be the owner of the CHP Plant generating the power and the cables, conduits, and other equipment necessary for providing each of the customers behind RPI's meter with electricity. National Grid will own the cables, conduits, and necessary electrical equipment to provide the CHP generated power to Samaritan Hospital.

The proposed microgrid configuration is to install a new Combined Heat and Power (CHP) Plant in the existing RPI Boiler House to provide electricity to all customers, and steam to the existing RPI distribution system. The CHP Plant will be comprised of one 7.9 MW Gas Turbine Generator (GTGs) that will operate on natural gas during normal operations but have dual fuel capabilities in times of natural gas curtailment. The existing backup No. 2 Fuel storage on RPI's campus has enough capacity to run the CHP system for two days without any refills or daily deliveries.

Electricity will be generated at the CHP Plant on RPI's campus, and then be distributed to the microgrid customers through underground concrete duct banks and cables. Steam generated by the CHP Plant will serve the existing RPI steam distribution system. The microgrid is anticipated to produce 63,526,000 kWh or 96.64% of total electricity annually for these four facilities with the remainder of power imported through National Grid. This system will remove approximately 8 MW of demand from the utility system. With an electric reduction of this magnitude on the distribution system, the utility will have more capacity for other customers on the National Grid utility system.

The microgrid capital costs for the design and construction is estimated at \$26.87M², with an estimated annual savings range of \$1.4-2.3M assuming all microgrid customers participate. The capital cost of \$26.87M does not include any anticipated costs for financing of the project through a third party entity.

¹ Accessed at <http://www.nysenda.ny.gov/All-Programs/Programs/NY-Prize/Opportunity-Zones-Map>

² 2016 dollars

NY PRIZE BENEFITS

The City of Troy microgrid is an ideal candidate for selection for NY Prize for several reasons. NY Prize seeks to demonstrate the viability of microgrids as an important component of a critical infrastructure resiliency strategy.

High among the list of metrics that are important for consideration in microgrids are those having to do with the value proposition. Outside of a handful of economic sectors (such as data centers, financial transactions processing, and high value-added manufacturing) most private, non-profit, and public institutions do not rigorously account for the value of energy resiliency at their site when making capital investment decisions.

NY Prize requires that at least one site involved be a critical infrastructure customer: All winning projects must be integrated into utility networks and serve multiple customers, including at least one "critical infrastructure" customer, such as a hospital, police station, fire station or water treatment facilities.³ At this stage of market development, once critical infrastructure component is met, microgrids that offer the greatest value proposition to customers are those that present the most attractive economic return.

Hospitals have a strong incentive to maintain reliability under any circumstances. Many hospitals are under intense pressure to reconcile increasing costs with diminished revenue streams. In order to stay viable, hospitals must invest in the latest revenue producing capital equipment so as not to fall behind in the battle to continue to attract patients and top physicians. As a consequence of this competition for capital, investments in high efficiency energy saving equipment and systems often fail to make the top list of a hospital's capital plan. For example, their management is more likely to see new radiology equipment as a better value proposition than a supplement to the physical plant. With such a scenario, under-investment in the physical plant leads to inefficiencies in operation, lost opportunities for income statement savings, and sub-optimal decisions on resiliency investments.

This project is exceptional insofar as it permits Samaritan Hospital, Kennedy Towers and the fire station to take advantage of the CHP system that would be physically located on the grounds of RPI. The resiliency and economic benefits of CHP would be extended beyond the RPI campus, to serve the hospital as well as the fire station and the low income senior community at Kennedy Towers.

³ Source: Governor Cuomo's press release announcing NY Prize Stage 1 Winners. July 8, 2015 at <http://www.nyserda.ny.gov/About/Newsroom/2015-Announcements/2015-07-08-Governor-Cuomo-Announces-Awards-to-83-Communities-to-Support-Clean-Energy>

RPI could pursue a Combined Heat and Power (CHP) investment independent of the inclusion of Samaritan Hospital, but Samaritan Hospital would likely not pursue a CHP project on its own. This microgrid project provides an exceptional opportunity for pairing customers with significant complementary load profiles and unlocks greater economies of scale. This brings costs low enough for the value proposition of the microgrid to be within Samaritan's requirements.

Samaritan is already planning for a large expansion of their facility and this will create requirements for additional power. The hospital has an existing, and now growing, need for generation resources to insure continuity of services during unplanned extended power outages. Such requirements are often met with the use of emergency and backup generators. However, it's become increasingly evident that relying on rarely used emergency generation to provide ample power during longer-term outages may be a risky strategy for several reasons:

- ~ Unexpected equipment failures
- ~ Availability of diesel fuel . refueling in impacted areas during emergencies may be difficult or impossible and this puts constraints on run times
- ~ The percentage of loads served by emergency power may be far less than what would be desired. To have a really well functioning hospital one has to invest in onsite generation significantly beyond the code requirements

Continuously operated CHP (and other forms of DER, including microgrids with CHP) are a superior choice for providing resiliency services. In addition to providing more resilient power, CHP can provide an economic return to the site owner. Whereas emergency and backup generators are akin to an insurance policy . you buy them and hope you never use them. Properly designed, configured, and operated DER systems assure with a very high probability a continuity of energy services when the power grid is out of service. Combined heat and power (CHP) in particular, provides heat resiliency+as a byproduct of greater electric power reliability at a site.

During Superstorm Sandy evacuations took place at several hospitals including Palisades Medical Center, Bellevue Hospital, Coney Island Hospital, and NYU Langone Medical Center. Hurricane Irene in August 2011 forced the evacuation of Johnson Memorial Medical Center in Stafford, CT.

Though emergency and backup generator failures are not the norm, their performance may warrant more detailed analysis as to whether or not they are proving a high enough reliability factor for critical healthcare facilities such as

hospitals and nursing homes. Even if generators operate flawlessly, they often do not provide important habitability needs (heating, cooling). In contrast, CHP systems can provide electricity and heat resiliency to a site . and can serve far more of the energy demands than the emergency generators typically handle.

UTILITY INVOLVEMENT

The City of Troy microgrid provides a unique opportunity for developing and testing the necessary systems and processes for National Grid to become a microgrid platform provider in New York State. The microgrid system owner/operator (whether it be Cogen or a third party entity) will work with National Grid and the Department of Public Service (DPS) staff to think creatively on how to integrate the team to create the most beneficial learning scenarios from this installation. The DPS will be in a unique position to be more directly involved in any potential utility services associated with this installation.

The City of Troy microgrid project has the potential to benefit from the National Grid Reforming the Energy Vision (REV) demonstration project in Potsdam, NY. One particular opportunity would be associated with metering and billing. Since National Grid already has existing metering and billing practices in place for the proposed microgrid customers, this would create a new utility revenue in the form of service fees. For this particular project, it is possible for National Grid to be the service provider of billing and financial transaction services.

Additionally, a significant issue remains regarding the ownership of the Medium Voltage (MV) switches and step down transformers at Kennedy Towers and Fire Station #5 facilities/substations. There would be a financial burden for the existing National Grid unit station services to be removed and replaced with a privately owned facility substation. Also, there are significant space constraints to install an additional station service in parallel. This project would be an opportunity to work out a structured procedure to buy, rent, or lease the facility substations from National Grid. This could create another new utility revenue in the form of monthly fees and save the project the associated debt service to buy out the utility or replace with new.

Lastly, while this microgrid project would potentially eliminate some revenue streams from National Grid in terms of lost electrical customers, there is the additional revenue stream created to supply fuel to the CHP Plant from the National Grid natural gas distribution system. This project presents an opportunity to demonstrate revenue balancing implications between the two utility services (electrical vs. natural gas) to clearly show an overall financial impact to the utility

company. A more holistic approach to microgrid services should look at all levels of potential revenue to the utility company.

A critical concept for the future viability of microgrids is the development of a transparent mechanism for generation owners to sell power to connected loads within the microgrid, while using the existing utility distribution. The sale of power and energy has to be set at a rate that allows for an economic return to the microgrid project. When the best course of action is to use existing utility wires, there must be a provision for microgrid developers to access that opportunity. It is in the best interest of ratepayers and society as a whole that some fair accommodations be met that would permit the microgrid the use of the existing distribution system, rather than incurring the full burden of the cost of building new and redundant systems. The utility ought to receive a fair compensation, a fair distribution wheeling rate for providing this service.

EXPLORING OPPORTUNITIES FOR TESTING REV CONCEPTS

The projects selected for NY Prize can and will provide information for refining the concepts and the regulatory structures that will be the future foundation for New York State's Reforming the Energy Vision (REV). Maximizing the value of Distributed Energy Resources (DER) as dynamic assets serving the grid requires new systems that integrate traditional utility tools such as DMS and SCADA systems, and leveraging existing and emerging utility databases and other systems such as Computer Information Systems (CIS), Utility Outage Management Server (OMS) and Advanced Metering Infrastructure (AMI).

As this project proceeds, the development team will make a concerted effort to collaborate with National Grid (NG) to identify and test new market concepts. As one example, there has been some discussion of National Grid hosting a pilot that might include collection of detailed information regarding the interaction of a microgrid with the distribution system for the purpose of developing a knowledge base that can optimize distributed energy management, grid operations, and planning.

Should this project be fortunate to be selected the inclusion into NY Prize Stage 2, the team suggests building into the design, to the extent feasible and cost justified, an analysis of the value of DER. That is an empirical analysis of the value of distributed energy resources, that may provide lessons learned, generalizable to the larger REV process. The following quotes from various Commission orders, demonstrates that establishing a sound rationale and empirical basis for LMP is integral to the entire REV process:

The Commission has stated that achieving a more precise articulation of the full value of distributed energy resources (DER) is a cornerstone REV issue.⁴

The development of the tools and methodologies required to fully implement an approach [for valuation of DER] on the value of Dqs likely a long term effort.⁵

The value of Dq can include load reduction, frequency regulation, reactive power, line loss avoidance, resilience and locational values as well as values not directly related to delivery service such as installed capacity and emission avoidance.⁶

The value of Dqtakes different forms and values depending on the application. For example, the first major application for the value of Dqis valuing alternatives to long term investments such as traditional utility investment, investment in DSP infrastructure and non-wire alternatives. A second application is compensation mechanisms, which includes rate design, LMP+D payments, as the basis for the transition from NEM.⁷

As a test case for the REV, this project offers a set of challenges that are problems that can be solved from an engineering standpoint, rather, these are issues of regulation and policy that need to be sorted out in an equitable fashion. This project is ideal in that it meets all tests of engineering and financial/economic viability, while presenting an opportunity to create and standardize a set of fair market rules that bridge the interests of the utility, the end-users and society's best interests. These are development concepts that are central to furthering the REV vision.

For each of the REV goals, below is a summary table outlining how this project would address each of the items:

⁴ NYS PSC, Case 15-E-0082, Proceeding on a Community Net Metering Program, Order Establishing a Community Distributed Generation Program and Making Other Findings, (July 17, 2015) p. 24 (CDG Order)

⁵ NYS PSC, CASE 15-E-0751, In the Matter of the Value of Distributed Energy Resources, Dec 23, 2015, Attachment A Page 1

⁶ NYS PSC, NEM Interim Ceilings Order, p. 9.

⁷ NYS PSC, CASE 15-E-0751, In the Matter of the Value of Distributed Energy Resources, Dec 23, 2015, Attachment A Page 3

REV Goal	Advancement of that Goal
Cutting Greenhouse Gas Emissions 50% by 2050	<p>" Large scale combined heat and power (CHP) is core to the project providing significant efficiency benefits</p> <p>" 8 MW CHP Plant will save 13,295 tons per year of CO₂equivalent (equal to 2,516 passager vehicles)</p>
Making energy more affordable for all New Yorkers	<p>" Extending the RPI system to Samaritan allows the Hospital to capture the benefits of CHP without having to build their own plant, reducing CAPEX needs</p> <p>" Economies of scale: allows design of larger, more efficient system to serve a hospital, a low income senior center and fire station in addition to RPI</p>
Improving our existing initiatives and infrastructure	<p>" Located in Troy, proximity allows for easy evaluation by, and collaboration with, NYSERDA and PSC</p> <p>" An ideal location for setting up a test case for several new and innovative features that REV is intended to explore</p> <p>" Private investment in high efficiency generation that frees up capacity extending the productivity and capabilities of the existing distribution system.</p>
Helping clean energy innovation grow	<p>" Creates an opportunity to examine new and innovative financing structures, e.g. a non-profit, third party financing model that could significantly lower the cost of capital improving economic viability</p> <p>" Unlocks a novel approach to energy management for hospitals who have been reluctant to embrace CHP as an alternative to backup generators</p>
Building a more resilient energy system	<p>" Provides cost effective resiliency for a large university, major hospital, and LMI residential tower (whose tenants are likely to shelter in place)</p> <p>" Dual fuel CHP systems will be able to completely island from utility in cases of grid outage or gas curtailment</p>
Creating new jobs and business opportunities	<p>" NY Prize funding enables a significant expansion, beyond the RPI campus, at a modest incremental cost, to meet an important REV objective of serving low and moderate income (LMI) customers, as well as the hospital and critical city services.</p>

RECOMMENDED REGULATORY AND POLICY CHANGES

The known regulatory and policy changes that would need to be evaluated and resolved for this project to proceed include those that lie with National Grid. After preliminary discussions with the utility and receiving feedback on a series of questions regarding the existing system, a list of the regulatory hurdles are below:

- 1) Rights of Way for crossing public roads
- 2) The aggregation of multiple electric services
- 3) Buying or leasing existing utility equipment
- 4) Utilizing existing National Grid infrastructure to export power to Samaritan Hospital

In 2008, issues one and two identified above were successfully overcome by Cogen Power Technologies and National Grid at the Burrstone Energy Center CHP Plant, located in Utica, NY.

SECTION I

TASK 1: DEVELOPMENT OF MICROGRID CAPABILITIES

SUBTASK 1.1 MINIMUM REQUIRED CAPABILITIES

The microgrid to serve Troy will include the following facilities: Rensselaer Polytechnic Institute (RPI), Samaritan Hospital, Kennedy Towers and Troy Fire Station #5. An aerial map of the proposed microgrid is included in Appendix A.

RPI, Samaritan Hospital and Troy Fire Station #5 can all serve as critical facilities in the event of a natural disaster or prolonged utility outage. The population of Troy, NY is approximately 49,910 people⁸. In the event of a natural disaster, the various facilities on RPI's campus could house multiple members of the community to provide a safe, energized facility of refuge. In addition to RPI's campus being able to house community members, neighbor Samaritan Hospital will be available to provide full medical services to the Troy community and additional nearby towns and villages. Samaritan Hospital has the capability to serve 100% of Troy's population, with an estimated 150,000 total population served by the hospital. Lastly, Troy Fire Station #5 is the largest and main fire station to serve the City of Troy.

The primary generation source for the microgrid will be one (1) dual-fuel Solar Taurus 70 gas turbine generator (GTG) exhausting to a duct-fired heat recovery steam generator (HRSG). The GTG is capable of generating an average of 8 MW of electricity to be distributed within RPI and to the microgrid customers. The GTG and duct burner will be fueled with natural gas. During periods of gas curtailment, the GTG only will be fueled by No. 2 fuel oil. RPI has 40,000 gallons of existing fuel oil storage capacity available.

The GTG will be operating and supplying power to the RPI electrical distribution system, which will normally be grid-connected. When the system is disconnected from the grid, it will be powered by the GTG operating in islanded mode.

When required, the microgrid can be intentionally separated from the utility grid, shed load, as required, and operate in islanded mode.

Under control of a Load Management System (LMS), the microgrid will have the capability to automatically separate from the grid on loss of utility power, shed load, as required, and operate in islanded mode. When normal utility power is restored, the LMS can automatically synchronize the generator to the grid and

⁸ July 2014 population of Troy, NY cited from the U.S. Census Bureau.

restore the shed loads. The exception is the Samaritan Hospital load which during the islanded mode will be manually switched to connect the load to the microgrid. When utility power is restored this load will be manually switched back to the utility supply.

Maintenance of the GTG will be provided under the manufacturer's extended service agreement, which includes OEM recommended preventative maintenance service inspections, parts and components, remote monitoring, reporting and troubleshooting, and on-site trouble calls. When an engine overhaul is required after 30,000 operating hours, a refurbished engine will be provided on an exchange basis to reduce the duration of the maintenance outage.

When connected to the grid, power generated by the GTG will be used for displacement of the microgrid utility load. Generator output in excess of the microgrid demand will be exported to the National Grid system. When islanded, the LMS will control the output of the generator to follow the system load and maintain voltage within the limits of ANSI C84-1 standards. Non-essential load will be shed to ensure that the islanded system load does not exceed the capacity of the generator.

It is expected that two-way communication between the microgrid and National Grid could be either Direct Transfer Trip (DTT) or Remote Terminal Unit (RTU). At this phase of the microgrid study, the communication requirements from National Grid have not been identified. However, the CHP Plant will have the full capabilities to meet DTT or RTU requirements from the utility.

The microgrid can provide power to potentially four (4) different facilities in Troy. The diversity of customers includes a university, hospital, low income housing unit, and a fire station. The mix of ownership includes the private university (RPI), a hospital network (St. Peter's Health Partners), the Troy Housing Authority, and the City of Troy.

The GTG will operate on natural gas during normal operations. However, as a dual fuel unit, it will be able to operate on No. 2 fuel oil during times of natural gas curtailment. Without natural gas, steam generation in the HRSG will be limited to the unfired capacity as capability of supplemental firing with liquid fuel will not be included on this unit. The existing RPI boiler will fire No. 2 fuel oil, as required, to meet the remaining steam load. The 11th Street Boiler House has a 40,000 gallon fuel oil storage tank allowing the Combined Heat and Power (CHP) Plant and the RPI boiler to operate for extended periods when no natural gas is available. For example, assuming that a natural gas curtailment occurs during a cold winter

period where the average steam demand for RPI is 80,000 lb/hr, the HRSG will generate 35,000 lb/hr, requiring the RPI boiler to produce the remaining 45,000 lb/hr. The total fuel oil consumption for the RPI boiler and CHP Plant would be 26,000 gal/day. The CHP Plant and the RPI boiler would be able to provide all of the thermal energy required for RPI and the electrical energy required for the microgrid with the necessary load shedding in effect. RPI will attempt to secure uninterruptable gas supply or increase oil storage capacity, if required, to ensure one week of fuel oil supply on-site.

Forces of nature typical to the Troy area include heavy precipitation, lightning and high winds associated with severe weather conditions. This could lead to downed power lines, flooding in some areas and travel disruptions due to heavy snow accumulations. Ice jams in the Hudson River during the spring thaw can also lead to flooding in some parts of Troy.

The location of the CHP Plant will be at the existing, well maintained, RPI 11th Street Boiler House. The GTG, Gas Compressor and Black Start Diesel Generator (BSDG) will be located outdoors in acoustic weather-proof enclosures. The HRSG and related auxiliary equipment will be located inside the boiler house. Electricity generated by CHP Plant will be delivered to the RPI campus and the microgrid customers through electrical duct banks. Electrical distribution equipment at RPI is located inside buildings or in weather proof enclosures. These features will protect against disruption of services due to severe weather conditions. Steam generated by the CHP and the RPI boiler will be distributed throughout the campus by piping routed through underground tunnels campus buildings providing protection from severed weather conditions.

The flood level for the Hudson River at Troy is 29.7 feet above mean sea level (amsl). Included in Appendix B is a list of historic Hudson River crests and recent crests for Troy from the National Weather Service database. The 11th Street Boiler house is constructed at a grade elevation of 186 ft amsl, sufficient to protect the boiler house and CHP from flooding disruptions. Flooding due to local run-off is not expected to occur due to the sloping nature of the area.

There have not been any additional weather events that have caused upsets in electrical supply to RPI for extended periods. The typical scenario would be a power dip due to a feeder issue (lightning, ice) but that in most cases is momentary and returns. In the case of an extended feeder loss (cable failure), the second feeder was available and took care of the load.

The most common weather event to disturb RPI would be extreme cold winter months and snow storms resulting in gas curtailment from the utility. When a gas curtailments and snow storm occur simultaneously, the storm often slows down the delivery of fuel oil. RPI will have less than two days of storage on-site and will require uninterruptable gas supply and delivery contracts to avoid disruption due to curtailment.

The project would include an 800 kW black start diesel generator to allow the CHP to be started and operated in islanded mode to provide power and thermal energy supply to RPI and additional microgrid customers.

The black start generator would be capable of providing sufficient power to supply the loads required to start up the GTG. The generator would supply the RPI Main Switchgear in an islanded mode. The loads of all microgrid customers would be adjusted using the LMS to ensure the remaining loads do not exceed the power delivered by the GTG.

SUBTASK 1.2 PREFERABLE MICROGRID CAPABILITIES

A state-of-the-art Plant Control System (PCS) for the microgrid CHP equipment would provide supervisory controls and monitoring of the gas turbine generator (GTG), the heat recovery steam generator (HRSG), the gas compressor and the black start diesel generator. The PCS will also control and monitor the Load Management System (LMS).

The Load Management System (LMS) is a custom logic controller-based automated system that will be used to monitor the available power supplies and loads making up the microgrid distribution system. A fiber optic network will connect the meters to the LMS to monitor these loads. If an event causes the power available to the distribution system to be less than the power required by loads connected to the system, the LMS would drop loads in accordance with a prearranged load shedding priority. This would occur when one or more utility feeds are lost and the load is greater than the power output of the GTGs. The LMS uses a high-speed automation controller to monitor and shed loads in milliseconds of an upset event.

The LMS performs the following functions in addition to load shed:

- Control the import/export of real and reactive power from the utility by controlling the output of gas turbine generator (GTG);
- Automatically shed load (with an LMS response time of 38 msec or less) upon loss of the utility;

- Automatically shed load to maintain a minimum GTG capacity reserve
- Provide manually initiated, automatic synchronization across main feeder breakers
- Provide automatic bus transfer control that will automatically close incoming breakers to restore power to either of the 13.2 kV busses 1 or 2 that has lost its supply
- The main LMS panel would connect to the microgrid data center's power monitoring system to receive load and supply information.
- Monitor and display the open / closed status and power levels of 34.5 kV and 13.2 kV breakers

The CHP Plant will be installed as an energy efficient operation to minimize any additional new microgrid generation.

The portion of the microgrid powering the Troy Fire House #5 and Kennedy Towers will be powered directly from breakers installed in the 13.2kV switchgear located at the CHP Plant. The power generated at the CHP Plant will be distributed to these two customers via underground duct bank. Power generated by the CHP Plant will be distributed to Samaritan Hospital by utilizing National Grid's newly upgraded switches in the Tibbets Street substation which will then feed Samaritan through a new underground duct bank.

Cogen Power Technologies has subcontracted the Pace Energy and Climate Center (Pace) to assist in the analysis of the Reforming Energy Vision (REV) as part of this study. Included as a part of the Pace energy analysis team are Thomas Bourgeois, Deputy Director; Daniel Leonhardt, Senior Energy Analyst; and Dr. Henrietta de Veer, Founder and Managing Partner of Adaptive Energy. Dr. Henrietta de Veer has been involved with the REV proceedings and will provide this microgrid project with the innovative ideas to embrace the REV platform. Further comments on the inclusion of REV ideas for the proposed microgrid will be addressed in the final report.

It is the responsibility of Cogen Power Technologies to provide the Facility Questionnaire and Microgrid Questionnaire to IEC to complete the CBA. These documents will be completed with respect to the microgrid customers, community, and utility. The report provided by IEC for the Cost-Benefit Analysis will be included in the final report for the feasibility study.

This project is expected to qualify for \$2.4 million from NYSERDA under PON-2701 the Combined Heat and Power (CHP) Performance Program. It is assumed that the funding available under this program is public dollars which will be used

for this project. The remainder cost of the project will be privately financed through energy investors familiar with the agreements and operations associated with a CHP Plant.

The microgrid will be powered by a Combined Heat and Power (CHP) facility using a Gas Turbine Generator (GTG) with low NOx burner technology. By displacing purchased electricity from the power grid and steam generated by gas and oil fired boilers, reductions in carbon dioxide emissions will be achieved.

The number of jobs created for operating the CHP Plant will be dependent on the operations and maintenance plan of the RPI staff as owners and operators of the plant. RPI will leverage their existing staff members to operate the plant as necessary but may need to hire additional personnel.

The existing power grid will be strengthened by the microgrid due to the reduced load stress on the utility's system. The innovative technology of the LMS and PCS system will be utilized to monitor the electrical systems of the entire microgrid.

SECTION II

TASK 2: DEVELOP PRELIMINARY TECHNICAL DESIGN COSTS AND CONFIGURATION

SUBTASK 2.1 PROPOSED MICROGRID INFRASTRUCTURE AND OPERATIONS

The Combined Heat and Power (CHP) Plant, the distributed energy resource (DER) for this microgrid, is located at the Rensselaer Polytechnic Institute (RPI) 11th Street Boiler House along with new switchgear for connection to the campus electrical system and distribution to nearby microgrid customers. The switchgear for the utility interconnection is located at the parking garage on the south side of the main RPI Campus. The switchgear for the distribution of electricity to Samaritan Hospital, is located at National Grid's Tibbits substation located on Tibbits Avenue, south of the main RPI Campus. The Microgrid Layout showing the locations of these facilities and the microgrid customers is included in Appendix A. The proposed microgrid electric cable layout diagram is included in Appendix C. The equipment layout diagram for the new CHP plant is included in Appendix D and the simplified electrical single line diagram of the proposed microgrid is included in Appendix E.

The CHP plant will operate continuously at full load to supply electricity to the microgrid and steam to the RPI campus. Excess electricity would be exported to the utility grid continuously, and supply Samaritan Hospital with the exported power.

When the microgrid electrical load is high, the GTG would operate at full output with additional load supplied by import power from the utility. When the microgrid load is low, the GTG will still operate at full load and any excess power will be exported to the utility. The exported power will then be consumed by Samaritan Hospital. The economic recovery mechanism for the exported electricity will be developed as a part of NYPrize Stage 2 with NYSERDA, the Public Service Commission and the utility (i.e. selling wholesale, net metering, etc.).

Steam generated by the CHP would be distributed to the RPI Campus using the existing steam distribution system. Steam output from the HRSG can be increased by firing the duct burner. It is expected that the RPI steam load will at times be less than the unfired steam output of the HRSG. A small portion of excess steam will be vented or condensed in an air-cooled condenser.

The existing steam boiler at the 11th Street Boiler House would be maintained in hot standby mode when the CHP Plant is in operation to allow for fast pickup of

the total steam load in the event of the CHP unit tripping out of service. The existing heating equipment would have adequate capacity to supply the full RPI heating load when the CHP unit is not available during scheduled maintenance or forced outages. The secondary boiler plant, on People's Avenue could be repurposed once the CHP Plant is in operation.

The CHP Plant will operate at all times when available. Scheduled maintenance will be planned for off-peak electricity rate periods when possible and extended maintenance outages will be planned during periods when risk of severe weather conditions are low. This maintenance scheduling strategy would reduce the impact on plant demand charges and improve plant efficiency by continuing to minimize the steam generation from the existing less efficient RPI boiler.

The normal electrical configuration of the microgrid is two load groups connected to the utility at the National Grid substation. Load group A consists of RPI with the new GTG, Troy Fire Station #5 and the Kennedy Towers. Troy Fire Station #5 and the Kennedy Towers will be connected behind the RPI utility meter. Load group B consists solely of Samaritan Hospital. Each group is connected to the utility at the Tibbits substation A and B feeds and switchgear.

For emergency conditions:

Upon the loss of the utility feeds, circuit breakers in the RPI garage substation load group A will be opened, isolating group A from the utility and, the Load Management System (LMS) would automatically shed facility loads connected to selected busses such that the GTG can operate in islanded mode with the remaining load. The LMS would have computational characteristics and would determine the priority scheme of shedding breakers such that the generator would not be overloaded and at the same time would have some spinning reserve to support starting of certain loads.

Initially load group B would be run independently from load group A upon the loss of the utility feeds and would rely on existing emergency systems to provide power to critical loads. If the utility power loss extends for a longer time period, the utility switches at the Tibbits substation will be manually opened and load group B will be synchronized to the islanded load group A. Load group B (Samaritan Hospital) is the only other customer on the electric service that also feeds RPI.

Upon restoration of the utility feed, the utility switches at the Tibbits substation will be closed and the LMS would synchronize the load group A distribution system with the utility through the incoming breakers at RPI. Load group B will be

manually isolated and then resynchronized to the utility through the incoming breakers at the RPI garage substation. After the two groups are re-synchronized, the facility distribution system would revert to normal operation with the gas turbine generator running in parallel with the utility.

In the event of the GTG being off-line or a turbine trip during a utility outage, the black start generator would start up automatically on a dead bus to supply the emergency CHP loads and power required to start the gas turbine generator. The automatic start would be initiated by its own synchronization panel. During the time when the GTG is off-line and there is a utility outage, emergency loads at each of the facilities connected to the microgrid distribution system would rely on its own emergency systems for power.

SUBTASK 2.2 LOAD CHARACTERIZATION

The microgrid electrical load includes all of the loads of RPI and the microgrid customer facilities. The monthly and annual loads are summarized in Table 1 of Appendix F giving average, minimum and maximum for each facility. These loads are presented graphically in Chart 1 in Appendix F. The monthly and annual electrical consumption for the individual facilities and the entire microgrid are provided in Table 2 of Appendix F.

The microgrid thermal load includes only the steam generated for the RPI campus. Chilled water for cooling in the RPI campus is produced by electric motor-driven centrifugal chillers. Two 500 ton single-effect absorption chillers will be added to the chilled water system to better utilize steam generated by the CHP HRSG and reduce the RPI electrical load, making more generated electricity available to the microgrid. Steam and chilled water will not be provided to the other microgrid customer facilities.

The microgrid monthly and annual thermal loads are summarized in Table 3 in Appendix F listing average, minimum and maximum for the system. This information is presented graphically in Chart 2 in Appendix F.

Chart 3 in Appendix G shows the combined electrical load profile for the RPI-Samaritan Microgrid for one year. The thermal loads (steam and chilled water) for the RPI campus were provided by RPI on a one-hour interval basis from their Process Information System. Electrical loads for RPI and Samaritan were provided on an hourly basis from National Grid. Electrical loads for Fire Station No. 5 and John F. Kennedy Towers were provided on a monthly basis in the form of the utility bills.

Chart 4 in Appendix G shows the steam load profile for the RPI Campus for one year. The loads were provided by RPI on a one-hour interval basis from their Process Information System.

The average microgrid electrical load connected to the RPI substation will be 5.9 MW, with a peak of 9.8 MW. By adding 1,000 tons of absorption chiller capacity, replacing electric motor driven centrifugal chillers, the average load drops to 5.7 MW and the peak is reduced to 9.1 MW. Although Samaritan Hospital is not connected to the RPI substation, it will be part to the microgrid and will have an average electrical load of 2.8 MW with a peak of 4.8 MW. The intent is to wheel electricity generated by the CHP Plant to Samaritan Hospital to meet all or part of the load there. This results in a combined microgrid average load of 8.7 MW with a peak of 14.0 MW. With the effect of the absorption chillers, the average load will be 8.4 MW with a peak of 13.4. Any excess electricity generated at times of low microgrid demand will be available for export to the utility grid.

Average output of the CHP will be around 7.3 MW, about 83% of the microgrid average load. However, output will at times be limited by low demand on the system. During these times, all power will be exported to the utility/Samaritan Hospital.

Under normal conditions when the microgrid load exceeds the capability of the CHP, additional electricity, as required, will be imported from the electrical utility feeds to Samaritan Hospital and RPI. If the GTG is down for maintenance or emergency repairs, all electricity required for the microgrid will be imported from the utility.

During emergency conditions where the electrical utility is unable to deliver electricity to the microgrid, the CHP will island from the system and generate electricity to meet the demand of the microgrid up to the full load output of the GTG. Loads in the RPI Campus will be shed as necessary to ensure that the microgrid demand will not exceed the capability of the GTG. Samaritan Hospital will rely on emergency systems until manual switching at the National Grid substation connects the hospital to the microgrid. Based on average annual loads, the CHP could meet about 75% of the RPI load while satisfying 100% of the loads of the microgrid customers.

It should be noted that during a major emergency event, most facilities would not be maintaining ~~business as usual~~. This would lead to a natural reduction in electrical load, apart from load shedding.

Regular maintenance outages of the GTG would be planned for periods when natural disasters are least likely to occur. If the GTG were to trip during an emergency condition, the facilities connected to the microgrid would rely on their emergency power systems for critical loads.

SUBTASK 2.3 DISTRIBUTED ENERGY RESOURCES CHARACTERIZATION

Type	Rating (kw/Btu)	Fuel
Combined Heat and Power	7.6 MW/34 MMBtu	Natural Gas (primary) No. 2 Fuel Oil (secondary)

The Distributed Energy Resources (DER) for the RPI-Samaritan microgrid will include a combined heat and power (CHP) facility located in the existing steam generating plant, RPI's 11th Street Boiler House, and connect to RPI steam distribution system also supplied by the Sage Avenue Boiler House.

The 11th Street Boiler House has one (1) dual fuel steam boiler which can generate 70,000 lb/hr of saturated steam at a pressure of 100 psig while firing natural gas or No. 2 fuel oil. Auxiliary systems in the Boiler House, shared with the CHP include, a makeup water treatment system, a condensate return system, a boiler feedwater system and fuel oil storage and pumping system.

The CHP will include one (1) dual fuel gas turbine generator (GTG), discharging exhaust gases to a heat recovery steam generator (HRSG) equipped with a gas-fired duct burner. The GTG is nominally rated at 8 MW but at site conditions will typically generate 7.6 MW at the generator terminals. The HRSG can generate 32,800 lb/hr of steam with no duct firing but is rated for 70,000 lb/hr of steam with maximum duct firing. Steam will be delivered from the HRSG at a pressure of 100 psig at saturated conditions.

In addition to the boiler, the 11th Street Boiler House includes space for one additional boiler with room for building expansion to the east to allow for addition of a third unit. For the CHP addition, the HRSG will occupy the area designated for the second boiler and the GTG will be installed outside of the building in a weather proof enclosure. The location of the CHP is indicated on the simplified microgrid layout in Appendix D.

Under normal conditions, the CHP will operate, firing natural gas, connected to the utility and generating most of the power required by the microgrid. The utility will supply additional electricity as needed. The steam demand of the RPI

Campus will be met with steam generated by the HRSG using duct firing, as required, up to the maximum HRSG capacity. If additional steam is required, it will be generated by the boiler in the 11th Street Boiler House. The boiler will be kept on hot standby to serve as the backup steam supply in case the CHP GTG trips.

In the event of gas curtailment or a disruption of the gas supply, the GTG will continue to operate, firing No. 2 fuel oil but the HRSG will be limited to its unfired steam output. The dual fuel boiler also firing No. 2 fuel oil, will fire up and increase output, as required to meet the RPI steam load.

On loss of the utility electricity feed to the microgrid, load shedding will be implemented, as required, and the GTG will switch to islanded mode. Some manual switching will be required in the National Grid substation to isolate Samaritan Hospital from the utility, allowing it to be supplied from the islanded RPI CHP. Natural gas will continue to be the primary CHP fuel, as long as it is available but switch over to liquid fuel will occur, if required. The steam generation strategy of the CHP and boiler will remain the same.

During the time when the GTG is off-line and there is a utility outage, emergency loads at each of the facilities connected to the microgrid distribution system would rely on its own emergency systems for power.

The operation of the CHP and the 11th Street boiler is not expected to be impacted by forces of nature. All of the critical equipment is located indoors or in suitable enclosures, protected from high winds and precipitation. Due to the elevation of the site, flooding has not previously occurred and is not anticipated in the future.

The primary fuel for the CHP is natural gas, delivered through an underground piping network and supplied by a system of underground pipelines. Disruptions in the gas supply are rare but can occur and could be precipitated by a natural disaster at some point along the supply system. Gas may be curtailed from time to time due to heavy demand or shortage of supply but since RPI will have firm gas contracts for the facility, disruption periods are expected to be limited to less than one day.

The backup fuel for the CHP and the 11th Street Boiler House is No. 2 fuel oil stored in a 40,000 gallon underground tank at the Boiler House. This is sufficient fuel storage to operate the CHP for at least 2 days. Without being refilled, a contract with a local fuel oil supplier would be established to produce daily fuel deliveries during the outage. Additional fuel will be available for steam generation

from the boiler, however, for periods with very high steam demand, steam generation by the boiler may be limited by liquid fuel available in storage and some non-critical steam loads would be limited or shutdown.

In the event of loss of grid power along with the shutdown (trip) of the CHP generator, a black start diesel generator will be available to restart one of the GTGs and the auxiliary equipment needed to operate the HRSG. Sufficient power would then be available to operate the RPI boiler. During the time when the GTG is off-line and there is a utility outage, emergency loads at each of the facilities connected to the microgrid distribution system would rely on its own emergency systems for power.

The GTG is capable of part load operation from 50% load to 100% load allowing it to load-follow over a wide range. Under normal conditions, when the electrical load exceeds the combined capacity of the GTG, the GTG will operate at full load and load variations will be accommodated from the grid supply. If the load is less than the capacity of the GTG, the excess output of the GTG is available for export from the CHP to the utility. Exporting of electricity will be limited to periods when the price paid for electricity is greater than the cost to generate or if necessary to ensure the GTG does not operate at less than 50% load.

The HRSG steam generation can be varied between the unfired output to fully fired output by modulating duct burner firing between 0 and 100%. The 11th Street Boiler can operate between 10% and 100% output. When the steam load exceeds the fired capacity of the HRSG, the duct burner will fire at 100%. Variations in the steam load will be followed by regulating the steam output of the boiler. When the steam load is less than the output of the fully fired HRSG, the boiler will not be operating but will be maintained on hot standby and the steam output of the HRSG will be controlled by regulating the duct burner firing rate. If the steam load falls below the unfired output of the HRSG, excess steam will be vented or condensed in an air-cooled condenser.

The microgrid's voltage and frequency are not expected to vary greatly from nominal as there are many loads and none of the loads are large enough to have any great effect on the voltage and frequency during load start-up or being taken off line. When connected to the utility, the microgrid's voltage and frequency will be controlled by the utility grid. When in islanded mode, the generator AVR and frequency control system will regulate the voltage and frequency and will be able to ride through voltage and frequency deviations. In an emergency event, if the voltage or frequency were to deviate largely from normal, the generator protection relays will shut down the system.

SUBTASK 2.4 ELECTRICAL AND THERMAL INFRASTRUCTURE CHARACTERIZATION

Electrical Infrastructure

The City of Troy microgrid area is currently fed by multiple voltages and National Grid feeders. The RPI Campus Substation is currently fed from National Grid's sub-transmission 34.5kV distribution system. The incoming feeders are connected to the substation via circuit breakers. Electronic relays provide overcurrent and re-closure functionality and power meters provide power metering parameters.

Samaritan Hospital is currently served from two 13.2kV distribution feeders but will be served from the same two 34.5kV sub-transmission taps as RPI as a result of the hospital's proposed expansion in time for the microgrid implementation. The proposed expansion includes the installation of two 34.5 kV to 13.2/7.62 kV step-down transformers at the incoming Samaritan substation. Electronic relays provide overcurrent and re-closure functionality and power meters.

The Kennedy Towers and the Troy Fire Station #5 are currently fed at 4.16 kV. National Grid currently provides a 4.16kV to 120/208 V distribution transformers at each location along with revenue metering. The microgrid configuration will remove the utility feeds and two new 13.2kV to 120/208 V distribution transformers fed from the new CHP facility switchgear to provide the power from the microgrid to feed these two loads.

New 34.5 kV switchgear is currently being installed at the Tibbits Avenue substation by National Grid which will allow the two load groups to be connected to the utility's North Troy feeders Tibbits #2 and #7.

Thermal Infrastructure Description

The RPI thermal energy infrastructure serves only the RPI Campus. Other electrical consumers on the microgrid will not be connected to the thermal energy distribution systems.

Steam is distributed from the 11th Street and Sage Avenue boiler houses through a network of underground piping and piping running through underground tunnels and campus buildings. The condensate system has a similar network returning condensate back to the boiler houses.

Chilled water for the RPI campus is produced in the main chiller plant and by various chillers located in various building around the campus. All chillers currently operating are electrical motor-driven centrifugal chillers.

Electrical infrastructure associated with delivery of CHP generated electricity to the microgrid and distribution throughout the microgrid is routed underground via ductbanks. This infrastructure will not be exposed to the forces of nature as it is sheltered from severe weather conditions and the area is not prone to flooding.

All thermal energy distribution infrastructure is located in underground tunnels and campus buildings or are direct buried. These too are protected from the forces of nature.

National Grid is currently in the process of installing new 34.5 kV switchgear at the Tibbits Avenue substation which will allow the load group A (RPI, CHP, Kennedy Towers and the fire station and the group B (Samaritan Hospital Campus) to be connected to the utility's North Troy feeders Tibbits #2 and #7. No additional infrastructure is required to isolate the microgrid from the utility.

Within the microgrid boundary, the two group substations will each include two 34.5 kV to 13.2/7.62 kV step-down transformers. The incoming feeders from National Grid have a set of PTs on the line side of the CBs and sets of CTs and PTs along with utility revenue metering on the load side. Electronic relays provide overcurrent and re-closure functionality and power meters. Synchronizing to the utility will be across these breakers.

SUBTASK 2.5 MICROGRID AND BUILDING CONTROLS CHARACTERIZATION

The microgrid will be controlled from the boiler house control room which will be constantly manned by operators. If the grid supplies are lost, disconnecting from the grid will take place automatically via the protection relay system and will be sensed by the load management system which will shed the microgrid loads to match the generated supply with the remaining loads. Upon return of grid supply, the operators will be notified and they will initiate an auto-synchronization sequence via the LMS control system to close the utility breaker and reenergize any loads dropped by the LMS.

A black start generator, capable of providing sufficient power to supply the loads required to start up the GTG will be provided. The microgrid loads will be adjusted using a Load Management System (LMS) to ensure the loads remaining do not exceed the power delivered by the GTG.

The microgrid's voltage and frequency are not expected to vary greatly from nominal as there are many loads and none of the loads are large enough to have any great effect on the voltage and frequency during load start-up or being taken

off line. When connected to the utility, the microgrid's voltage and frequency will be controlled by the utility grid.

When in islanded mode, the generator AVR and frequency control system will regulate the voltage and frequency and will be able to ride through voltage and frequency deviations. In an emergency event, if the voltage or frequency were to deviate largely from normal, the generator protection relays will shut down the system.

During the design phase of the project, the system will be modelled and a protection and coordination study will be undertaken to provide the protection settings for the various protection systems throughout the microgrid distribution system.

Data logging features will take place in the CHP control system's plant historian.

The microgrid and building controls will not be impacted by severe weather. The controls will be run off its own UPS supplies fed from 125 VDC battery and charger system. Both the LMS and PCS control systems will have redundant processors.

SUBTASK 2.6 INFORMATION TECHNOLOGY (IT)/TELECOMMUNICATIONS INFRASTRUCTURE CHARACTERIZATION

The microgrid's control systems will operate on a system consisting of managed switches, various cable types and protocols. The CHP building plant control system (PCS) will allow supervisory control and monitoring of the CHP equipment from a centralized control room via operator workstations connected via a network switch. The CHP generator will have a remote workstation allowing it to be controlled locally or from the control room. The black start diesel generator, gas compressor, HRSG and the 13.8 kV and the 480V switchgear can all be controlled and monitored from the control room as well as locally.

The LMS will be connected to the PCS allowing the LMS to be controlled and monitored from the CHP building plant control system. A fiber optic communication system will connect all the microgrid equipment to the LMS system for load management signals and power monitoring. Remote IO equipment will be located at each building in the system to allow the control systems to monitor the buildings' circuit breakers' positions and to open or close the breakers. A variety of control protocols may be used such as Ethernet IP, Modbus TCP/IP and Control Net using a variety of mediums such as copper Cat

6, hardwired analog and digital points, fiber optic multi- or single mode etc. The final configurations will depend on equipment and vendors selected.

The communications between the microgrid and the utility will be in accordance with the utility procedures and protocols. A phone will be available in the operator control room to call the grid control center if communications are required.

The operation of the microgrid is not effected by any loss of communications with the utility. The grid sources are detected by the protection relays (dead bus) to determine if the grid is offline or online. If the source has been offline and the operator wishes to synchronize to the grid when the grid is reenergized, the operator may call the grid control center to confirm if it is okay to do so. Communications with the utility will be in accordance with the utility procedures and protocols.

SECTION III

TASK 3: ASSESSMENT OF MICROGRID'S COMMERCIAL AND FINANCIAL FEASIBILITY

SUBTASK 3.1 COMMERCIAL VIABILITY – CUSTOMERS

It is difficult to quantify the exact number of individuals that would be affected if these loads were to go unserved. To simply look at the available statistics for each customer, over 57,000 people could be affected. A summary table of this value is included below.

Microgrid Customer	Statistic⁹
Rensselaer Polytechnic Institute (RPI)	7,028 students
Samaritan Hospital	238 beds
Kennedy Towers	135 units
Troy Fire Station #5	49,974 community members

Ancillary services that will be provided by this microgrid include the option to black start the CHP plant. Improved operation of the utility system will be realized due to the CHP Plant generating 63,526,000 kWh or 96.64% of total microgrid load that the utility will no longer have to generate and/or provide the generated electricity to other customers. The plant will take approximately 8 MW of demand off the utility system.

All of the customers will purchase electricity only from the microgrid. Rensselaer Polytechnic Institute (RPI) will receive the steam generated from the CHP plant.

Microgrid stakeholders for the proposed microgrid would include either the third party financing entity or Cogen Power Technologies (CPT) as the stakeholder. Installation of this project would benefit each of the microgrid customers and the City of Troy population of 49,974 community members.

A third party financing entity or CPT will be the owner of the CHP Plant generating the power and the cables, conduits, and other equipment necessary for providing each of the customers behind RPI's meter with electricity. National Grid will own the cables, conduits, and necessary electrical equipment to provide the CHP

⁹ Appendix O includes references for the statistics provided in this table.

generated power to Samaritan Hospital. Once a third party financing partner is selected for this project, Cogen Power Technologies (CPT) will work with the financing entity to develop a Power Purchase Agreement (PPA) with each of the customers to recover the capital required for the project, the cost of generating power, and annual maintenance fees. CPT will work with the financier to assist in where appropriate meters should be located to ensure that proper energy measurements are recorded for billing purposes.

CPT will utilize the approach and PPAs developed and used at their Burrstone Energy Center (BEC) plant with their three customers. These documents have been used since the plant started commercial operations in August 2009.

All microgrid customers will purchase electricity from the microgrid during normal operation. During islanded operation, there are two potential scenarios which could occur:

- 1) The CHP Plant could supply 83% of total power to RPI and 100% of electric consumption to all other customers. In this scenario, the RPI would shed load to reduce its consumption.
- 2) If the CHP Plant was to provide the same percentage of power to each facility, the output is 89% to each facility. Each of the included facilities would need to shed load to reduce consumption.

As mentioned previously, the financing entity will have a PPA with these customers and will manage each of the PPAs with the individual customers. Critical load customers make up 75% of the microgrid; RPI, Samaritan Hospital, and Troy Fire Station #5. CPT will use the PPAs developed for their Burrstone Energy Center CHP Plant.

The plan for gaining customer acceptance of this project is to work with each of the customers to review the 1) potential savings, 2) reliability benefits, 3) environmental benefits, and 4) societal and community benefits which can be had from this project. It is the expectation that the savings brought forth will be enough to warrant customers to join the microgrid, however the additional customers be motivated to gain the additional reliability and community benefits as well. Preliminary discussions with the additional customers have already begun and the project has been well received.

The CHP Plant would provide 97% of RPI's annual steam demand and the new absorption chillers will produce 1,000 tons of chill water that will be used as the campus's base load during the cooling season.

SUBTASK 3.2 COMMERCIAL VIABILITY – VALUE PROPOSITION

There are a variety of benefits that this project will bring to the Troy community. The proposed microgrid will generate electricity for a private entity, a hospital, a fire department and low income housing . an ideal mix for the NY Prize competition.

In the event that there was a natural disaster or super storm to affect the area, the RPI could house their 7,000 students plus a significant number of community members in their buildings, Samaritan Hospital would be able to have full operational capabilities, the Fire Station would be able to fully operate, and the 150-300 members in the Kennedy Towers would not need to be evacuated.

Each of the facilities currently has back up generation, but only enough to maintain emergency services and not all services. The microgrid would provide additional power to the facilities to be able to operate for longer durations at full capacities.

There has been no feedback received from the utility on any benefits that would be recognized by National Grid with installation of this project. However, it is evident that there must be some system benefit. The microgrid is anticipated to produce 63,526,000 kWh or 96.64% of total electricity annually for these ten facilities. With an electric reduction of this magnitude on the distribution system, the utility will be able to distribute the power that is now not being consumed by the microgrid customers, to other customers on the National Grid utility system. In addition, total demand for this system will be reduced by approximately 8 MW in this location.

The electrical interconnection process has not been completed yet; however the cost of interconnection would be expected to be within \$250,000-\$300,000 for the microgrid. This is not firm, nor provided by the utility, only an estimate based on experience at other projects (Albany Medical Center, St. Joseph's Hospital, Union College, etc.).

There is an opportunity for the utility to obtain additional revenue from this project by selling the existing customer transformers and vaults at fair market value. Since the utility did not outline any costs that would be associated with this project, further investigations will be uncovered in Stage 2.

The proposed business model for this microgrid would be for a third party financing entity to finance the construction of the project. Prior to construction of the system, the financing firm would enter into a Power Purchase Agreement

(PPA) with each of the microgrid customers. It would be anticipated that the PPA would be contracted for a 15-20 year term. The term is typically determined by the amount of infrastructure costs that will have to be paid back by the customers over time. Although the customers will need to enter into the PPA, it is important to recognize the customers will still save money each year.

Each month, the microgrid customers would receive a bill from the microgrid owner. This bill would contain infrastructure recovery costs, CHP Plant fuel costs, and other negotiated costs. The model developed at BEC by CPT would be used.

SWOT ANALYSIS

Strengths

- Public, private, city and low income housing agencies are all included in the customer mix of the microgrid. These agencies are long term customers and will not be closing their business/operations during the 15-20 year PPA term.
- Most facilities included in the microgrid are mature organizations; therefore electricity consumption will not significantly increase/decrease over time.
- Troy Fire Station #5 and Kennedy Towers receive power from the utility at a lower voltage than the microgrid will provide. Therefore, by being electrically connected behind the RPI 34.5kV utility meter, these customers will be favored under better utility rates. Second, Samaritan Hospital will receive benefit from the power generated by the CHP Plant, not traditional electric generation.
- RPI is already a large thermal and electric consumer of energy that the additional customers are not needed to make the project realistic. However, the additional customers will increase savings for each of the customers while meeting the goals set forth by New York State.

Weaknesses

- Due to diverse customer mix (private, public, city and low income housing) there are various channels may reflect potential project delays associated with establishing commercial terms and conditions of the PPA.

Opportunities

- The development of pilot tariffs to lower the delivery costs of natural gas and electricity to microgrid customers, lower the state taxes associated with the energy consumed, and allow net metering for any excess power sold back to the utility. These potential changes will significantly increase the financial benefit the microgrid customers will realize.

- For the utility to recognize there is a system benefit of 63,526,000 kWh taken off of the existing system and this financial benefit to be shared with the microgrid customers.
- To increase the number of construction jobs in the Capital Region during the construction period.

Threats

- The potential (but rare) threat of customers withdrawing from the microgrid.
- The inversion of natural gas and electricity prices. However, with the abundance of shale gas in the region and natural gas storage levels being at an all-time high, this should not be a viable concern for microgrid customers.
- The threat of the utility deciding not to support the project and try to halt the project due to their concerns with crossing public roads and aggregation of their customers electric services.

There are several characteristics to the proposed microgrid which have been identified below:

- 1) The aggregation of Multiple Customer Services onto the RPI system behind the utility meter.
- 2) The purchase of existing National Grid assets.
- 3) Robust Load Management System which will monitor and shed loads as necessary during normal and emergency situation. There are buildings on RPI's campus that can be shed to maintain turbines in addition to each of the microgrid customers will be able to shed load at their facilities to keep the system running through a power outage.
- 4) Existing Backup No. 2 Fuel Storage at RPI's campus that has enough storage on site to run the CHP system for 2 days without any refills.
- 5) The existing bay available in the RPI Boiler House can be taken advantage of to house components of the CHP Plant.
- 6) The microgrid will provide power to a diverse customer mix of private, public, city and low income housing entities.
- 7) RPI and Samaritan Hospital are fed from the same 34.5 kV electric service with no other customers connected. These power lines are installed underground and are immune to weather events. These power lines will be used to distribute power from the CHP Plant to Samaritan Hospital during normal operations and during loss of utility power.

The CHP and microgrid technologies that we are proposing have a long track record of success have been tried and are true to success. This project is scalable because the base project includes a solid thermal host, and adding the other microgrid customers to consume electricity allows the CHP Plant Gas Turbine to

be larger which only increases efficiency, savings, and reliability. A microgrid as such will continue to remain scalable as long as the right mix of energy customers participates within a scalable physical proximity. The proposed project is a similar yet larger project than the existing Burrstone Energy Center located in Utica, NY.

The need for this project comes from the congested utility infrastructure located in Troy, NY (identified in NY Prize Opportunity Zone)¹⁰. In addition, a project of this magnitude serves many energy, policy, and societal benefits. Primarily, Samaritan Hospital will be able to operate with full capacity during a power outage to provide medical attention to community members. Additionally, the Fire Station is the main (and largest) fire department of Troy, therefore full operational capabilities of this facility are critical to the community. Members of the Kennedy Towers will not need to be evacuated to add chaos and confusion during a prolonged utility outage. And lastly, RPI will not need to send students home or find alternative housing. In addition to providing shelter for students, RPI would have additional capacity to house community members.

The microgrid will be designed to withstand any weather disruptions that are typical to the area. The CHP Plant will be installed indoors and above sea level, resilient to any flooding or additional weather disruptions. All of the electrical cables will be installed underground, in concrete encased duct back which will provide full resiliency against any weather phenomenon. If a severe weather event was to impact the area, the microgrid would be able to operate fully for a minimum of two days. This is due to the existing No. 2 Fuel Oil storage on site. The CHP Plant has the ability to operate for a longer duration via refueling trucks.

The overall value proposition can be outlined below:



- 1) Each of the customers will save money, have more reliable power and have power available to their facilities during a prolonged utility outage.
- 2) An annual utility reduction in 63,526,000 kWh or 96.64% on their system.
- 3) Bette & Cring Construction, CHA Consulting, and Cogen Power Technologies . the three companies that comprise the Design-Build team are all Upstate New York companies with headquarters in NYS to promote their standing in the state and the northeast for developing the complex microgrids.
- 4) Multiple construction jobs will be created throughout the installation and construction of this project.

¹⁰ Appendix N includes reference for NYSERDA Opportunity Zone Map.





At current commodity pricing, the savings that can be realized by this project can be with a \$1.3M - \$2.4M range for the total of the microgrid customers. Analyses of the potential savings for various cases of the microgrid have been provided in Appendix H.

There are a variety of potential revenue streams that can be developed due to the installation of this microgrid. It is dependent on the participation of NYSERDA, National Grid, and Public Service Commission to move forward with the development of these opportunities. Various revenue streams have been identified in a report issued by Pace Climate and Energy Center, included as Appendix I. The potential revenue streams are identified in Section 11.4 ~~Potential~~ Future Revenue Streams+.

This project supports each of the REV goals as outlined in the table below:

REV Goal	Advancement of that Goal
 Cutting greenhouse gas emissions 80% by 2050	<p>~ Large scale combined heat and power (CHP) is core to the project providing significant efficiency benefits</p> <p>~ 8 MW CHP Plant will save 13,295 tons per year of Carbon Dioxide equivalent (equal to 2,516 passenger vehicles)¹¹</p>
 Making energy more affordable for all New Yorkers	<p>~ Extending the RPI system to Samaritan allows the Hospital to capture the benefits of CHP without having to build their own plant, reducing CAPEX needs</p> <p>~ Economies of scale results in more customer savings. This allows design of larger, more efficient system to serve a hospital, a low income senior center and fire station in addition to RPI</p>

¹¹ Appendix J includes carbon reduction calculations from the EPA-CHP Partnership.

 <p>Improving our existing initiatives and infrastructure</p>	<p>“ Located in Troy, proximity allows for easy evaluation by, and collaboration with, NYSERDA and PSC</p> <p>“ An ideal location for setting up a test case for several new and innovative features that REV is intended to explore</p> <p>“ Private investment in high efficiency generation that frees up capacity extending the productivity and capabilities of the existing distribution system.</p>
 <p>Helping clean energy innovation grow</p>	<p>“ Creates an opportunity to examine new and innovative financing structures, e.g. a non-profit, third party financing model that could significantly lower the cost of capital improving economic viability</p> <p>“ Unlocks a novel approach to energy management for hospitals who have been reluctant to embrace CHP as an alternative to backup generators</p>
 <p>Building a more resilient energy system</p>	<p>“ Provides cost effective resiliency for a large university, major hospital, and Low to Moderate Income (LMI) residential tower (whose tenants are likely to shelter in place)</p> <p>“ Dual fuel CHP systems will be able to completely island from utility in cases of grid outage or gas curtailment</p>
 <p>Creating new jobs and business opportunities</p>	<p>“ NY Prize funding enables a significant expansion, beyond the RPI campus, at a modest incremental cost, to meet an important REV objective of serving LMI customers, as well as the hospital and critical city services.</p>

A robust Load Management System (LMS) would be installed to promote new technology. The LMS works by recognizing within 80 milliseconds that utility power has been lost, and isolating the CHP system from the utility to create and island and continue to provide uninterrupted power to the microgrid customers. The LMS will also detect and shed load where necessary on the microgrid loads to prevent the turbine from tripping offline.

Additionally, the LMS would potentially communicate to the upstream utility switches to ensure continuous power flow to Samaritan Hospital. The LMS would also communicate to the utility's operational command center providing real time data. This will keep the utility personnel informed on key CHP microgrid parameters.

SUBTASK 3.3 COMMERCIAL VIABILITY – PROJECT TEAM

The approach to gaining support from local government, community groups and residents would be similar to the approach that will be used to gain microgrid customer support. An overview of the project would be had with the appropriate groups, outlining the proposed scheme, customer savings, environmental benefits and societal benefits that would be a result of installation of this project.

The Design-Build team would consist of the following firms:

- 1) Bette & Cring Construction Group (B&C) as the General Contractor. Roles would include construction management, holding contracts with the client and subcontractors, cost estimating, project scope and budget, field management, subcontractor selection, self-performing construction work, providing the Payment and Performance Bond, and providing the Guaranteed Maximum Price (GMP) Guarantee.
- 2) Cogen Power Technologies (CPT) as the CHP Program Manager. Roles would include Development of GMP, manage interfaces with the client, design team, major equipment suppliers and utility; manage financial, technical, and scheduling aspects of major equipment contracts, testing and commissioning of the microgrid. It is anticipated that CPT will assist with at least the first year of operations and possibly more.
- 3) CHA Consulting, Inc. (CHA) as the Design Engineer of Record. Roles would include being the responsible design engineer of the microgrid system, interconnection with the utility and all necessary permits.

The third party financing partner and owner of this microgrid has yet to be identified; however there are a variety of entities in CPT's partnership pool that are capable of providing this financing structure. Additionally, Cogen Power

Technologies has the capability to provide third party financing, ownership and operations.

NYSERDA, Samaritan Hospital, and Troy Fire Station #5 are all public entities. The private entities included in this project are The Troy Housing Authority, RPI, and Bette & Cring.

The owner of this project has not been finalized, therefore comment on the financial strength cannot be provided. However, CPT and their parent company is a potential owner and routinely have annual revenues in the \$100M-\$200M range, successfully financed the \$15M Burrstone Energy Center plant, and have completed the following CHP projects in NYS in the last six years:

Project	Value
Albany Medical Center 4.6 MW	\$23 M
GUSC Biomass 1 MW	\$18 M
St. Joseph's Hospital 4.6 MW	\$15 M
Union College 1.8 MW	\$14 M

Cogen Power Technologies (Cogen) has joined with CHA Consulting, Inc. (CHA), and Bette & Cring Construction (B&C) to form a proven team to has worked together for over 7 years and forged a strong complementary bond to deliver design-build CHP solutions across the Northeast as a team.

Cogen Power Technologies (Cogen) . Our business is cogeneration - plain and simple. As a CHP program manager, integrator, and operator, Cogen provides client-focused comprehensive cogeneration solutions. Cogen has worked with a number of institutions - including Albany Medical Center and Utica College to deliver successful CHP projects from feasibility studies to design through build-out and operation. Since 2007, we developed and now own and operate a cogeneration microgrid . Burrstone Energy Center that serves Utica College, Faxton-St. Luke's Hospital, and St. Luke's Nursing Home, that has produced over 100 Million kilowatt hours of electricity. John Moynihan, Managing Partner of

Cogen was the recipient of the 2014 North East Combined Heat and Power Initiative (NECHPI) Champion of the Year award.

CHA Consulting, Inc. (CHA) - With over 1400 employees and 50 offices, CHA is a highly diversified, full service engineering firm providing a wide range of planning and design services to clients for over 60 years. A licensed Mechanical, Electrical, and Structural Engineering firm headquartered in Albany, CHA has designed more than 20 different CHP plants, from 1 MW to over 110 MW, over the past 15 years in the US and Canada. CHA's signature projects include Albany Medical Center CHP Plant and the 30 MW CHP plant installed at Cornell University. CHA has extensive experience with permitting coordination for gas supply and electrical system interconnection, and has been complimented by National Grid for its detailed, high quality application packages.

Bette & Cring (B&C) - Since 1999, Bette & Cring has been one of the region's largest General Contractors with offices in Latham and Watertown, NY. B&C has managed the design-build construction of six (6) CHP Plants including Burrstone Energy Center Microgrid, and Albany Medical Center CHP. B&C offers extensive experience in all phases of design, planning, and construction, and have constructed numerous commercial, institutional, and related capital projects over the past fifteen years. Our annual business volume was \$133 Million in 2014.

Summary of Key Combined Heat & Power Projects - PROPOSER TEAM									
PROJECT	TEAM			PRIME MOVERS			FEATURES		
	COGEN	CHA	B&C	CHP PLANT CAPACITY	STEAM CAPACITY	STEAM PRESSURE	CAMPUS MICROGRID	COMMUNITY MICROGRID	CRITICAL FACILITIES
Burrstone Energy Center CHP Microgrid Utica, NY	★		★	3.6 MW Gas Engine	7,000 pph	85 psig	★	★	★
Albany Medical Center CHP Plant Albany, NY	★	★	★	4.6 MW Gas Turbine	60,000 pph	85 psig	★		★
St. Joseph's Hospital CHP Plant Syracuse, NY	★	★	★	4.6 MW Gas Turbine	45,000 pph	85 psig	★		★
Cornell University CHP Plant Ithaca, NY		★		30 MW Gas Turbine	300,000 pph	400 psig	★		★
Kingston General Hospital/Queen's University CHP Microgrid Kingston, ON		★		15 MW Gas Turbine	150,000 pph	275 psig	★	★	★
Union College CHP Plant Schenectady, NY	★	★	★	1.75 MW Gas Turbine	45,000 pph	90 psig	★		★
GUSC Energy Biomass Plant Rome, NY	★	★	★	1 MW	40,000 pph	\$16 Million			
CHP FEASIBILITY STUDIES (BY COGEN/CHA/B&C TEAM)									
4.6 MW – St. Joseph's Hospital Cogeneration Plant, Syracuse, NY • 4.6 MW - Bay State Hospital Cogeneration Plant, Springfield, MA • 1.8 MW - Union College Cogeneration Plant, Schenectady, NY • 1 MW - Skidmore College Cogeneration Plant, Saratoga Springs, NY • 1 MW - Williams College Cogeneration Plant, Williamstown, MA • 555 kW Oneida Healthcare Facility, Oneida, NY • 10 MW - Central Pennsylvania Manufacturer									

The General Contractor for this project would be Bette & Cring, LLC. Services provided would be construction management, holding contracts with the client and subcontractors, cost estimating, project scope and budget, field management, subcontractor selection, self-performing construction work, providing the Payment and Performance Bond, and providing the Guaranteed Maximum Price (GMP) Guarantee.

The proposed financing for this project has not been secured at this time. The approach for gaining a financial partner on the team for this project would be for CPT to reach out to a handful of pre-qualified third party financing entities that specialize in the development in CHP projects.

Including on the team is Thomas G. Bourgeois, Deputy Director and his team at the Pace Energy and Climate Center (Pace) who will aid in the regulatory advisement of the project. For more than 25 years, Pace has worked in New York and across the Northeast region engaging government, communities, businesses, and key stakeholders in action that leads to better energy and climate policy. Pace's diverse staff conducts research and analysis, finding solutions to meet today's complex energy and climate change challenges.¹²

Legal advisement for the project team will include Robert Loughney at Couch White, LLP. Couch White, LLP is a full-service business law firm with nationally-recognized leadership in the practice of energy and construction law. Their business law practice areas include banking, commercial and corporate law, environmental, renewable energy, land use, zoning and real estate development, government contracts, labor and employment, litigation, real estate and trusts, estates and business succession planning.¹³ Couch White was the attorney used for the development of Burrstone Energy Center and was instrumental in helping to navigate through the same microgrid issues that face this project.

SUBTASK 3.4 COMMERCIAL VIABILITY – CREATING AND DELIVERING VALUE

The technologies chosen for the RPI-Samaritan microgrid include electricity generation in the form of a gas turbine generator (GTG) installed as part of a Combined Heat and Power (CHP) plant, installation of absorptions chillers and controls for electric load control and load shedding. The CHP will provide electricity to the RPI campus and microgrid loads connected to the RPI system and steam to the RPI campus. Electricity will also be supplied from the CHP through the National Grid electric service to the Samaritan Hospital. The small amount of excess electricity generated would be available to sell into the NYISO

¹² Cited per Pace Climate and Energy Center proposal to CPT dated November 5, 2015.

¹³ Cited per Couch White, LLP website at http://www.couchwhite.com/about_us/

controlled system. A GTG powered CHP sized to supply the average combined electrical load of RPI and Samaritan Hospital as well as the average thermal energy load of the RPI campus would result in reduced cost for the supply of energy to these facilities. The absorption chillers will operate to utilize CHP generated steam in the summer when thermal demand is typically reduced. This CHP technology is well proven as a reliable electricity supply system from previous similar installations. The addition of electrical loads from microgrid customers would improve the utilization of the GTG.

The main benefit of the CHP is that it produces the majority of electricity to the microgrid customers, and it can remain in operation during loss of utility supplied electricity and/or the loss of the natural gas fuel supply. Under normal conditions, the microgrid is connected to the utility system and can import electricity, as needed to Samaritan Hospital. The GTG can fire natural gas or No. 2 fuel oil to power the microgrid while in islanded mode. This allows the microgrid to continue operation during loss of utility power, even if the natural gas supply is interrupted. Fuel oil storage is available on site. Each facility will have its own emergency power supply system to handle life safety electrical loads and a black start generator will be available to restart the CHP in case of a trip during a utility power outage. The CHP will also supply steam for heating and cooling of facilities on the RPI Campus.

An additional benefit of the CHP is that it will result in cost savings to RPI and the microgrid customers during normal operation due to improved efficiency of the combined generation of electricity and thermal energy resulting in lower cost energy being supplied to these facilities.

The challenge of employing the CHP technology will be to ensure that adequate electricity and steam can be supplied to all users during loss of the utility electrical supply. Although the installed generation capacity will meet a significant part of the microgrid electrical load, load shedding will be required to ensure that GTG capacity is not exceeded during high load periods. The challenge will be to effectively implement the load shedding in order to balance the needs of all facilities connected to the microgrid. Steam demand may at times exceed the steam output capacity of the CHP. During these periods, additional steam can be generated by the existing dual fuel boilers in the RPI steam plants firing natural gas when available and fuel oil when the gas supply is interrupted. The intent is to contract a firm supply of natural gas to minimize the requirement for fuel oil.

To ensure reliability of the CHP, a comprehensive maintenance schedule will be implemented requiring periodic shutdowns to conduct inspections and service the

equipment. One of the challenges will be to schedule these shutdowns to avoid periods when forces of nature events are most likely to occur. The maintenance schedule will also aim to ensure that the lengths of scheduled outages are minimized.

The existing RPI boiler plant is a critical component of infrastructure that can be leveraged to house half of the CHP Plant and save a significant amount of construction costs. Located in the boiler plant would be the Heat Recovery Steam Generator (HRSG), with the GTG, gas compressor and black start generator housed outside of the boiler plant in an available parking lot. Appendix K includes renderings of the proposed CHP Plant and how the existing boiler plant can be utilized. Natural gas, fuel oil, and steam tie in points are available for use for the CHP Plant. Steam will be distributed from the boiler house to the RPI campus via existing steam systems. The existing steam system is a significant asset which can be leveraged, since the cost of running thermal distribution systems over long distances can often be uneconomical. The No. 2 Fuel Oil tanks are existing assets of the RPI campus which has substantial benefit and cost savings towards the project.

The CHP will be operated by a collaboration of RPI facility personnel and the third party owner operations team. To ensure that electrical generation capacity of the CHP is not exceeded during an outage of the utility electrical supply, load shedding will be implemented, as necessary, affecting only RPI. Other microgrid customers will also be connected to the LMS and would not be affected.

RPI will have full control of the steam generation at the CHP and the campus boiler plants as well as consumption on the campus. If necessary, to conserve fuel oil during an extended natural gas interruption, non-critical steam loads can be shut down or reduced.

During the construction of the project, standard construction building permits would be required. In addition, the team will work with the New York State Department of Environmental Conservation (DEC) to modify the Air Permit for inclusion of this project.

A comprehensive electrical interconnection with the utility will have to be successfully navigated to ensure the proper requirements are met.

Special permissions for this project will need to come from the utility regarding the following items:

- 1) Rights of Way for crossing a public road

- 2) Aggregation of multiple electrical customers down to one through the RPI meter
- 3) Leasing or buying existing utility infrastructure
- 4) Utilizing existing National Grid infrastructure to export power to Samaritan Hospital

The proposed approach for development and construction of this project will be a Design-Build method. Through this method, project costs can be minimized due to less engineering fees and this method significantly reduces the project duration for design and construction so that the microgrid customers may realize the benefits and savings sooner.

The community will recognize a variety of benefits from the deployment of this project. First being that in the event of a natural disaster, the microgrid facilities will be available to provide shelter to community members for a prolonged duration. Community members will also be provided full medical and fire services during the event of a natural disaster. Due to the savings the microgrid will bring the customers, this will result in a lower cost of service for community members. Also, there will be more energy available to the community from the utility since the microgrid will be producing its own. It is not expected that the community should incur any costs due to implementation of this project.

In order the utility to ensure that this project can benefit the microgrid customers and the community, the utility will need to provide cooperation with the following items:

- 1) Rights of Way for crossing a public road
- 2) Aggregation of multiple electrical customers down to one through the RPI meter
- 3) Leasing or buying existing utility infrastructure

Each of the microgrid technologies that will be used as a part of this project have been previously implemented elsewhere. The Solar Turbines Taurus 70 has over 800 units worldwide, generating electricity and recovering the exhaust heat in a thermal application. The Load Management System (LMS) has been employed at a variety of sites, including Albany Medical Center and St. Joseph's Hospital specifically.

It is anticipated that the CHP Plant will operate at a minimum of 97% of the year, only unavailable during times of scheduled maintenance outages. Given the availability of the system, the system will be operating almost all year round to ensure that all of the goals of the system are being met.

A third party financing entity will act as the energy provider and issue monthly bills to the microgrid customers. The CHP Plant will generate power and distribute to the microgrid customers at the cost of generating power. An additional fixed monthly fee to recover the capital investment in the microgrid infrastructure and third party return on investment requirements will be applied. A small administrative fee may be included as well for the overall management and development of the monthly bills. Usage of the microgrid customers will be metered by the installation of standard revenue grade meters at each location.

This project is a slight variation of the successful microgrid implementation at Burrstone Energy Center in Utica, NY and therefore replicable. This approach is scalable and portable to any city or community in the country with an appropriate energy profile.

The barriers to market entry for this project lie solely with participation of the utility.

Based on past success at the Burrstone Energy Center, CPT feels very optimistic that this project is similar and on a grander scale and fully capable to step through the barriers of this project.

SUBTASK 3.5 FINANCIAL VIABILITY

A variety of savings analyses have been included in Appendix H. The breakdown shows that the largest portion of the savings would flow to RPI as the largest electrical load and only thermal load. It is expected that the third party financing party would receive a portion of each of the customers savings as a return on their investment.

In order for the microgrid customers to save money, the issues outlined in the SWOT Analysis in Section 3.2 regarding delivery charges of commodities, state taxes, etc. will need to come to fruition to enhance the economics to the customers and microgrid owner. Without these types of changes in the microgrid landscape, it will be difficult (if not impossible) for other projects that are not as robust as this project to materialize. The major incentive that will be required for this project to be deployed and successful is the \$5M-\$7M NYSERDA subsidy available through NY Prize.

A summary of the anticipated capital and operating costs of this microgrid have been included in Appendix L. The values provided in this table include the installation cost of the CHP Plant and microgrid connections, not any additional overhead of a third party financing firm.

The business model for this project will be profitable because all of the microgrid customers will save money. RPI is a perfect installation for a CHP Plant without the microgrid system, but adding additional customers will benefit the efficiency of the turbine, savings, and the overall proposition of NY Prize.

The financing structure for this project during development, construction and operation has not been identified at this time due to no selection in a third party financing entity. Terms of the financing structure will be negotiated during the selection process.

SUBTASK 3.6 LEGAL VIABILITY

The proposed ownership of the CHP Plant and microgrid assets will fall under the third party financing entity or Cogen Power Technologies (CPT). The third party/CPT will act as an energy provider to the microgrid customers and have full ownership.

The project owner will be either the third party financing firm or CPT. The applicant is CPT. The approach to securing another entity who is not CPT is described in Section 3.3.

Since RPI owns the proposed CHP Plant location site identified in Appendix D, there should be no issue with the project owner gaining access to the site. Similar to the approach used at BEC, a 25 year land lead between RPI and the CHP Plant Owner will be put in place. It is anticipated that the cooperation of the microgrid customers will enable the same scenario for the remaining clients.

The approach to protecting the privacy rights of the microgrid customers would be to engage each customer individually to discuss if they would want their name associated with the project. The approach would be to explain to Troy Fire Station #5 and the Kennedy Towers that the customer would become a part of the RPI electrical infrastructure and no longer be a customer of National Grid. All energy consumption would be monitored and measured by the RPI measurement and verification (M&V) systems, not by National Grid. Eliminating National Grid and keeping the M&V more centralized within the RPI system provides an additional level of privacy. Additionally, any contractual agreements between customers and RPI would be confidential.

Samaritan Hospital would remain a customer under National Grid, as well as RPI. The confidentiality between Samaritan Hospital and National Grid would remain

the same, and RPI would apply the same confidentiality agreement with Samaritan Hospital as its other customers.

The major regulatory hurdles that could implicate this project are:

- 1) Crossing public roads
- 2) The aggregation of multiple electric services
- 3) Buying or leasing existing utility equipment

The plan to address these issues is to follow the same path that was used at Burrstone Energy Center. Robert Loughney at Couch White, LLP will be hired to help navigate a waiver to cross public roads with the PSC and National Grid support. The Burrstone Energy Center's waiver number through the PSC for this project is Case 07-E-0802 and included in Appendix M. Thomas G. Bourgeois of the Pace Energy and Climate Center has been included on the project team to navigate the aggregation of multiple electric services and the buying/leasing of existing utility equipment.

SECTION IV

TASK 4: DEVELOP INFORMATION FOR BENEFIT COST ANALYSIS

Each of the Facility Questionnaires and the Microgrid Questionnaire were submitted to IEC for proper analyzing for the Benefit Cost Analysis (BCA). The BCA result for this microgrid study is 0.8 without any days of power outages, with a Net Benefits . Present Value of -\$24,200,000 and an Internal Rate of Return at -4.7%. A second case for a BCA of 1.0 or greater was necessary to reach the BCA goal of 1.0 or greater. The BCA calculated that 3.1 days/year of major power outages would be needed to return a BCA of 1.0. With a BCA of 1.0, the Net Benefits . Present Value is \$674,000 and an Internal Rate of Return at 8.1%. The information provided by IEC for the BCA has been included in Appendix N.

SECTION V

TASK 5: FINAL WRITTEN DOCUMENTATION

The final presentation is scheduled to be held at Rensselaer Polytechnic Institute on May 9th. In attendance will be members from RPI, Samaritan Hospital, NYSERDA, CHA, and CPT.

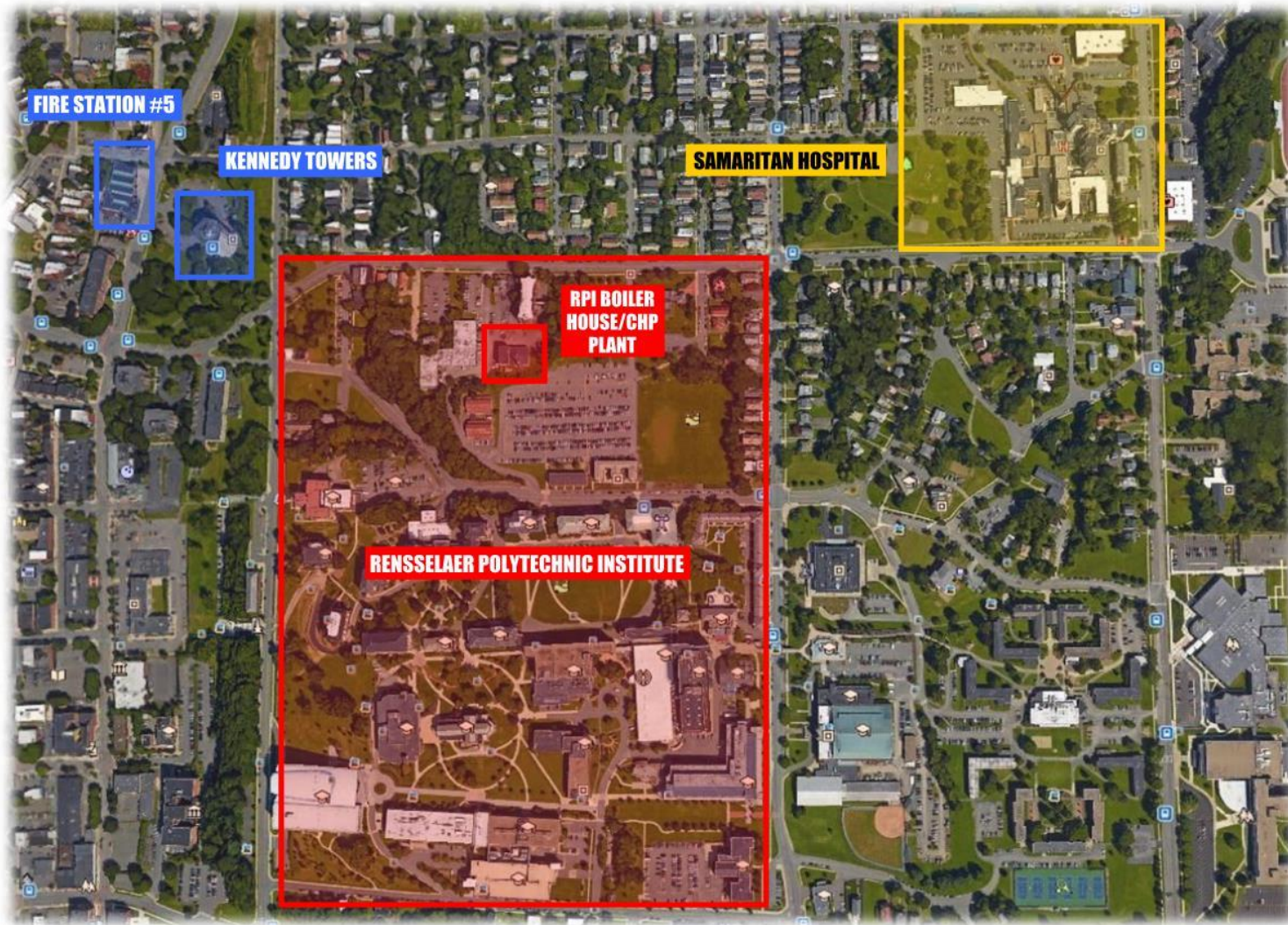
SECTION VI

APPENDICES

- A. GEOGRAPHICAL LOCATION OF PROPOSED MICROGRID
- B. HISTORICAL AND RECENT CRESTS FOR ALBANY, NY
- C. ELECTRICAL CABLE LAYOUT DIAGRAM
- D. CHP PLANT EQUIPMENT LAYOUT DIAGRAMS
- E. ELECTRICAL SINGLE LINE DIAGRAMS
- F. MONTHLY ENERGY LOADS
- G. LOAD PROFILES
- H. SAVINGS ANALYSIS BY CASE
- I. PACE CLIMATE AND ENERGY CENTER . NY PRIZE REPORT
- J. CARBON REDUCTION CALCULATIONS
- K. PROPOSED CHP PLANT RENDERINGS
- L. CAPITAL AND OPERATING COSTS
- M. BURRSTONE ENERGY CENTER PSC WAIVER
- N. BENEFIT COST ANALYSIS
- O. REFERENCES

APPENDIX A

GEOGRAPHICAL LOCATION OF PROPOSED MICROGRID



APPENDIX B

HISTORICAL AND RECENT CRESTS FOR TROY, NY

Historic Crests

- (1) 29.70 ft on 03/28/1913
- (2) 29.48 ft on 03/19/1936
- (3) 27.10 ft on 09/22/1938
- (4) 27.05 ft on 08/29/2011
- (5) 27.05 ft on 12/31/1948
- (6) 26.53 ft on 03/14/1977
- (7) 26.22 ft on 01/20/1996
- (8) 24.82 ft on 03/06/1964
- (9) 24.77 ft on 01/09/1998
- (10) 24.41 ft on 04/05/1960
- (11) 24.40 ft on 03/13/1936
- (12) 24.22 ft on 04/04/2005
- (13) 24.20 ft on 09/09/2011
- (14) 23.79 ft on 04/05/1987
- (15) 23.67 ft on 06/29/2006
- (16) 23.64 ft on 03/07/1979
- (17) 23.62 ft on 03/22/1980
- (18) 23.57 ft on 03/30/1993
- (19) 23.41 ft on 03/16/1986
- (20) 23.31 ft on 12/02/1996
- (21) 23.30 ft on 02/29/2000
- (22) 23.13 ft on 10/17/1955
- (23) 23.13 ft on 04/17/2007
- (24) 23.02 ft on 04/30/2011
- (25) 22.98 ft on 05/30/1984
- (26) 22.83 ft on 04/26/1983
- (27) 22.82 ft on 04/02/1976
- (28) 22.74 ft on 06/14/2013
- (29) 22.72 ft on 10/18/1977
- (30) 22.67 ft on 12/14/1983
- (31) 22.64 ft on 03/24/2010
- (32) 22.48 ft on 05/05/1972
- (33) 22.39 ft on 04/17/1994
- (34) 22.39 ft on 12/27/1973
- (35) 22.33 ft on 04/03/1970
- (36) 22.16 ft on 03/31/2010
- (37) 22.12 ft on 03/24/1968
- (38) 22.08 ft on 03/23/2003
- (39) 22.02 ft on 03/28/1963
- (40) 21.96 ft on 11/11/1990
- (41) 21.95 ft on 04/16/2014
- (42) 21.94 ft on 04/05/1973
- (43) 21.93 ft on 02/25/1975
- (44) 21.86 ft on 04/23/1969
- (45) 21.71 ft on 03/12/2011
- (46) 21.62 ft on 03/10/1998
- (47) 21.53 ft on 03/12/2011
- (48) 21.53 ft on 03/19/2011
- (49) 21.36 ft on 04/02/1998

(50) 20.95 ft on 01/25/1999
(51) 20.91 ft on 05/03/1992
(52) 20.90 ft on 01/28/1996
(53) 20.88 ft on 05/05/1971
(54) 20.59 ft on 04/04/1967
(55) 20.55 ft on 03/27/1988
(56) 20.25 ft on 03/25/1966
(57) 20.22 ft on 03/31/1998
(58) 20.04 ft on 12/06/1994
(59) 19.46 ft on 04/13/1965
(60) 19.02 ft on 03/05/1999

(P): Preliminary values subject to further review.

Recent Crests

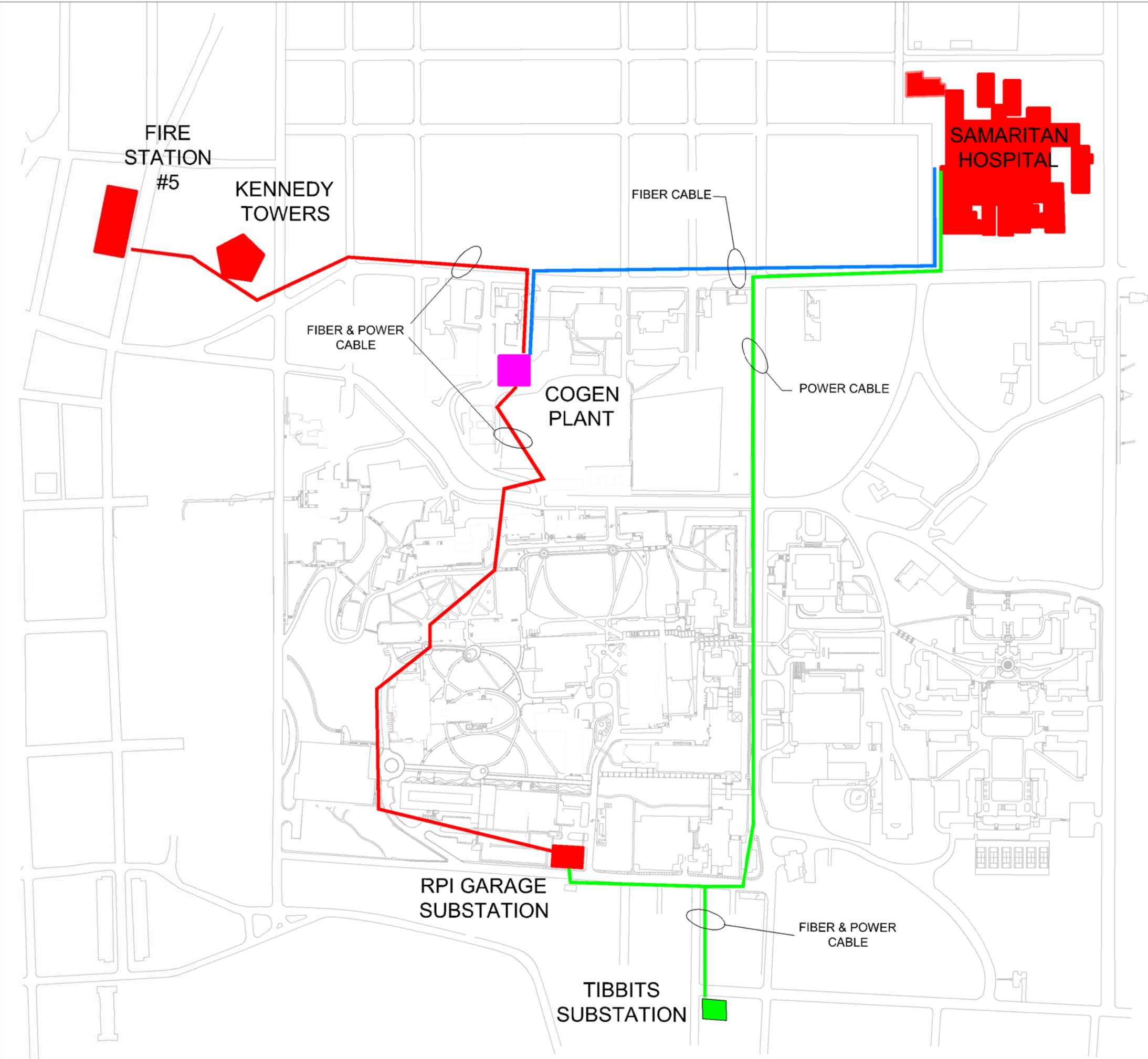
- (1) 21.95 ft on 04/16/2014
- (2) 22.74 ft on 06/14/2013
- (3) 24.20 ft on 09/09/2011
- (4) 27.05 ft on 08/29/2011
- (5) 23.02 ft on 04/30/2011
- (6) 21.53 ft on 03/19/2011
- (7) 21.53 ft on 03/12/2011
- (8) 21.71 ft on 03/12/2011
- (9) 22.16 ft on 03/31/2010
- (10) 22.64 ft on 03/24/2010
- (11) 23.13 ft on 04/17/2007
- (12) 23.67 ft on 06/29/2006
- (13) 24.22 ft on 04/04/2005
- (14) 22.08 ft on 03/23/2003
- (15) 23.30 ft on 02/29/2000
- (16) 19.02 ft on 03/05/1999
- (17) 20.95 ft on 01/25/1999
- (18) 21.36 ft on 04/02/1998
- (19) 20.22 ft on 03/31/1998
- (20) 21.62 ft on 03/10/1998
- (21) 24.77 ft on 01/09/1998
- (22) 23.31 ft on 12/02/1996
- (23) 20.90 ft on 01/28/1996
- (24) 26.22 ft on 01/20/1996
- (25) 20.04 ft on 12/06/1994
- (26) 22.39 ft on 04/17/1994
- (27) 23.57 ft on 03/30/1993
- (28) 20.91 ft on 05/03/1992
- (29) 21.96 ft on 11/11/1990
- (30) 20.55 ft on 03/27/1988
- (31) 23.79 ft on 04/05/1987
- (32) 23.41 ft on 03/16/1986
- (33) 22.98 ft on 05/30/1984
- (34) 22.67 ft on 12/14/1983
- (35) 22.83 ft on 04/26/1983
- (36) 23.62 ft on 03/22/1980
- (37) 23.64 ft on 03/07/1979
- (38) 22.72 ft on 10/18/1977
- (39) 26.53 ft on 03/14/1977
- (40) 22.82 ft on 04/02/1976
- (41) 21.93 ft on 02/25/1975
- (42) 22.39 ft on 12/27/1973
- (43) 21.94 ft on 04/05/1973
- (44) 22.48 ft on 05/05/1972
- (45) 20.88 ft on 05/05/1971
- (46) 22.33 ft on 04/03/1970
- (47) 21.86 ft on 04/23/1969
- (48) 22.12 ft on 03/24/1968
- (49) 20.59 ft on 04/04/1967

(50) 20.25 ft on 03/25/1966
(51) 19.46 ft on 04/13/1965
(52) 24.82 ft on 03/06/1964
(53) 22.02 ft on 03/28/1963
(54) 24.41 ft on 04/05/1960
(55) 23.13 ft on 10/17/1955
(56) 27.05 ft on 12/31/1948
(57) 27.10 ft on 09/22/1938
(58) 29.48 ft on 03/19/1936
(59) 24.40 ft on 03/13/1936
(60) 29.70 ft on 03/28/1913

(P): Preliminary values subject to further review.




APPENDIX C

ELECTRICAL CABLE LAYOUT DIAGRAM



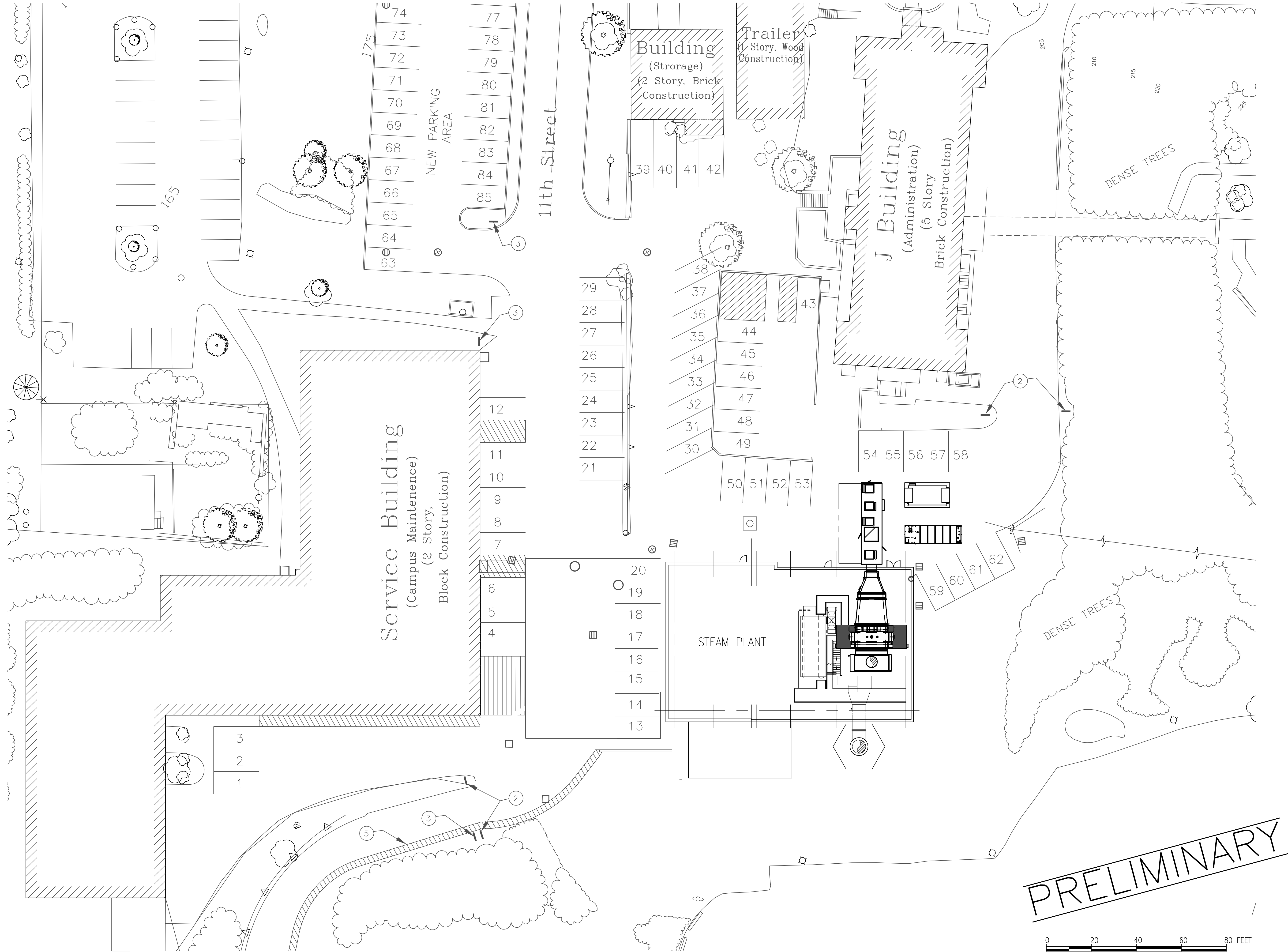
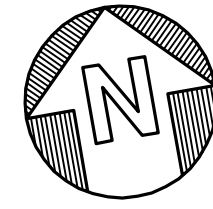
NYPRIZE TROY
MICROGRID LAYOUT

LEGEND

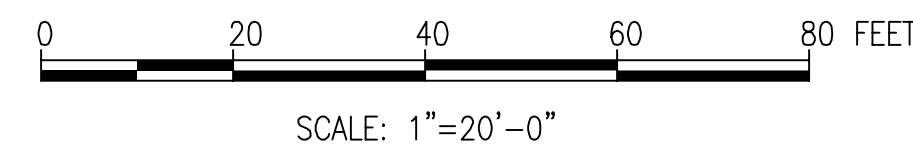
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-  NEW MICROGRID LOADS
-  NATIONAL GRID POWER FEEDS

APPENDIX D

CHP PLANT EQUIPMENT LAYOUT DIAGRAMS



OPTION B SITE PLAN
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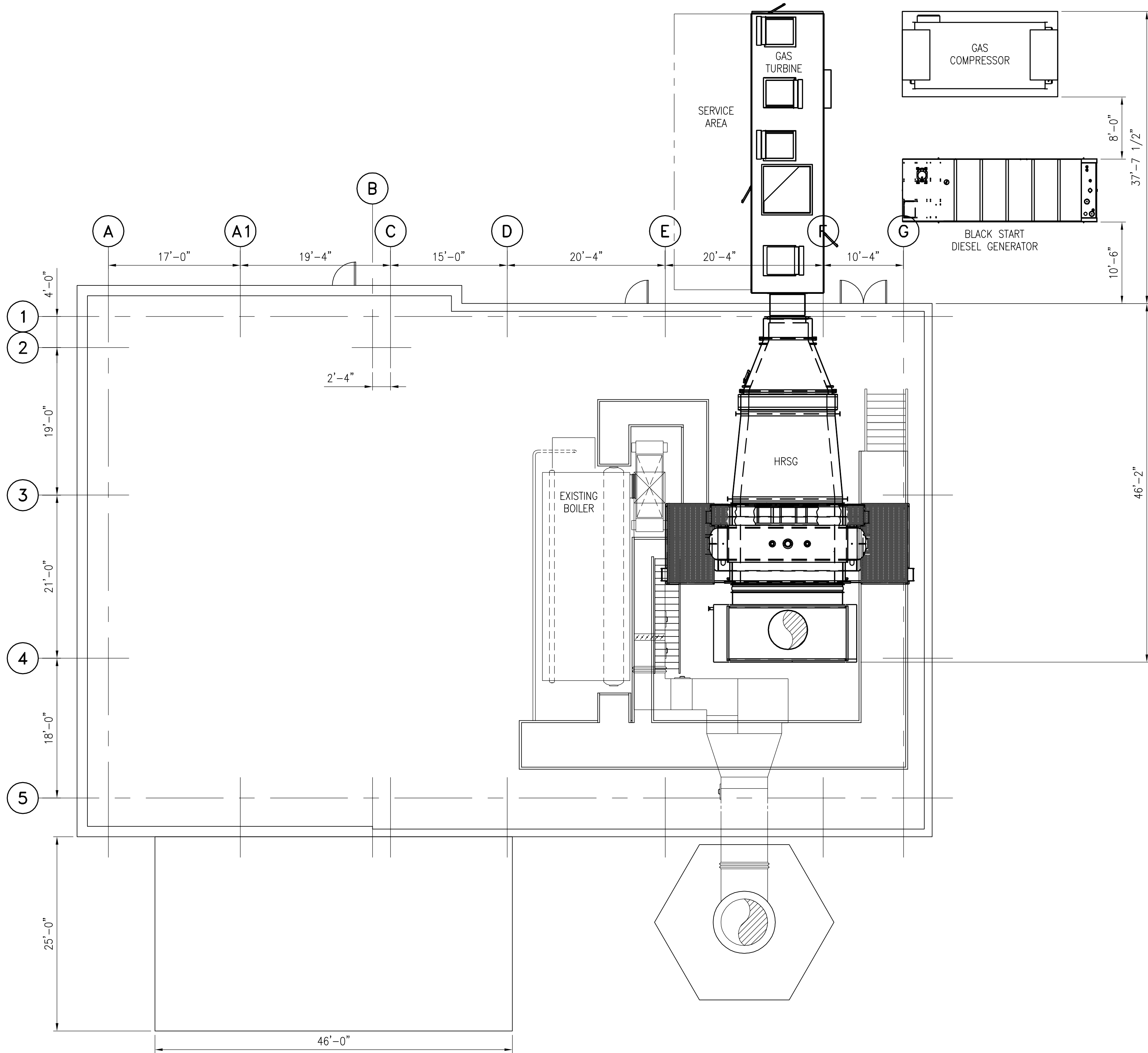
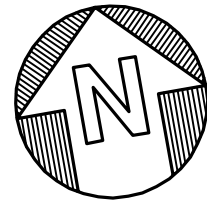


PRELIMINARY

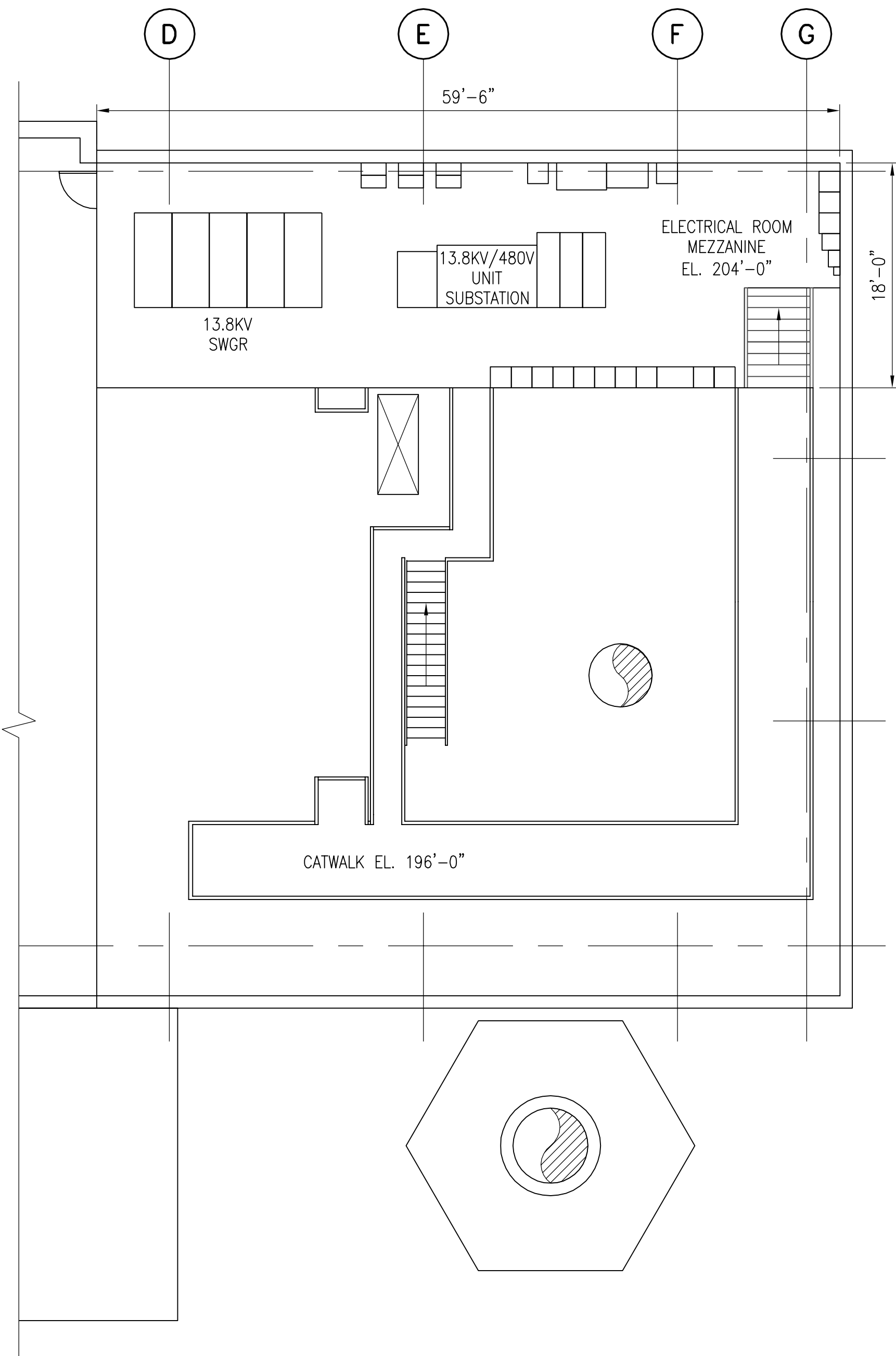
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Drawing Copyright © 2014 CH2A		Designed:	Drawn:	Checked:	UNAUTHORIZED ALTERATION OR ADDITION APPLICABLE STATE AND/or LOCAL LAWS	
NO.		SUBMITTAL / REVISION		APPD	BY	YYMMDD
PA	ISSUE FOR COMMENT		RM	20151208	RM	
PB	ISSUE FOR COMMENT		RM	20151208	RM	
PC	ISSUE FOR COMMENT		RM	20151214	RM	

30601-5201B

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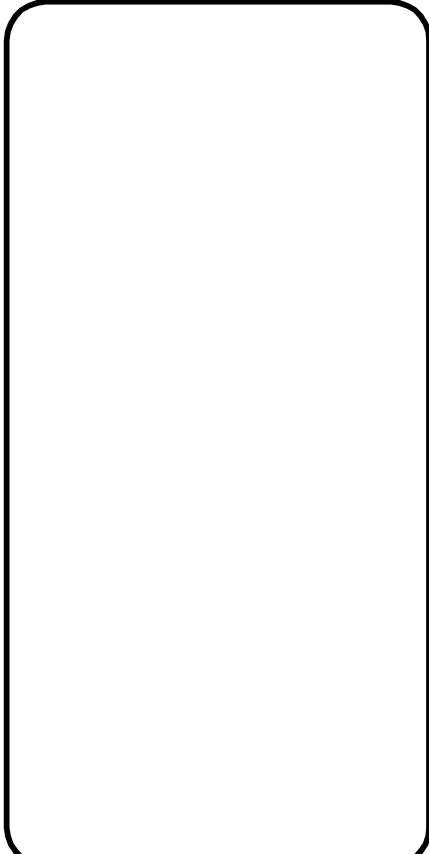


OPTION B PLAN VIEW
EL. 186'-0"
SCALE: 3/16"=1'-0"



MEZZANINE
EL. 204'-0"
SCALE: 3/16"=1'-0"

NO.	BY	APPD	SUBMITTAL / REVISION	DATE
PA	RM		ISSUE FOR COMMENT	2015/12/08
PB	RM		ISSUE FOR COMMENT	2015/12/08
PC	RM		ISSUE FOR COMMENT	2015/12/14
PD	RM		ISSUE FOR COMMENT	2015/12/15

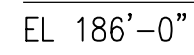


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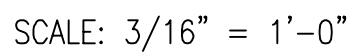
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SCALE: $3/16"=1'-0"$

PRELIMINARY

[illegible]

	Drawing Copyright © 2014	
	Designed:	Drawn: RM Checked:

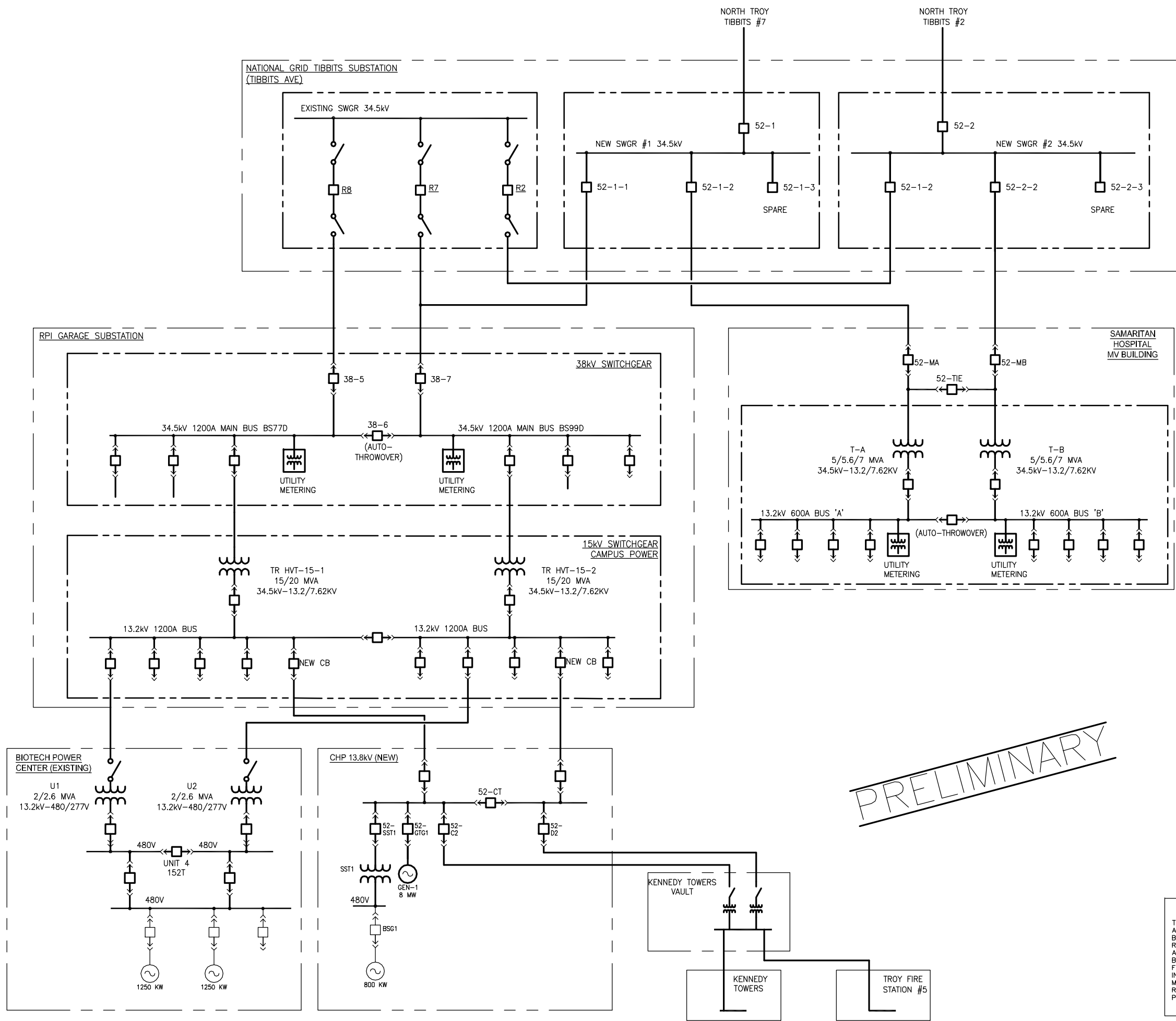
UNAUTHORIZED ALTERATION OR ADDITION
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 APPLICABLE STATE AND/OR LOCAL LAWS

NE R PRI E RPI SAMARTAN MICR GRID 11TH STREET B I ERH SE TR NE R	GTG HRSG A T	Issue Date: 2015/204 Project No.: 30601 Scale: 3/16"=1'-0"
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APPENDIX E

ELECTRICAL SINGLE LINE DIAGRAMS

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COGEN

POWER TECHNOLOGIES

RPI / SAMARITAN
TROY, NY
MICROGRID STUDY

Rev.	Submitted	Revision	App'd.	By	Date
PA	FOR REVIEW	TV	MMH	11/30/15	

ELECTRICAL
34.5kV/13.8kV
OVERALL SINGLE LINE
DIAGRAM

Designed By:	Drawn By:	Checked By:
TV	MMH	-
Issue Date:	Project No:	Scale:
20151130	30601	NONE

Drawing No.:

30601-6100

APPENDIX F

MONTHLY ENERGY LOADS

CHART 1

NY PRIZE RPI-SAMARITAN MICROGRID

MONTHLY ELECTRICAL LOADS

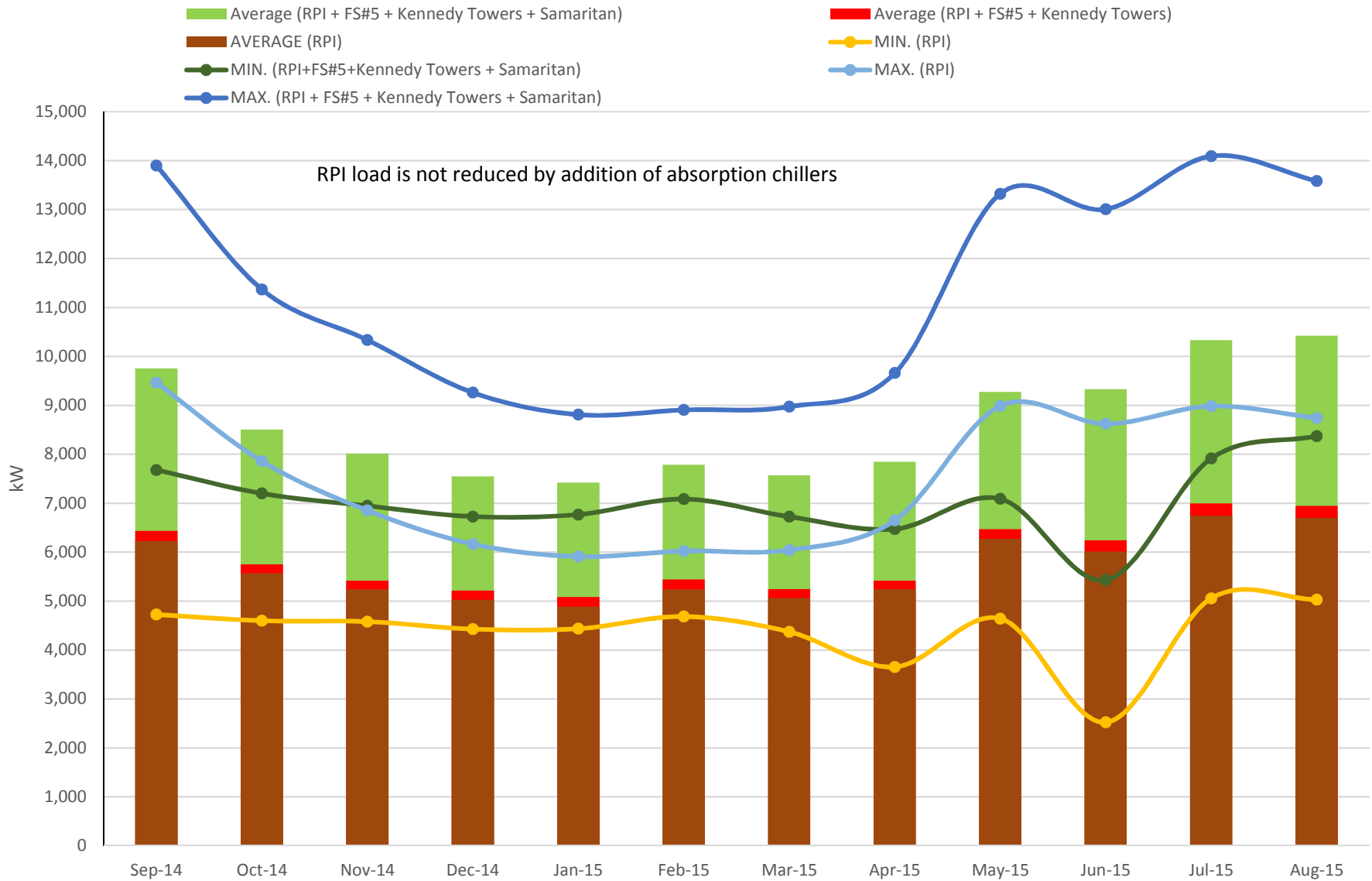


CHART 2
NY PRIZE - RPI-SAMARITAN MICROGRID
Monthly Steam Load

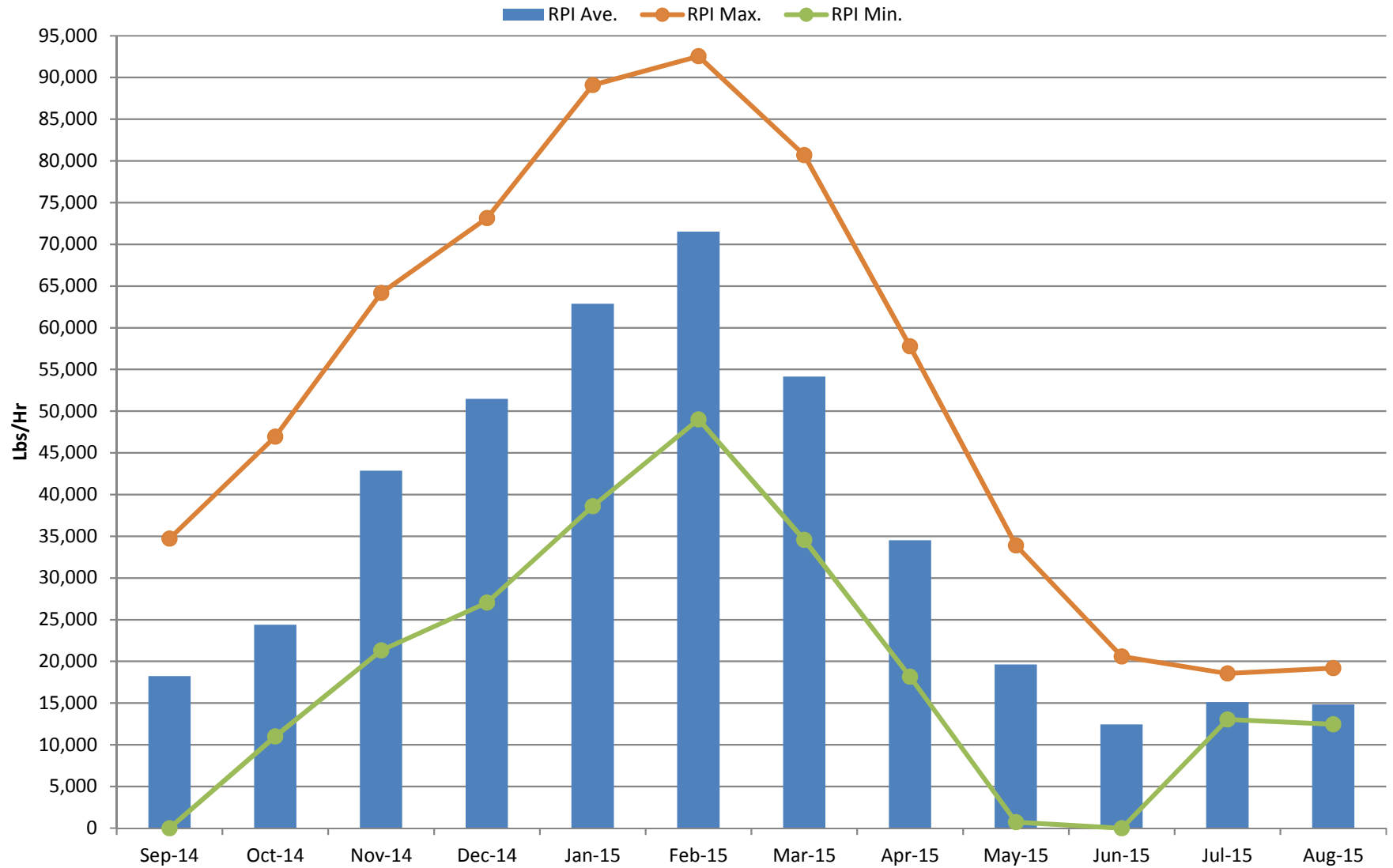


TABLE 1 - ELECTRIC LOAD SUMMARY

Electric	Actual Data											
	RPI			Fire Station #5			Kennedy Towers			Samaritan		
	Min. [kW]	Average [kW]	Max. [kW]	Min. [kW]	Average [kW]	Max. [kW]	Min. [kW]	Average [kW]	Max. [kW]	Min. [kW]	Average [kW]	Max. [kW]
Sep-14	4,727.0	6,226.0	9,465.0	N/A	24.2	38.4	N/A	181.7	296.8	2,606.1	3,319.6	4,349.3
Oct-14	4,599.0	5,566.2	7,857.0	N/A	24.7	43.2	N/A	160.0	235.4	2,210.1	2,749.0	3,464.9
Nov-14	4,581.0	5,236.9	6,851.0	N/A	27.0	42.4	N/A	151.7	203.4	2,117.8	2,595.7	3,565.7
Dec-14	4,428.0	5,027.3	6,165.0	N/A	28.4	45.6	N/A	157.8	201.4	2,052.6	2,331.4	2,847.7
Jan-15	4,436.0	4,885.9	5,910.0	N/A	29.0	50.4	N/A	168.2	217.8	2,061.1	2,335.3	2,758.0
Feb-15	4,685.0	5,239.7	6,024.0	N/A	29.1	43.2	N/A	171.3	224.6	2,107.9	2,342.8	2,685.6
Mar-15	4,372.0	5,062.3	6,044.0	N/A	27.6	48.8	N/A	153.0	225.7	2,119.3	2,321.4	2,769.4
Apr-15	3,656.0	5,241.9	6,651.0	N/A	24.8	42.2	N/A	150.7	189.9	1,798.5	2,425.6	2,901.4
May-15	4,643.0	6,268.8	8,987.0	N/A	23.1	36.8	N/A	177.0	329.6	2,214.4	2,801.2	4,039.8
Jun-15	2,523.0	6,013.4	8,622.0	N/A	27.5	39.2	N/A	201.1	286.9	2,086.6	3,084.1	4,059.7
Jul-15	5,057.0	6,738.6	8,984.0	N/A	31.9	59.2	N/A	221.2	300.8	2,462.8	3,338.7	4,768.0
Aug-15	5,030.0	6,701.0	8,740.0	N/A	26.9	76.8	N/A	214.0	306.4	2,580.6	3,478.6	4,590.6

NY PRIZE - Troy NY
RPI Samaritan MicroGrid

Project: 30601
Date: Feb 4/16

TABLE 2 - ELECTRIC CONSUMPTION SUMMARY

<u>Electric</u>	<u>Actual Data</u>			
	RPI	Fire Station #5	Kennedy Towers	Samaritan Hospital
	[kWh]	[kWh]	[kWh]	[kWh]
Sep-14	4,482,742	17,449	130,819	2,390,080
Oct-14	4,141,280	18,383	119,042	2,045,272
Nov-14	3,770,589	19,448	109,202	1,868,913
Dec-14	3,740,302	21,156	117,421	1,734,575
Jan-15	3,635,097	21,547	125,164	1,737,434
Feb-15	3,521,064	19,529	115,123	1,574,383
Mar-15	3,766,352	20,551	113,839	1,727,105
Apr-15	3,774,183	17,836	108,471	1,746,422
May-15	4,663,951	17,219	131,651	2,084,096
Jun-15	4,329,634	19,785	144,813	2,220,535
Jul-15	5,013,551	23,725	164,590	2,484,009
Aug-15	4,985,525	20,002	159,188	2,588,047

NY PRIZE - Troy NY
RPI Samaritan MicroGrid

Project: 30601
Date: Feb 4/16

TABLE 3 - STEAM LOAD SUMMARY

<u>STEAM</u>	<u>Actual Data</u>		
	RPI		
	Min. [Lbs/Hr]	Average [Lbs/Hr]	Max. [Lbs/Hr]
Sep-14	0	18,220	34,723
Oct-14	11,014	24,367	46,948
Nov-14	21,322	42,855	64,177
Dec-14	27,035	51,460	73,158
Jan-15	38,615	62,873	89,092
Feb-15	49,013	71,500	92,548
Mar-15	34,575	54,147	80,690
Apr-15	18,155	34,513	57,766
May-15	713	19,621	33,894
Jun-15	0	12,436	20,581
Jul-15	13,049	15,111	18,545
Aug-15	12,454	14,817	19,183

APPENDIX G

LOAD PROFILES

CHART 3
NY PRIZE - RPI-SAMARITAN MICROGRID
ELECTRIC LOAD PROFILE

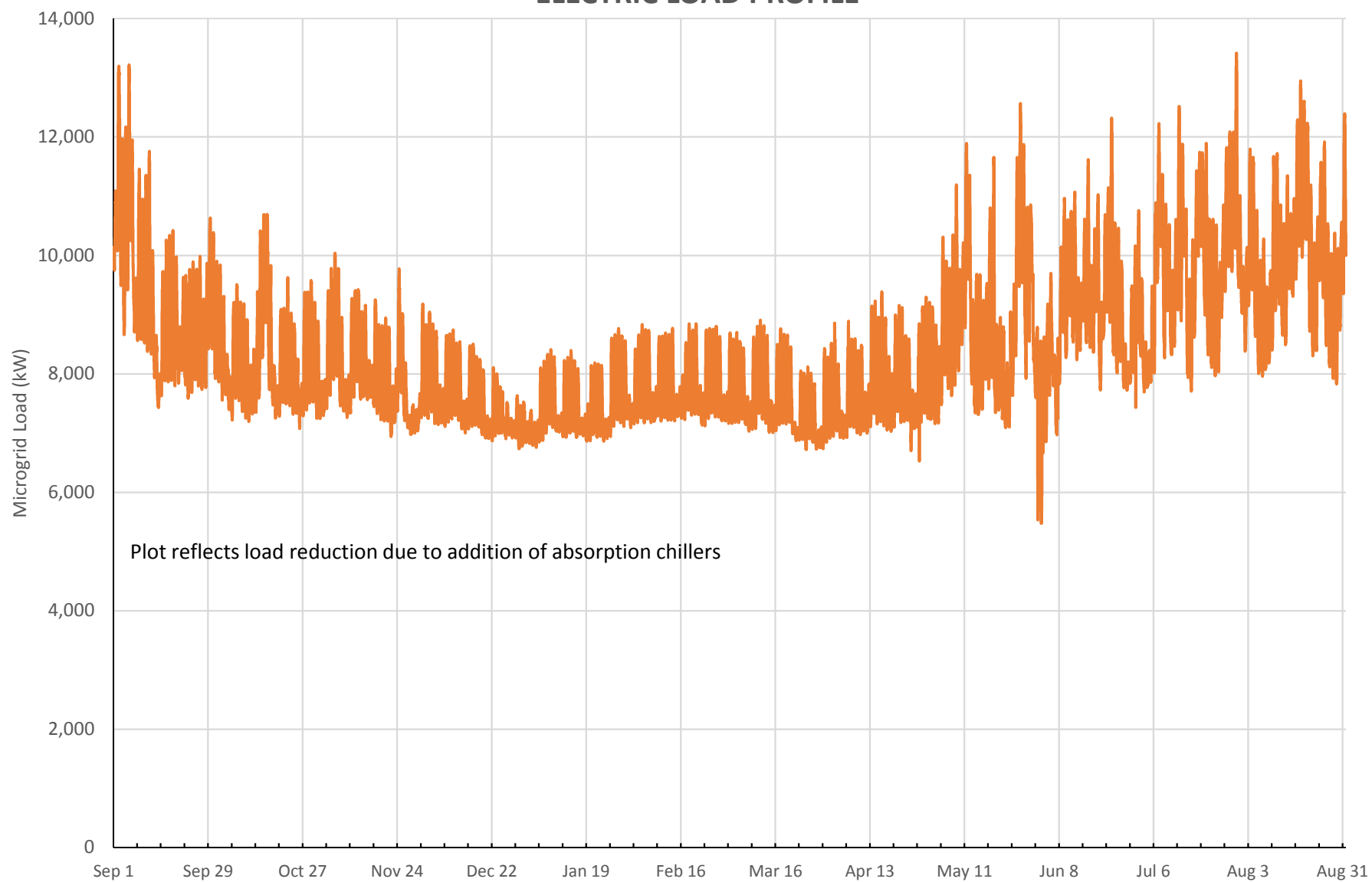
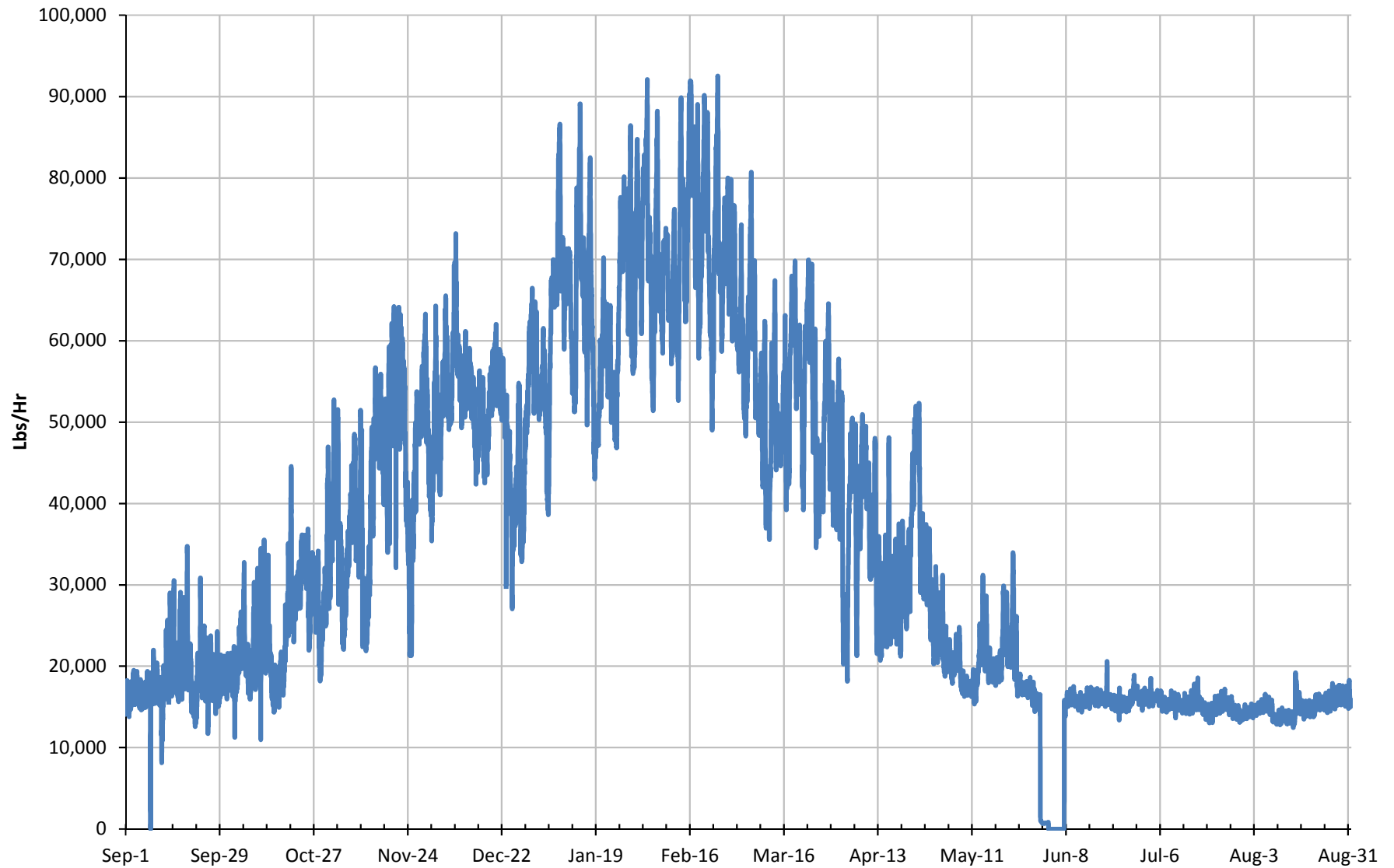


CHART 4
NY PRIZE - RPI-SAMARITAN MICROGRID
RPI Hourly Steam Load



APPENDIX H

SAVINGS ANALYSIS BY CASE

COGEN POWER TECHNOLOGIES
NY PRIZE- RPI-SAMARITAN MICROGRID
MICROGRID SAVINGS COMPARISONS

Project: 30601
Date: Apr 27/16
Issue: 06

	BASE CASE												
Inputs	1	2	3	4	5	6	7	8	9	10	11	12	13
Add Fire Station No. 5 Load	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Add Kennedy Towers Load	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Add Samaritan Load	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Use RPI NG ESCO billing rates for Base Case	no	no	no	no	no	no	no	no	no	no	no	no	yes
Use RPI NG ESCO billings rates for Cogen Case	no	no	no	no	no	no	no	no	no	no	no	no	no
RPI Gas Basis Reduction for Cogen Case - \$/Dth	0.000	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625
Electricity Sold at Retail Price	no	no	no	no	no	no	no	no	no	yes	no	no	no
Microgrid Customer Mark-up/Discount	no	no	no	no	no	no	no	no	no	no	yes	yes	no
Markup/Discount Amount - \$/MWh	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$15.00	\$15.00	\$0.00
Eliminate Incr State Assessment*	no	no	yes	no	no	no	no	no	no	no	no	no	no
Reduction of CHP Elec Contract Demand	0%	0%	0%	0%	0%	0%	50%	50%	50%	0%	0%	0%	0%
Reduction of Samaritan Distribution Delivery for MG Elec	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%
T&D Rate Discount for MG Elect to Samaritan	0%	0%	0%	50%	0%	50%	0%	0%	50%	0%	0%	50%	0%
T&D Rate Discount for Electricity to RPI	0%	0%	0%	0%	50%	50%	0%	0%	0%	0%	0%	0%	0%
Savings	1	2	3	4	5	6	7	8	9	10	11	12	13
RPI	\$1,205,723	\$1,655,140	\$1,713,605	\$1,655,140	\$1,732,242	\$1,732,242	\$1,706,659	\$1,706,659	\$1,706,659	\$1,872,309	\$1,891,041	\$1,891,041	\$2,066,156
Customer													
Fire Station No. 5	\$16,732	\$17,582	\$17,734	\$17,582	\$17,881	\$17,881	\$17,779	\$17,779	\$17,779	\$17,544	\$14,032	\$14,032	\$17,582
Kennedy Towers	\$83,456	\$88,948	\$89,936	\$88,948	\$90,954	\$90,954	\$90,237	\$90,237	\$90,237	\$88,727	\$65,859	\$65,859	\$88,948
Samaritan	\$111,790	\$164,153	\$173,115	\$268,551	\$164,153	\$268,551	\$164,153	\$206,968	\$268,551	\$103,992	-\$45,110	\$59,288	\$164,153
Total Customer	\$211,978	\$270,683	\$280,785	\$375,081	\$272,988	\$377,386	\$272,170	\$314,985	\$376,568	\$210,263	\$34,781	\$139,179	\$270,683
Total Savings	\$1,417,701	\$1,925,823	\$1,994,390	\$2,030,221	\$2,005,230	\$2,109,628	\$1,978,828	\$2,021,644	\$2,083,226	\$2,082,572	\$1,925,823	\$2,030,221	\$2,336,839
Vented Steam Potential Savings	\$205,014	\$190,103	\$190,103	\$190,103	\$190,103	\$190,103	\$190,103	\$190,103	\$190,103	\$190,002	\$190,103	\$190,103	\$190,103
Difference in Cogen Savings	-\$449,417	\$0	\$58,465	\$0	\$77,103	\$77,103	\$51,519	\$51,519	\$51,519	\$217,169	\$235,902	\$235,902	\$411,017
Difference in Total Savings	-\$508,122	\$0	\$68,568	\$104,398	\$79,408	\$183,806	\$53,006	\$95,821	\$157,404	\$156,749	\$0	\$104,398	\$411,017

*Applied to both gas and electricity bills. Not a reliable way to implement savings - Charges per kW for electricity and per therm for gas are adjusted occasionally and can go negative

APPENDIX I

PACE CLIMATE AND ENERGY CENTER – NY PRIZE REPORT

Business Model Analysis

1 Troy: RPI & Samaritan Hospital Project Overview

High among the list of metrics that are important for consideration in microgrids are those having to do with the value proposition. Outside of a handful of economic sectors (such as data centers, financial transactions processing, and high value-added manufacturing) most private, non-profit, and public institutions do not rigorously account for the value of energy resiliency at their site when making capital investment decisions.

NY Prize requires that at least one site involved be a “critical infrastructure” customer: “All winning projects must be integrated into utility networks and serve multiple customers, including at least one “critical infrastructure” customer, such as a hospital, police station, fire station or water treatment facilities.”¹ At this stage of market development, once critical infrastructure component is met, microgrids that offer the greatest value proposition to customers are those that present the most attractive economic return.

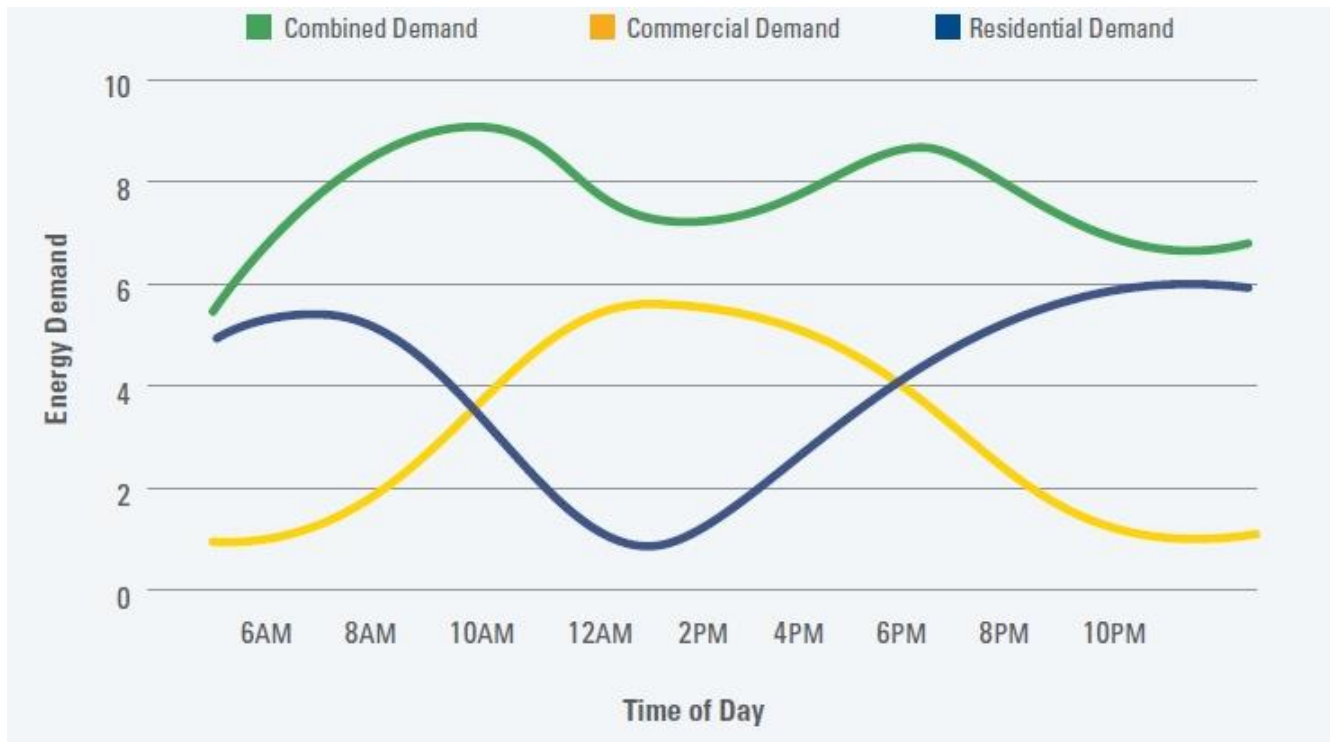
Hospitals have a strong incentive to maintain reliability under any circumstances. Many hospitals are under intense pressure to reconcile increasing costs with diminished revenue streams. In order to stay viable, hospitals must invest in the latest revenue producing capital equipment so as not to fall behind in the battle to continue to attract patients and top physicians. As a consequence of this competition for capital, investments in high efficiency energy saving equipment and systems often fail to make the “A” list of a hospital’s capital plan. For example, their management is more likely to see new radiology equipment as a better value proposition than a supplement to the physical plant. With such a scenario, under-investment in the physical plant leads to inefficiencies in operation, lost opportunities for income statement savings, and sub-optimal decisions on resiliency investments.

This project is exceptional insofar as it permits Samaritan Hospital and Kennedy Towers to take advantage of the CHP system that would be physically located on the grounds of RPI. The resiliency and economic benefits of CHP would be extended beyond the RPI campus, to serve as well the hospital and the low income senior community at Kennedy Towers

1.1 Extending the Economic, Resiliency, and Societal Benefits of CHP to Samaritan Hospital

RPI could pursue a Combined Heat and Power (CHP) investment independent of the inclusion of Samaritan Hospital. But Samaritan Hospital would likely not pursue a CHP project on its own. The Troy: RPI/Samaritan project provides an exceptional opportunity for pairing customers with significant complementary load profiles (see below chart for a representative example) and unlocks greater economies of scale. This brings costs low enough for the value proposition of the microgrid to be within Samaritan’s requirements.

¹ Source: Governor Cuomo’s press release announcing NY Prize Stage 1 Winners. July 8, 2015 at <http://www.nyserda.ny.gov/About/Newsroom/2015-Announcements/2015-07-08-Governor-Cuomo-Announces-Awards-to-83-Communities-to-Support-Clean-Energy>



ILLUSTRATIVE EXAMPLE OF COMPLEMENTARY LOAD PROFILES

Samaritan is already planning for a large expansion of their facility and this will create requirements for additional power. The hospital has an existing, and now growing, need for generation resources to insure continuity of services during unplanned extended power outages. Such requirements are often met with the use of emergency and backup generators. However, it's become increasingly evident that relying on rarely used emergency generation to provide ample power during longer-term outages may be a risky strategy for several reasons:

- Unexpected equipment failures
- Availability of diesel fuel – refueling in impacted areas during emergencies may be difficult or impossible and this puts constraints on run times
- The percentage of loads served by emergency power may be far less than what would be desired. To have a really well functioning hospital one has to invest in onsite generation significantly beyond the code requirements

The below side by side comparison shows why CHP is a better choice than backup generators.

	CHP	Backup Generation
System Performance	<ul style="list-style-type: none"> • Designed and maintained to run continuously • Improved performance reliability 	<ul style="list-style-type: none"> • Only used during emergencies
Fuel Supply	<ul style="list-style-type: none"> • Natural gas infrastructure typically not impacted by severe weather 	<ul style="list-style-type: none"> • Limited by on-site storage
Transition from Grid Power	<ul style="list-style-type: none"> • May be configured for “flicker-free” transfer from grid connection to “island mode” 	<ul style="list-style-type: none"> • Lag time may impact critical system performance
Energy Supply	<ul style="list-style-type: none"> • Electricity • Thermal (heating, cooling, hot/chilled water) 	<ul style="list-style-type: none"> • Electricity
Emissions	<ul style="list-style-type: none"> • Typically natural gas fueled • Achieve greater system efficiencies (80%) • Lower emissions 	<ul style="list-style-type: none"> • Commonly burn diesel fuel

Source: U.S. Department of Energy CHP Technical Assistance Partnerships

Continuously operated CHP (and other forms of DER, including microgrids with CHP) are a superior choice for providing resiliency services. In addition to providing more resilient power, CHP can provide an economic return to the site owner. Whereas emergency and backup generators are akin to an insurance policy – you buy them and hope you never use them. Properly designed, configured, and operated DER systems assure with a very high probability a continuity of energy services when the power grid is out of service. Combined heat and power (CHP) in particular, provides “heat resiliency” as a byproduct of greater electric power reliability at a site.

During Superstorm Sandy evacuations took place at several hospitals including Palisades Medical Center, Bellevue Hospital, Coney Island Hospital, and NYU Langone Medical Center. Hurricane Irene in August 2011 forced the evacuation of Johnson Memorial Medical Center in Stafford, CT.

Though emergency and backup generator failures are not the norm, their performance may warrant more detailed analysis as to whether or not they are proving a high enough reliability factor for critical healthcare facilities such as hospitals and nursing homes. Even if generators operate flawlessly, they often do not provide important habitability needs (heating, cooling). In contrast, CHP systems can provide electricity *and* heat resiliency to a site – and can serve far more of the energy demands than the emergency generators typically handle.

The blackout of August 13, 2003 lasted for just 24 hours yet, over this fairly brief time period, performance of emergency generators at New York City hospitals was spotty. President David Rosen of the health network that owns Jamaica, Flushing and Brookdale Medical Centers said New York should be thankful it dodged a bullet. “Hospital patients were moved around like checkerboard pieces yesterday as about half the city's 58 Hospitals suffered backup power failures during the black out.” He went on to say: “This is frustrating. A lot of applications are riding on one generator. We got calls: could we take ventilated patients, can we take dialysis patients - because of infrastructure breakdowns. We deserve better.”²

1.2 Troy Project Aids LMI Community

John F. Kennedy Towers, Senior Housing Apartments located at 2100 Sixth Ave, includes 135 units all serving a low and moderate income (LMI) population. The Troy: RPI/Samaritan project will extend the benefits of distributed energy and

² Patients shuffled, By MAGGIE HABERMAN and OWEN MORITZ DAILY NEWS STAFF WRITERS Saturday, August 16th, 2003.

resiliency to a population that is often left behind in new distributed energy investments. Incorporating this building into the microgrid will allow for the resident seniors to shelter in place in the event of a major storm or grid outage. This is far preferable from a quality of life aspect for them, as well as to the wider community by reducing this size of the vulnerable population that will need to be served by local government shelters and support agencies. Supporting such low and moderate income (LMI) housing is in direct alignment with REV goals as per the below excerpts from the Track 2 Staff Whitepaper:

“As the Commission stated clearly in the Framework Order, even while technological change has brought about significant opportunities for improvement through market mechanisms, electricity remains an essential service imbued with multiple public policy demands. Superstorm Sandy and other major climatic events that New York has experienced over the last several years demonstrate the growing need for reliable, resilient, affordable, and clean energy. The ratemaking principles and changes proposed here reflect the public policy objectives that surround power delivery, including, but not limited to, ensuring system reliability and security, protections for low-income customers, and actions to support attainment of the State’s environmental goals.”³

“Other crucial public policy objectives concerning the protection of the interests of low-income customers and continued gains in energy efficiency do, however, require additional emphasis and near term intervention to ensure their continued success.”⁴

“Customers with low and moderate incomes or who may be vulnerable to losing service for other reasons should have access to energy efficiency and other mechanisms that ensure they have electricity at an affordable cost.”⁵

“Because there is a separate proceeding to establish a uniform low-income discount approach, the first stage of REV rate design should be to incorporate any determination in that proceeding.”⁶

As the last excerpt points out, REV also calls for an additional proceeding specifically targeting the LMI sector:

“Low income programs must allocate a finite amount of dollars for assistance, and no amount of available funding is likely to meet the total needs of all eligible households; however, a stronger and more comprehensive approach to the design and delivery of these programs can be taken. Such an approach is warranted in light of pending industry changes, and in order to ensure that these programs address the most vulnerable customers, the most important program objectives, and the most pressing policy goals.”⁷

“The PSL States ‘It is hereby declared to be the policy of this state that the continued provision of all or any part of such gas, electric and steam service to all residential customers without unreasonable qualifications or lengthy delays is necessary for the preservation of the health and general welfare and is in the public interest.’ The 2014 Draft State Energy Plan updates this goal: ‘[To] facilitate greater access and support for energy efficiency opportunities in low income and underserved communities to provide those who are most vulnerable to increasing energy prices and least able to invest in clean energy with access and means to reduce their energy costs.’”⁸

³ CASE 14-M-0101 - STAFF WHITE PAPER ON RATEMAKING AND UTILITY BUSINESS MODELS - JULY 28, 2015 – Page 8

⁴ Id Page 45

⁵ Id Page 96

⁶ Id. page 103

⁷ Case 14–M-0565 - Proceeding on Motion of the Commission to Examine Programs to Address Energy Affordability for Low Income Utility Customers – Staff Report - June 1, 2015 - Page 2

⁸ Id. page 61

1.3 An Ideal Test Case for New Microgrid Market Development

The success of technically feasible, environmentally superior microgrids in New York State will take a maturing of the current state of regulation. The existing regulatory structure was not designed for incorporation of microgrids regardless of how beneficial they might be to end-users, the utility system, the surrounding community, or to the general public interest. There will be a need for balancing the interests of creating new markets for distributed energy resources, as contemplated by the REV, with the interests and fair treatment of the utility. This project can accomplish that.

The microgrid puts to the test the regulatory treatment of certain types of business transactions: between utility and microgrid and between participating microgrid customers, using utility assets. The economic viability of the project could be enhanced if the end users could reach an agreement to buy or lease select existing National Grid (NG) assets. The project would not be burdened by the cost of purchasing entirely new assets to facilitate the delivery of power from RPI to Samaritan. On the other hand, National Grid and its customers could benefit from the sale or lease of its existing equipment (the alternative being that the microgrid replicates the utility equipment, making it redundant, and thereby stranding NG's asset).

The technical deployment and configuration of the associated equipment is by no means new or exceptional in electrical engineering terms and the developer has prior experience in such work. This project can be implemented safely and without physical risk to the utility's assets or grid system.

There are no substantive financial reasons to block this implementation either. In fact, there are financial benefits to *both* the microgrid and the utility; and by extension, all ratepayers. The developer is willing to offer fair market value to acquire the utility's assets.

This is an instance where the barriers are neither technical nor financial; the obstacles to resolution are largely regulatory. Without this acquisition the microgrid will have to incur substantial capital costs to connect the university campus to the hospital. In so doing, this makes otherwise useful equipment owned by the utility redundant. If parties are unable to strike an agreement to exchange at fair market value the utility, and by extension its ratepayers, suffer a loss on the remaining economic value of the assets. This is a "lose – lose" result, whereby the proposed development is burdened with an unnecessary increase in capital costs and the ratepayers lose payment for the remaining economic value of these distribution system assets.

In the case of the CT Microgrid Pilot program, at least one development that we are aware of has taken advantage of this ability to purchase and utilize existing utility assets that are on the premises of the Microgrid customer. There may be more CT projects that will use this opportunity, but as of this writing our analysis has found that one project has utilized this method in their business and operational plan.

Another critical concept for the future viability of microgrids is the development of a transparent mechanism for generation owners to sell power to connected loads within the microgrid, while using the existing utility distribution. The sale of power and energy has to be set at a rate that allows for an economic return to the microgrid project. When the best course of action is to use *existing utility wires*, there must be a provision for microgrid developers to access that opportunity. It's in the best interest of ratepayers and society as a whole that some fair accommodations be met that would permit the Microgrid the use of the existing distribution system, rather than incurring the full burden of the cost of building new and redundant systems. The utility ought to receive a fair compensation, a fair distribution wheeling rate for providing this service.

As a test case for the REV, this project offers a set of challenges that are problems that can't be solved from an engineering standpoint, rather, these are issues of regulation and policy that need to be sorted out in an equitable fashion. The Troy: RPI/Samaritan project is ideal in that it meets all tests of engineering and financial/economic viability, while presenting an opportunity to create and standardize a set of fair market rules that bridge the interests of the utility, the end-users and society's best interests. These are development concepts that are central to furthering the REV vision.

1.4 Financing Model

At Stage 1 of NY Prize, the project team has not done, nor was it expected that we would complete, a detailed description of the financing plan and the capital structure for this proposed project. However managing and optimizing the financial is a critical factor for the ultimate success of the project. Consequently the team has begun an early stage analysis of various financing models and the benefits that might accrue with each. We have identified some interesting and innovative alternative approaches that would be thoroughly developed in a Stage 2 analysis.

For example, one model that has come to our attention is the use of a non-profit, third party ownership financial model can add value to any project that benefits a non-profit organization (hospital, school district, etc.) or public tax exempt entity (town, city, county or state). The non-profit third party ownership model has the potential of offering a very attractive cost of capital. Third party ownership may be desirable for hospitals, universities and other entities that are concerned about adding additional debt to their own balance sheets. If they are able to find an off balance sheet solution, where the cost of capital remains competitive with the tax exempt rates that they are used to incurring, this might prove to be an interesting avenue of exploration.

1.5 Exploring Opportunities for Testing REV Concepts

The projects selected for NY Prize can and will provide information for refining the concepts and the regulatory structures that will be the future foundation for REV. Maximizing the value of DER as dynamic assets serving the grid requires new systems that integrate traditional utility tools such as DMS and SCADA systems, and leveraging existing and emerging utility databases and other systems such as CIS, OMS and AMI.

Should this project be fortunate to NY Prize Stage 2, the team suggests building into the design, to the extent feasible and cost justified, an analysis of the value of “D”, that is an empirical analysis of the “value of distributed energy resources”, that may provide lessons learned, generalizable to the larger REV process. The following quotes from various Commission orders, demonstrates that establishing a sound rationale and empirical basis for LMP+’D’ is integral to the entire REV process

“The Commission has stated that achieving a more precise articulation of the full value of distributed energy resources (“DER”) is ‘a cornerstone REV issue.’”⁹

“The development of the tools and methodologies required to fully implement an approach [for valuation of DER] on the ‘Value of D’ is likely a long term effort.”¹⁰

“[the] ‘value of D’ can include load reduction, frequency regulation, reactive power, line loss avoidance, resilience and locational values as well as values not directly related to delivery service such as installed capacity and emission avoidance.”¹¹

“The “value of D” takes different forms and values depending on the application. For example, the first major application for the “value of D” is valuing alternatives to long term investments such as traditional utility investment, investment in DSP infrastructure and non-wire alternatives. A second application is compensation mechanisms, which includes rate design, LMP+D payments, as the basis for the transition from NEM.”¹²

⁹ NYS PSC, Case 15-E-0082, Proceeding on a Community Net Metering Program, Order Establishing a Community Distributed Generation Program and Making Other Findings, (July 17, 2015) p. 24 (CDG Order)

¹⁰ NYS PSC, CASE 15-E-0751, In the Matter of the Value of Distributed Energy Resources, Dec 23, 2015, Attachment A Page 1

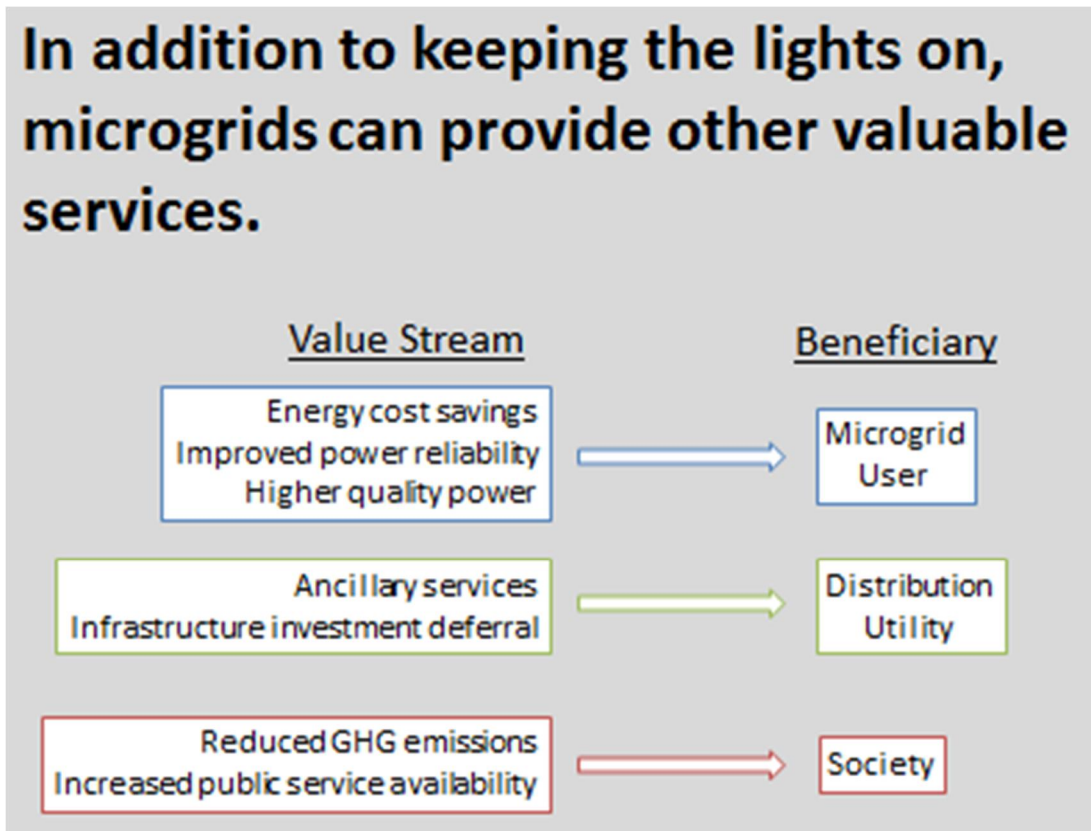
¹¹ NYS PSC, NEM Interim Ceilings Order, p. 9.

¹² NYS PSC, CASE 15-E-0751, In the Matter of the Value of Distributed Energy Resources, Dec 23, 2015, Attachment A Page 3

2 Microgrids – Overall Value Proposition

2.1 Beneficiaries

Three main groups benefit from the presence of microgrids: owner/users, the utility transmission and distribution grid, and societal at large.



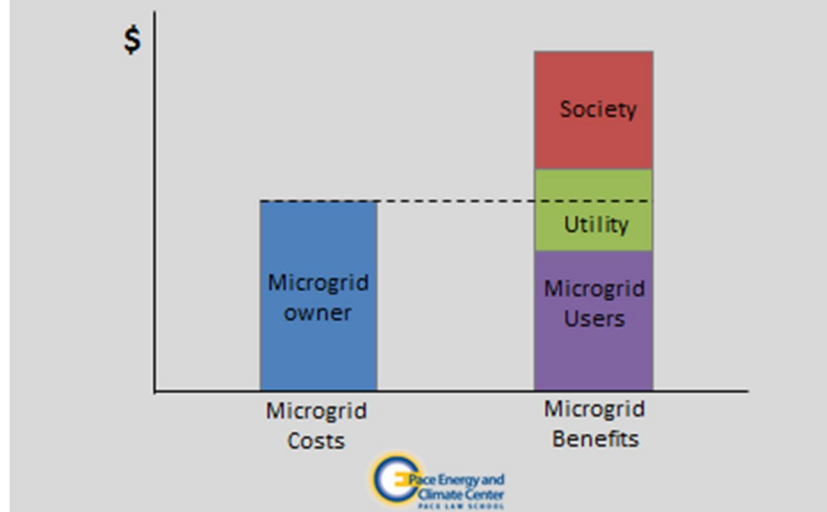
2.2 Total Benefits are Greater than Costs

NY Prize is an innovative, first-in-nation program that will speed the development of successful markets for multi-party microgrids. At this early stage of market development, New York is willing to invest some public funds in order to stimulate the market for projects with significant and demonstrable social benefits.

The ultimate objective is to create an environment where no public subsidies are required. Once REV markets are in place we can expect that high efficiency, environmentally superior, resilient microgrids will attract sufficient private sector investment capital, where they are economically viable.

The sum of total benefits (to the end-user, the utility and society) are greater than the total costs. However, due to the fact that end-users aren't compensated for the utility benefits and societal benefits that they create, meritorious projects will not materialize. The owner will not invest unless the benefits that they receive outweigh the costs that they incur. At the current time, some form of government support is likely to be necessary, in order to stimulate such an investment.

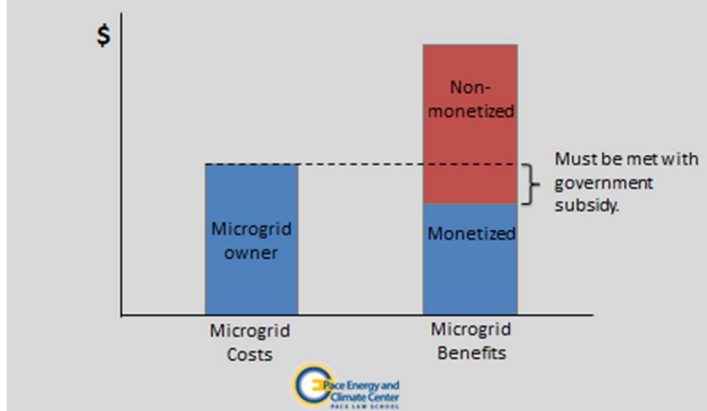
The private, utility, and public benefits produced by a microgrid may far exceed the microgrid's costs.



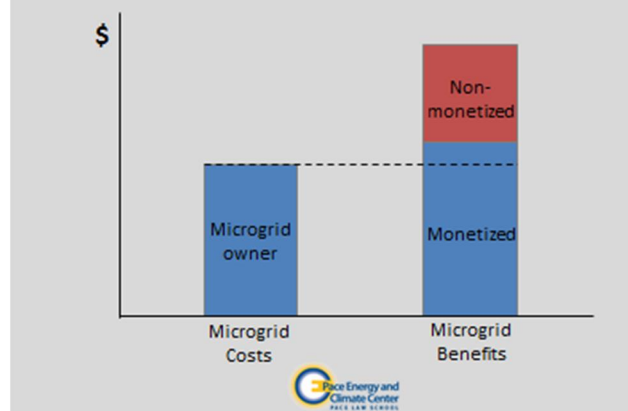
2.3 New Markets Are Needed

The objective should be creation of new markets for microgrid owners to capture a greater share the presently non-monetized benefits that they create. Self-funded microgrid development will arise over time by making progress on two

The microgrid developer must monetize enough of these benefits to obtain an adequate ROI.



The goal is self-funded microgrids that provide more resilient energy for our communities.



fronts. A self-sustaining industry will come about in part as a result of a reduction over time in microgrid costs.

3 Capital Reserves

As with any business, the microgrid will need to maintain an appropriate level of working capital to ensure adequate liquidity. As an example, with the inherent volatility in energy markets the microgrid will need to keep sufficient capital reserves on hand to cope with spikes in the price of natural gas or electricity due to the delay between the utility billing periods and those of the microgrid's customers.

The economic viability of the microgrid necessitates a strategy for continuity of operations of their customers. If the microgrid is offline the customers can't be without electricity or heat. Backup electric and thermal energy costs can be costly and will erode the value proposition for the customer and the economic return to the project. The microgrid must have in place arrangements for continuity of service. Sufficient cash reserves, or lines of credit, allow quick response to emergencies and other service interruptions: malfunctioning equipment, damaged distribution systems, etc. Such situations may be covered in part by insurance policies. Payments from such policies can have long delays; sometimes measured in months. Continuity planning and adequate capital reserves will be needed to bridge such a gap.

4 Metering

All electrical customers within the microgrid will have advanced metering hardware capable of measuring data at least as frequently as the utility (e.g., 15 minute data points). Meters will also measure a number of electricity variables beyond consumption: demand, voltage level, voltage frequency, and reactive power. If measurements are taken more frequently than the utility they will be at round multiple thereof. The microgrid might sample more frequently, particularly if this would facilitate the microgrid's participation in new ISO or distribution level markets that we anticipate are going to be developed as a consequence of the NY PSC REV proceeding.

Distributed Energy Resources (DER) such as auto-DR loads and combined head and power equipment will be metered at least as frequently as the end users (see above). Technical control and administration protocols will likely necessitate real time, or near to real time, monitoring. Participation in future ISO (wholesale) or utility (distribution / retail) markets for services, will require sophisticated and fast response communications, controls, and metering.

5 Billing and Customer Risks

The generation resources will be designed to meet specifically modeled consumption patterns (after accounting for energy efficiency). Absent long-term procurement arrangements, customers may decide to scale back or opt-out of their anticipated consumption shares. Such an occurrence would negatively impact the microgrid's ability to service debt and would reduce returns to equity partners. Financing is a major component of capital cost. The risk of customer defection and revenue erosion must be addressed otherwise it will increase the cost of debt and equity and could severely impact economic viability. There should be a mechanism in place for the microgrid to ensure long-term commitments that reasonably under-gird multi-year revenue projections from the sale of electricity and thermal energy to customers. This obligation needs to be secure several years into the future in order to support repayment of debt and to insure reasonable expectations for return on equity.

The microgrid should secure a contractual minimum billing level from their customers to insure adequate revenue. Additionally, there should be exit fees associated with early withdrawal from the microgrid supply agreement (decreasing over time) perhaps backed through an encumbrance on the real estate or with an agreement from the local municipality to guarantee payment in the event of default.

Ideally, such obligations should be structured to have some degree of transferability. For example, a current customer might wish to scale back their usage. At the same time a current customer (or new one) may be adding capacity and have an increasing energy need. Customers should be allowed to engage in "energy services trading" amongst themselves provided it doesn't mean a reduction in minimum billing thresholds or other negative impact on the microgrids required cash-flow. This type of structure will bring greater liquidity to the contractual obligations that will simultaneously make the long term procurement decisions more palatable to microgrid participants and less risky for debt and equity providers.

Note that the above considerations apply to both the electrical and thermal outputs of the system. Both types of energy should have specific quotas or thresholds set lest the demand of thermal and electrical power output from the CHP resources become mismatched.

6 Thermal Energy

6.1 Combined Heat and Power – Unit Sizing

The microgrid will generate thermal energy from local combined heat and power (CHP) equipment. This thermal energy will be sold to customers to address their thermal loads (space heating, hot water, and/or cooling). Certain customers may opt to contract with the microgrid to provide some or all of their thermal need(s) thereby allowing them to remove or substantially downsize their own local boiler plants, water heaters, and/or air conditioning systems.

Thermal energy generation benefits greatly from economies of scale. By aggregating customer loads together a lower marginal cost per unit can be achieved which provides good earnings potential for the microgrid. Additionally, if customers are able to completely outsource this portion of their operations then their costs are reduced through lower staffing requirements, maintenance expenses, and freed up floor space. Such benefits can be priced into the charges for thermal energy that the microgrid levies on customers, further increasing profitability.

There are several points of risk that the microgrid business plan must thoroughly take account of. First, if decommissioning their own equipment, thermal customers will expect that the microgrid will be able to provide their full peak demand: they expect that their building should be well heated on very cold winter days, and cooled to their desired level of comfort on hot summer days. Failing to do this will not only represent a loss of revenue and reputation for the microgrid but may also subject it to legal liability or fines. This may require the system to be designed with higher than anticipated capacity or redundancy to ensure a safety margin. That increased capacity could mean a higher initial capital expenditure and/or a minor degradation in system efficiency which could erode profitability.

The business plan for the microgrid should thoroughly investigate the building envelopes and heating systems of their customers ahead of time. The microgrid should avoid a situation where they design their thermal system assuming a load based on an old building that is poorly sealed. If that building is later weatherized, or has its distribution system updated, this could result in a much lower thermal requirement from the microgrid. That reduced demand would decrease thermal energy revenues from that customer as well as decrease the efficiency of the system overall because it now runs at a lower overall utilization level. The latter issue can be somewhat guarded against through the use of more prime movers; 6-7 smaller capacity units rather than 3-4 larger ones with the same total output, for example. This would allow units to be cycled on and off with greater efficiency and would help ensure that, when they *are* running, they do so at nearer to 100%.

A minimum threshold of *electricity* consumption is something customers will likely feel comfortable committing to, especially if cooling loads don't figure highly into that minimum threshold. Lighting, equipment, machinery, etc. are used year round. So this is a viable option for that revenue stream. However, this may not be viable for customers for heating charges. Rightly or wrongly they may perceive this as a potential penalty for them in the event of a warm winter; something out of their control. Likewise if the microgrid is providing cooling services. Inspection of buildings to model thermal needs and right-sizing the system is the recommended course of risk mitigation, rather than minimum charges, for thermal revenue.

6.2 Natural Gas Procurement

The microgrid will purchase natural gas for use in CHP systems. New York's Distributed Generation Gas Service Classifications provide for a significant discount for qualifying systems where natural gas is purchased for use in CHP systems. This will allow for input cost savings improving the economic viability of the microgrid.

As fuel costs are the primary factor in the cost structure of the microgrid there may be value to hedging input fuel cost risks. This risk can be somewhat mitigated by long term supply contracts but the longest of these are typically four (4) years. Longer contracts typically charge a much higher premium, to account for the greater uncertainty, and this premium often costs more than the downside risk customers are looking to hedge against. Therefore, on a 15+ year time horizon this risk factor will still be present for the microgrid.

As noted above, New York State's DG gas service classifications do provide preferential natural gas rates which are lower for gas utilized in CHP installations. The microgrid may be able to offer those customers purchasing thermal energy an attractive value proposition while maintaining sufficient margins on electricity and useful thermal energy sales.

One additional factor is that the cost of natural gas in New York State is largely influenced by the price of natural gas. As prices for gas increase, so do those for electricity. So while fuel costs for the CHP system may increase, this is directly correlated to an increase in the cost of the electricity that would otherwise have to be purchased from the utility by the microgrid's customers.

7 Electricity – Microgrid Owned Distribution

This section assumed that most or all microgrid customers will be connected into a common electricity distribution system that is owned and operated by the microgrid. In this instance, individual customers will be aggregated and will appear to the utility as "one large load" at the point of common coupling.

7.1 Electricity Generation

Output from the CHP system will provide a large portion of the microgrid's income. The greater the portion of customer loads accounted for by the microgrid, assuming economically attractive aggregated thermal / electric load profiles, the greater the revenue generation for the microgrid. Realizing economies of scale and high levels of asset utilization by connecting and aggregating loads, is key to maximizing this revenue source. Running at/near full load levels the CHP equipment (with heat recovery), for as many hours per year as possible, increases efficiency and enhances profit margins. The microgrid business model assumes that local generation at one site can be consumed by other customers either through direct connection or, in the case of connection via utility infrastructure, at the "retail rate."¹³

7.2 Demand Charges

Combining all customers into a single aggregated load will, by definition, reduce the level of demand seen at the point of common coupling (PCC). Separate connections result in an *additive* calculation method where each customer's monthly peak is summed together regardless of the day or time it occurred. Aggregation results in a *coincidental* peak demand calculation which, by definition, cannot be higher than the additive method. Since it's highly unlikely that all customers on the microgrid will incur their peak demand at the same time and on the same day, this will result in savings on grid purchased electricity. Energy efficiency investments and on site generation from CHP will further reduce aggregate demand and associated charges.

This reduction in demand charges from supplemental electricity purchases made from the macrogrid will mean a lower cost for electricity purchases from the grid on a per kilowatt hour basis. Consequently customers will save relative to the T&D charges that they would otherwise incur had they remained full service customers purchasing electricity from a competitive supplier and paying T&D charges to the utility.

7.3 Electricity Procurement

For supplemental power demands, over and above that provided by the onsite generation, the microgrid will be able to competitively procure grid purchased electricity for the aggregate load of its customers. This allows for lower per-unit costs from third party suppliers. There should be a net savings between what individual customers would have paid, absent the microgrid, and the group procurement arrangement that the microgrid can negotiate. This margin can be shared with some part accruing to a more attractive price to connected microgrid customers and the remaining share going to profitability of the microgrid.

7.4 Time Variant Pricing

Time Variant Pricing (TVP), also known as hourly pricing and time of day pricing, adds additional complexity to the measurement and verification (M&V) procedures, increases customer billing complexity, and offers an additional source

¹³ Akin to virtual net metering, or passing benefits to customers via an "offset tariff" type of arrangement

of potential revenue for the microgrid. The microgrid would be treated as a single large customer behind the common point of coupling. The microgrid should reserve space for battery storage to be added to the network.

The time difference in electricity prices for grid purchased electricity offers an arbitrage opportunity: charge the batteries up during less expensive time periods (e.g., at night) and discharge them in the grid during peak demand periods (e.g., 2-6 PM). The microgrid may choose to wait until after the system is up and running in order to get a more accurate measurement of specific usage profiles. However, a basis benefit-cost analysis for battery storage should be conducted as part of the phase 2 design.

The NYS REV proceeding is likely to advance the use of time variant pricing throughout the State. Having connectivity and physical space available for batter storage will allow the microgrid to more easily take advantage of new pricing schemes for electricity.

7.5 Customer Billing Procedure

The business model calls for microgrid customers to be billed for electricity from the microgrid at a fixed rate (with yearly escalation factors) while grid purchased electricity will be passed through at retail cost. Customer billing procedures, while not a source of financial risk, are a potential source of reputational risk.

The method by which local power is allocated to customers should be transparent and specifically spelled out in their contract. The cost of microgrid generated power will differ from the retail cost and on average it must be cheaper otherwise the value proposition of providing power at or less than current cost (with resiliency as a bonus) cannot be fulfilled.

At a minimum, retail prices for electricity will vary from month to month. If the microgrid is subject to time variant pricing this will increase the complexity of these calculations. In the latter case, prices vary from day to day and from hour to hour within the day and so microgrid generated power and supplemental power charges will need to take account of this.

The allocation method should take into account several key considerations including:

- When 100% of local microgrid electricity is being consumed, how is the output allocated among the customers? (Proportionally by average monthly load, by peak demand, by proportion on contracted minimum billing, or some other method?)
- How will demand charges (from the grid) be allocated among customers? Or will they be billed based on kWh only? If the former, how will the microgrid communicate the timeframe of the monthly peak demand to customers? In any case, will there be an incentive for customers to shift this demand? If subject to minimum demand billing in shoulder months, how are such charges allocated?

Customers will need key parameters included on their bills so that they can understand the variables that lead to specific costs.

7.6 Resiliency Configuration

The microgrid will not be able to supply peak demand to all customers when in island mode. Therefore the amount of electrical capacity allocated to customers during grid outages of extended duration should be clearly delineated in their contracts. The microgrid must ensure that customer's systems are configured to manage their load and make sure their thresholds are not exceeded. This may involve rewiring buildings and/or reconfiguring existing control systems. Likewise, their ability to join the microgrid must be contingent on installation and successful commissioning of this enabling equipment. It must be determined ahead of time whether the costs of these retrofits are to be embedded in the levelized cost of energy (LCOE) and borne by customers or paid for by them upfront.

As noted prior, the total cost of energy, including the embedded capital and operating cost of energy will be priced at a price per unit energy that gives connected customers a bill for electricity and purchased fuels that is less than or equal to

their “business as usual” costs. The expected savings from an agreed upon baseline, as well as the amount of electric (and thermal where applicable) energy services that would be provided during islanded operations, must be clearly communicated and defined in their contracts.

The microgrid may wish to provide “additional” resiliency as a service. Suppose for example, it’s determined that the services provided during an outage of extended duration would be X% of the total site demand and would encompass a specified list of life safety and critical infrastructure functions. It may be the case that a particular site would want additional capacity and more building services available. The microgrid may seek to negotiate a cost of “additional resiliency” and provide the financing of this into the microgrid contract. Furthermore, any additional operating expense that would be incurred by the microgrid to provide a “premium” resiliency service, on the demand of one site, would be an additional cost charged to that site. This would be especially valuable if the costs of capital for the microgrid is lower than the customer’s and if the incremental operations cost of resiliency are such that customers seeking “premium resiliency” are willing to pay the marginal cost for capturing this incremental benefit. Both of these options that comprise a “premium resiliency package,” and include incremental retrofit, capital financing and marginal operations costs are potential sources of additional revenue.

7.7 Demand Response

Some utilities offer their customers the option of participating in demand response programs. This typically involves the customer curtailing demand at a pre-set period after they’ve been notified of the time window in advance. The microgrid may be able to participate in this program through several possible methods:

- Microgrid dynamically curtails loads customer load (if they’ve opted in) scaling back HVAC systems and turning off ancillary equipment such as extra elevators
- Increases local generation to reduce the microgrid’s draw from the utility
- Discharges batteries charged at off peak times

Programs typically give compensation for participation in the summer/winter season (paid out regardless of the number of DR events, even if that is zero). Additional payments are made for energy provided in each DR event. Penalties are levied if customers fail to curtail load when dispatched. Enrollment in this program is another source of revenue for the microgrid; possibly with some cost share to specific customers that curtail load (by turning down the intensity of air conditioning, for example).

7.8 Net Metering and Electricity Export

Inherent in the very structure of a microgrid, is the ability to “internally net meter” between various local distributed energy resources and across microgrid connected buildings. This cost offset, from building to building and from customer to customer, is a major factor in the overall value proposition.

The business plan does not identify the export of electricity to the grid as a source of revenue for the microgrid. However, the success of the business plan rests upon the ability of securing an agreement to sell electricity to the hospital at a rate sufficient to recover variable and fixed charges. In the normal course of business Samaritan hospital will receive _____ of its electricity requirements from generation sited at the RPI campus. The agreement should fairly compensate National Grid for the use of its distribution system.

8 NY ISO Incentives

There are a variety of revenue streams; existing, proposed and anticipated that may be available to support the economic viability of the microgrid projects. The projects proposed here are not likely to be able to take advantage of the existing NYISO programs. However, at this writing, the NY ISO has authorized a new Behind the Meter: Net Generation program (BTM:NG) This program is expected to be launched for the Winter period of 2016. It will not be available during the summer capability period until the 2017 Summer Capability period, which runs from June 1, 2017 – September 30, 2017.

NY ISO – Day-Ahead Demand Response Program (DADRP)

Program where participants bid into the Day-Ahead Market for load curtailment at a specific rate (i.e., \$X/MWh). Accepted offers are notified by 11:00 a.m. of scheduled commitment for the next day (midnight-midnight) and a response is mandatory when selected (penalties are levied if participants fail to provide scheduled load reduction in real time). Note that the rules to permit behind-the-meter generation to participate are currently under review by FERC (Docket # EL13-74-000). Participants must provide an aggregate reduction of at least 1 MW. Offer floor price of \$75/MWh.

NY ISO – Emergency Demand Response Program (EDRP)

Voluntary program, similar to DADRP but the ISO offers a specific price (locational based marginal price – LBMP) for electricity. Customers perform load reduction through interruptible loads or loads with a qualified behind-the-meter local generator. Minimum reduction is 100kW. Payment is based on measured energy reduction during an event, with a minimum rate of \$500/MWh or the actual LBMP, if higher.

NY ISO – Installed Capacity (ICAP) Special Case Resources (SCR)

Similar to the EDRP except that customers offer into installed capacity (ICAP) auctions or may sell capacity in bilateral contracts. Customers perform load reduction through interruptible loads or loads with a qualified behind-the-meter local generator. Minimum reduction is 100kW. Note that for CHP this will generally require an “N+1” configuration of prime movers with the “extra” unit being brought online for participation in this program. There is a mandatory response during reliability events for a minimum of four hours. Payments are based on sales made through ICAP auctions or bilateral contracts and additional payments are made based on performance in events & tests (LBMP with daily guarantee of strike price recovery).

NY ISO – Behind the Meter: Net Generation (BTM:NG)

This program¹⁴ will allow participation in the wholesale market for customers that have on-site generation capability that routinely serves a Host Load (e.g., on site user) and has excess generation capability after serving that Host Load. Resources will be allowed to participate in the energy, capacity, and ancillary services markets.

Generation resources for this program must:

- Be designed and operated to facilitate the business function of the on-site load by providing electricity in the regular course of business
- Meet NYSDEC requirements to operate under non-emergency conditions
- Have an effective interconnection agreement
- Meet minimum net generation requirements (see program details for exact formula)
- Have appropriate metering configurations
- Be responsive to dispatch instructions as a single entity interfacing with the grid

9 Incentives

New York offers numerous incentives that reduce the initial capital cost for qualifying distributed energy resource investments. Oftentimes the higher initial capital costs are a deterrent to cost effective investments in efficiency, CHP, and renewable energy resources. Distributed energy resources may require higher upfront capital outlays, with recurring savings over time that more than offset this higher initial costs.

NYSERDA CHP Programs

NYSERDA will provide financial incentives of up to \$2.5M for CHP systems. These programs are currently being modified due to updates from the recently passed Clean Energy Fund (CEF). Prior programs include PONs 2568 & 2701. There is an incentives and services budget of \$22 Million, set aside for CHP in calendar year 2016.

¹⁴ This program is still in the design phase within the NYISO shared governance process. Currently the timeline for the incorporation of this program into NYISO tariffs is Q4 2016. For more info:

http://www.nyiso.com/public/webdocs/markets_operations/committees/bic/meeting_materials/2015-12-09/agenda_8_BTMMNG_BIC_Presentation.pdf

Targeted Utility/DSP DG Incentives

Strategically sited, appropriately configured and operated microgrids can allow the utility to defer or avoid significant distribution system capital expenditures. An example of one such program, now in existence is Con Edison's Case 14-E-0302 – Order Establishing Brooklyn/Queens Demand Management Program, issued and effective December 12, 2014. The BQDM program, currently in process with ConEd, offers a glimpse into how REV may drive incentives for CHP and DER.

Announced on December 8, 2015, qualifying CHP projects were being offered an incentive of \$1,800/Kw. Projects will have to meet Con Ed and NYSEDA terms of performance and be operational by June 1, 2017, the start of the 2017 Summer Capability period.

Modified Accelerated Cost Recovery System (MACRS)

The microgrid will investigate which of the assets comprising the system can take advantage of this portion of the tax code,¹⁵ a system by which entities can modify the way in which tangible assets are depreciated, to decrease their tax liability. For example, CHP systems qualify for the tax benefits accorded by the five year Modified Accelerated Cost Recovery System (MACRS). Accelerated depreciation generates savings to taxpayers by permitting them to take large percentages of their depreciation expense in qualifying physical capital in the early years of the investment. MACRS is only available to tax paying entities. Therefore, the choice of ownership model, for profit or not for profit, will determine the relevance of MACRS

Business Energy Investment Tax Credit (ITC)

Federal corporate tax credit: 10% for micro turbines and CHP. If not renewed through legislative action, the ITC will expire in 2016 <http://programs.dsireusa.org/system/program/detail/658>

- Maximum Incentive – Micro turbines: \$200 per kW, all other eligible technologies: no limit
- Eligible System Size – Micro turbines: 2 MW or less, CHP: 50 MW or less¹⁶

As noted above, Investment Tax Credits, production tax credits and preferential depreciation treatment are mechanisms that are only available to for profit entities. If the legal form of ownership that is chosen for the Troy: RPI / Samaritan project involves 3rd party ownership by a taxpaying entity, then these incentives will come into play. However, if the legal form of ownership is a non-profit or government entity, then these ownership forms are not eligible for the tax credits reported above.

Tax Exempt Financing

The microgrid will investigate ownership structures, through local government participation, that would allow for the issuance of tax exempt bonds or other tax-advantaged and low-cost financing. This would allow for lower interest rates and longer tenors. Hospitals, universities, nursing homes, and assisted living facilities are often economically attractive candidates for microgrid operations as well as high priorities for the provision of resiliency services. These institutions may benefit from low interest debt financing available from sources such as the Dormitory Authority of the State of New York (DASNY).

State authorities will typically have the capability to issue debt across the state, whereas local issuers of tax-exempt bonds, such as a city, a town or a county, can only finance activities within that governmental unit's geographic

¹⁵ <https://www.irs.gov/publications/p946/ch04.html>

¹⁶ Combined heat and power systems can only receive the full credit if the system has an electrical capacity of 15 MW or less, and a mechanical energy capacity of 20,000 HP or less, or an equivalent combination of electrical and mechanical energy capacities. Larger combined heat and power systems (up to a maximum of 50 MW and 67,000 HP) can qualify for a reduced tax credit equal to the ratio between the actual system capacity and 15 MW. For example, a 45 MW system can qualify for a tax credit worth 15/45 of the otherwise allowable credit.

boundaries. If the microgrid crosses a town's boundary this may restrict certain options. The eligible borrowers for tax-exempt bonds are defined in the federal tax code¹⁷ as:

- Nonprofit healthcare
- Nonprofit higher education
- Nonprofit K-12 schools
- Other nonprofit institutions such as museums, YMCAs, and YWCAs
- Low-income multifamily housing
- Industry and manufacturing for defined types of exempt facilities

NYPA Financing

The cost of capital is an important factor in the economic viability of a microgrid. After fuel cost, financing costs are the second largest component of cost. As a consequence, the obvious opportunities for a project to bring down costs is to address fuel cost and financing charges.

The cost of capital at today's rates for projects of similar scale and of a similar credit rating would likely be significantly greater, absent the strategic advantage of NYPA financing. This advantage makes the economics and the project rate of return more favorable than would otherwise be the case.

10 Reforming the Energy Vision (REV)

Reforming the Energy Vision (REV) is New York's comprehensive strategy to align state regulatory policies, clean energy programs and the development of new and expanded retail and wholesale markets to transform the production, consumption and delivery of energy in the State. The New York Department of Public Service declared that "REV is a strategy to build a clean, resilient and affordable energy system for all New Yorkers. REV proposes to achieve several goals that support the mission of a clean, resilient energy system."

In the REV Track 1 Order¹⁸ the Commission specified its policy on microgrids under REV, which is focused around five "attributes":

1. Ability to optimize system efficiency within the microgrid and advance REV objectives such as integration of clean distributed generation and addressing grid constraint
2. Interconnection with the larger utility system, assuming a DSP market that allows mutual benefits and services to be monetized
3. Resilience and the ability to island in the event of system outage, particularly where critical customer facilities are involved
4. The obligation to provide reliable power at just and reasonable rates within the microgrid
5. Consumer protections for residential customers as required by the Home Energy Fair Practices Act (HEFPA).¹⁹

10.1 REV Track 1 Goals

As identified in the Track 1 Order for Reforming the Energy Vision (REV) there are six main goals. Each of these goals (listed in the below sections) will be achieved through the creation of a community microgrid that adheres to these attributes.

Enhanced customer knowledge and tools that will support effective management of their total energy bill

Most parties committing to joining a community microgrid will be private, government, or non-profit groups, who have analyzed the benefits and costs and decided that the former outweighs the latter, making them highly educated customers. The customers served will be better informed about their energy breakdown because of their participation in

¹⁷ <http://energy.gov/eere/tax-exempt-bond-financing-nonprofit-organizations-and-industries>

¹⁸ <http://energy.pace.edu/sites/default/files/REV%20TRACK%201%20ORDER.pdf>, hereafter as "Track 1 Order"

¹⁹ *Id.*, at 112.

the microgrid, and the Special Purpose Entity (SPE) that oversees the microgrid will be managing energy production, distribution, and consumption, to ensure that everything is functioning efficiently.

Market animation and leverage of ratepayer contributions combined with system wide efficiency

(Note that this section addresses two of the six goals)

Under REV, utilities are urged to find innovative ways to put the ratepayers' dollars to work, specifically through contracting with outside sources of ancillary services. In the REV Staff Report and Proposal, the New York State Department of Public Service explains the value of microgrids, stating that they "support the overall utility grid, lightening the burden on congested infrastructure and avoiding investment in traditional system upgrades." By encouraging the implementation of ancillary services, like "frequency regulation, voltage support, and black start capability", the utilities will, as the REV Track 2 White Paper acknowledges, "optimize energy efficient and reliable electricity delivery," benefiting their own employees and business, as well as maximizing their use of revenue.

Another incidental ancillary service that a microgrid provides to the grid is a decrease in risk of total grid failure as a result of special circumstances, like a lapse in system security. As stated in the Track 1 Order, "[a] decentralized system... that is capable of segmentation and contains self-sufficient microgrids or similar configurations with appropriate firewalls, may be more resilient against the impacts of a wide scale cyber-attack." The utility also receives the benefit of having segments of the grid's design and infrastructure upgraded, e.g., with more resilient wiring and advanced methods of monitoring demand-response.

The establishment of a decentralized system featuring the use of community microgrids also improves system efficiency by lightening the load on utilities, especially during peak energy use hours. This is partially due to the use of energy storage, but also because of the addition of new energy sources, like PV arrays and CHP.

Fuel and resource diversity

The new sources of energy installed to power the microgrid improve the diversity of the energy market. While there is an initial installation cost to be accounted for, this can be offset by several incentives that these community microgrids can take advantage of.

System reliability and resiliency

Microgrids are especially important when it comes to system reliability and resiliency. Microgrids decentralize the electrical grid, and as stated in the Staff Report & Proposal, "during a utility grid outage, a microgrid can intentionally island itself to maintain critical loads." Subsisting only off of the power produced and stored in its community unit allows critical facilities within the microgrid to continue to have the capacity to serve the public in times of crisis or emergency, when the rest of the grid is down, without any danger of surges. Community microgrids that use underground wiring to create the islanded system are even more protected from outages due to storms or other weather events.

Reduction of carbon emissions

The energy mix consumed in these microgrid projects, partnered with the ancillary services provided, increase the efficiency of the energy consumed and decrease the amount of energy produced from fossil fuels, both of which lead to a reduction in carbon emissions.

If any more proof is needed of the success of a community microgrid partnering public and private stakeholders is needed, the multi-stakeholder microgrid in Utica, overseen by Burrstone Energy Center LLC, has been supporting the community since 2009. The group has even developed an algorithm that helps it make hourly decisions on how to most economically operate the plant, which could be applied in these projects if that is a concern that needs to be addressed.

10.2 Additional REV Initiatives

Several initiatives are underway that are expected to create new markets and revenue opportunities for microgrids and distributed energy resources generally.

New markets will take some time to develop. They are likely to take shape over a multi-year time frame. However there are some areas where DER's and microgrids can provide demonstrable support and value to the distribution utility.

Targeted Utility/DSP DG Incentives

Strategically sited, appropriately configured and operated microgrids can allow the utility to defer or avoid significant distribution system capital expenditures. An example of one such program, now in existence is Con Edison's Case 14-E-0302 – Order Establishing Brooklyn/Queens Demand Management Program, issued and effective December 12, 2014. The BQDM program, currently in process with ConEd, offers a glimpse into how REV may drive incentives for CHP. ConEd is working to reduce peak load demand on their Brownsville substation through energy efficiency and DER initiatives. One current incentive being offered is up to \$1,800/kW for CHP installations. This is in addition to any incentives the customer may receive from NYSEDA or other sources. The incentives received cannot be >100% of the installed cost. A qualifying project must be operational by the start of the 2017 Summer Capability Period (June 1, 2017).

Distribution utilities are being encouraged to submit “non-wires” pilots. The incentive levels will vary from location to location as the value of avoided marginal distribution capacity costs are highly variable across the State.

The value of Microgrids, operating in the right locations and at the right time of day and season of the year is now being realized in New York State.

Operational Services

Microgrids, and the suite of DER resources that comprise them, can serve as dynamic assets supporting the grid. REV envisions new markets, at the distribution system level and in concert with the NYISO, to mirror new wholesale markets for DER services. Some of the new services that might be offered by appropriately designed, configured and operated microgrids include:

- Frequency regulation
- Volt-ampere reactive (VARs) compensation
- Demand response services

There is precedent for distributed energy resources to capture revenue streams for the value that they create in wholesale markets. Princeton University reports that they first implemented FERC 755 Frequency Regulation in January 2013. They initially started by offering a 1 MW grid load change, accomplished by changing gas combustion turbine output (up / down). They report²⁰ that payments were averaging \$200,000 per MW/year PLUS a performance multiplier of up to 3X (\$600,000). In addition to utilization of the gas turbine for measured grid load changes, they expect also to be utilizing VFD's for this purpose.

Princeton is also providing Synchronous Reserves (FERC 755) in the PJM market. They entered the Synchronous Reserves market in October 2012. They report that potential savings are \$30,000/MW-year²¹

Solar Grid Storage (SGS) business focus is in the PJM Independent System Operator service territory. They are operating 4 storage projects in the PJM fast frequency regulation market. Response to FERC SGS has a pilot project at the Philadelphia Navy Yard, a stand-alone battery system. They have 2 projects in New Jersey co-located with PV projects at a commercial customer's site. What they describe as their flagship project is a solar microgrid at the Konterra Headquarters in Laurel, Maryland. It's a 500kW project providing frequency regulation services to PJM and backup power from the customer's 400kW PV parking lot canopy.²²

²⁰ “New Market Opportunities for CHP: Next Steps in Market Participation at Princeton and MIT. Presented at the International District Energy Association's 26th Annual Campus Energy Conference. February 18-22, 2013

²¹ Ibid.

²² TESTIMONY OF Christopher Cook President, Solar Grid Storage BEFORE THE HOUSE SUBCOMMITTEE ON ENERGY AND POWER LEGISLATIVE HEARING ON DISCUSSION DRAFT ON ACCOUNTABILITY AND DEPARTMENT OF ENERGY PERSPECTIVES ON TITLE IV: ENERGY EFFICIENCY JUNE 4, 2015

Though not publicly released yet, we expect to see one or more new microgrid projects, sited in the PJM footprint, which will be designed to capture revenues from PJM markets for ancillary services.

10.3 Recommendations to Facilitate Microgrid Market Development

There has long been a recognition that Microgrid development is hampered by the absence of formal statutory or regulatory recognition. Microgrids exist in New York but are addressed by PSC on a case-by-case basis. There is no clear set of rules to guide a microgrid developer, thus creating significant uncertainty and market risk.²³

The State of Connecticut addressed this matter, for certain types of customers and for particular public purposes. CT Public Act 13-298, section 39 authorizes that “a municipality, state or federal governmental entity authorized to distribute electricity across a public highway or street pursuant to section 39 of this act.”

Sec. 39. (NEW) (Effective July 1, 2013) The Public Utilities Regulatory Authority shall authorize any municipality or state or federal governmental entity that owns, operates or leases any Class I renewable energy source, as defined in section 16-1 of the general statutes, as amended by this act, Class III source, as defined in section 16-1 of the general statutes, as amended by this act, or generation source under five megawatts, to independently distribute electricity generated from any such source across a public highway or street, provided (1) any such source is connected to a municipal microgrid, as defined in subdivision (5) of subsection (a) of section 16-243y of the general statutes, as amended by this act, and (2) to ensure the reliability and availability of the microgrid delivery system and the safety of the public, such municipality or state or federal governmental entity shall engage the applicable electric distribution company, as defined in section 16-1 of the general statutes, as amended by this act, to complete the interconnection of such microgrid to the electric grid in accordance with the authority's interconnection standards. For purposes of this section, any such municipality or governmental entity shall not be considered an electric company, as defined in section 16-1 of the general statutes, as amended by this act.²⁴

10.4 Potential Future Revenue Streams

The PSC has laid out their initial vision for the revenue streams that will be enabled for DER under REV as part of their Benefit-Cost Analysis (BCA) Staff Whitepaper. The REV proceeding is still a work in process and so the exact mechanisms and revenue streams, and the incentive models for them, have not yet been solidified.

While the precise mechanisms are not fully developed the fact that the PSC anticipates that DERs, including microgrids with CHP, will be able to compensated for the measured value that they provide to utility operations and planning is not in doubt.

Below we have summarized numerous expected services that DERs may provide, as they were discussed in the Staff Benefit-Cost Analysis (BCA) Whitepaper. We also note that the Commission has ordered that the utilities file an Initial Distributed System Implementation Plan (DSIP) June 30, 2016 and a Supplemental Plan September 30, 2016²⁵

The importance of the DSIP is that it is expected that it will provide to market participants information on utility system needs and to identify opportunities for DERs to offer services to assist distribution system operation and distribution system capital investment requirements. The DSIP will also identify the mechanisms to deliver information that will facilitate market participation. It will define specific market mechanisms that will effectively elicit and compensate DER that can satisfy operations needs and capital investment requirements that have always been self-procured by the distribution utility.

²³ Case 13-E-0030, et al. Collaborative Working Group 2 Meeting, Summary of NYC DG Collaborative. Presentation By: Robert Loughney, Couch White LLP and Tom Bourgeois Pace Energy & Climate Center, October 3, 2013

²⁴ Public Act No. 13-298 AN ACT CONCERNING IMPLEMENTATION OF CONNECTICUT'S COMPREHENSIVE ENERGY STRATEGY AND VARIOUS REVISIONS TO THE ENERGY STATUTES. Page 72 or 110.

²⁵ Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, Order Adopting Regulatory Policy Framework and Implementation Plan, (issued February 26, 2015) (Track I Order).

The BCA Whitepaper indicates the range of various potential activities that provide value to the system. Historically DERs may have provided some of these values, though they were never measured, monitored, taken account of in utility planning and operations, and as a consequence they went uncompensated. In the future we expect that appropriately designed, configured and operated Microgrids with CHP, those that are in the right locations and operating at the right time of day and season of year, will be paid for the value(s) that it is creating for the utility system.

The precise available revenue streams will become clearer as the DSIP model(s) are fleshed out. However, it is illustrative to examine the categories that have been identified in the paper (and summarized below). Material is from Staff Whitepaper on Benefit-Cost Analysis in the Reforming Energy Vision Proceeding 14-M-0101, July 1, 2015.²⁶

A key point to note is that a CHP centric microgrid is poised to take advantage of many of these revenue streams; though it would be rare for a project to be able to leverage all of them. Also, it will mean tighter constraints on the design, configuration, and operations of the microgrid. The developer will do their own internal BCA to determine if the costs of these tighter constraints are exceeded by the benefits of the extra revenue that can be brought in.

Avoided Generation Capacity (ICAP) Costs, including Reserve Margin: ICAP costs are driven by system coincident peak demand. Thus, this component of benefits applies to the extent to which the resources under consideration reduce coincident peak demand.

Avoided Energy – Location Based Marginal Pricing (LBMP): This includes costs for a number of other factors: (1) compliance costs of various air pollutant emission regulations including the Regional Greenhouse Gas Initiative and now-defunct SO₂ and NO_x cap-and-trade markets; (2) transmission-level line loss costs; and (3) transmission capacity infrastructure costs built into the transmission congestion charge.

Avoided Transmission Capacity Infrastructure and O&M: A portion of the Avoided Transmission Capacity Infrastructure and related O&M costs are included in both the Avoided Generation Capacity (ICAP) and Avoided Energy (LBMP) benefit categories. Transmission capacity and O&M costs are reflected in the difference between zonal ICAP clearing prices. Generation assets located in high load and congestion areas, such as New York City, the lower Hudson Valley, and Long Island, clear the ICAP market at a higher price in reflection of the fact that load serving entities in those areas are required to purchase generation from local assets due to restrictions on the transmission system, which precludes the purchase and transport of generation from cheaper assets further away from the load. Transmission congestion charges, related to the availability of transmission infrastructure to carry energy from zone to zone, are included in the LBMP. Both the ICAP prices and transmission congestion charges would be decreased in the event that additional transmission assets are built or load is reduced.

Avoided Transmission Losses: A portion of the Transmission Loss costs are included in the LBMP, and are therefore partially counted already through the Avoided Energy (LBMP) benefit category as part of the costs included in the LBMP. To the extent that there are avoided transmission losses above and beyond what is included in the LBMP, such losses should be considered separately herein.

Avoided Ancillary Services: Required ancillary services, including spinning reserve, frequency regulation, voltage support and VAR support would be reduced if generators could more closely follow load. Certain projects will enable the grid operator to require a lower level of ancillary services or to purchase ancillary services from sources other than conventional generators at a reduced cost without sacrificing reliability.

Avoided Distribution Capacity Infrastructure: A utility's decision of what infrastructure to invest in, and when to make that investment, is generally driven by two factors: first, its need to meet the peak demand placed on its system; and

²⁶ [http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/c12c0a18f55877e785257e6f005d533e/\\$FILE/Staff_BCA_Whitepaper_Final.pdf](http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/c12c0a18f55877e785257e6f005d533e/$FILE/Staff_BCA_Whitepaper_Final.pdf)

second, the amount of available excess capacity on its system. The importance of these factors can vary depending upon the voltage at which an incremental load is connected to the utility grid.

Avoided O&M Costs: Certain projects could result in lower operation and maintenance costs, due to, for example, lower equipment failure rates, while other measures may increase operation and maintenance expenses due to, for example, increased DER interconnections. These changes in O&M should be determined by using the utility's activity-based costing system or work management system.

Avoided Distribution Losses: The difference in the amount of electricity measured coming into a utility's system from the NYISO or distributed generators and the amount measured by the Company's revenue meters at customer locations is defined as the "Loss" or "Losses" experienced on the Utility's system. Losses can be categorized as technical and non-technical losses, where technical losses are the amount of energy lost on the utility's system as heat and the magnetic energy required to energize various pieces of equipment used by the utility, and non-technical losses represent energy that is delivered but not registered by utility revenue meters. For the purposes of these analyses, the PSC will focus on technical losses. Technical losses can be further categorized into fixed and variable losses, and attributed to various pieces of equipment. While both fixed and variable losses are significant, actions taken by customers and the utility will have a greater impact on variable losses since fixed losses can only be reduced marginally by replacing equipment with lower loss models or removing equipment from service. Variable losses should be considered when a project increases or decreases the load served on a utility's system. The impact of the increased or decreased load should be considered for all levels which will be affected. For example, a self-supplying microgrid connected at a utility's transmission voltage would reduce transmission line losses, but not distribution line losses.

Net Avoided Restoration Costs: Projects such as automated feeder switching or improved diagnosis and notification of equipment conditions could result in reduced restoration times. To calculate this avoided cost, utilities could compare the number of outages and the speed and costs of restoration before and after the project is implemented. Such tracking would need to include the cause of each outage. The change in the restoration costs could then be determined.

Net Avoided Outage Costs: Avoided outage costs could be determined by first determining how a project impacts the number and length of customer outages then multiplying that expected change by an estimated cost of an outage. The estimated cost of an outage will need to be determined by customer class and geographic region. We note that outage mitigation often factors into a utility's decisions to invest in T&D infrastructure, so some portion of outage costs are already included in the Avoided T&D Infrastructure category described above.

Externalities: in addition to pecuniary costs and benefits, utilities need to consider out-of-market public costs and benefits that DER impose or provide. Many of these (such as land, water, and neighborhood impacts) will depend on the specific alternatives considered and will likely need to be weighed in a qualitative and judgmental way. However, the quantitative impact of three damaging gas emissions— SO_2 , NO_x , and CO_2 —are measured and modeled at the bulk level and can be estimated at the DER level. Both externality "taxes" and C&T programs result in a price being placed on each ton of damaging gas emitted, so both approaches "internalize" some or all of the external damage costs. This is important to keep in mind when valuing the net, or un-monetized, portion of marginal damage costs caused by bulk power generation. If externality prices were set high enough to equal marginal damage costs per ton emitted, wholesale LBMPs would fully reflect the social value of emission-free generation with respect to the pollutants covered by the emission pricing program.

Net Non-Energy Benefits: Non-energy benefits include, but are not necessarily limited to, such things as health impacts, employee productivity, property values, reduction of the effects of termination of service and avoidance of uncollectible bills for utilities. While Staff recognizes the existence of these costs and/or benefits, we propose that such difficult-to-quantify costs and benefits not be monetized at this time. However, when utilities consider specific alternatives, they should recognize any of these impacts when relevant, and weigh their impacts, quantitatively, when possible, and qualitatively, when not. For example, if a DER proposal for low and moderate income customers results in a reduction in

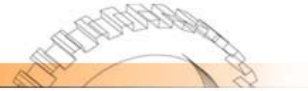
the number of utility service terminations, the corresponding resource savings should be reflected in the SCT cost test results.

Wholesale Market Price Impacts: Distributed energy resources reduce the need for wholesale generation. DERs can obviate the need for calling on the next marginal generating unit. The marginal unit sets the price for all infra-marginal generators. That increase in price, which is avoided by DER, provides a benefit to all electricity consumers (reducing the price of energy and the price of demand). This is sometimes referred to as Demand Reduction Induced Price Effect (DRIPE).

APPENDIX J

CARBON REDUCTION CALCULATIONS

CHP Results



The results generated by the CHP Emissions Calculator are intended for educational and outreach purposes only; it is not designed for use in developing emission inventories or preparing air permit applications.

The results of this analysis have not been reviewed or endorsed by the EPA CHP Partnership.

Table 1

Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO _x (tons/year)	23.92	21.61	18.66	16.36	41%
SO ₂ (tons/year)	0.24	43.32	0.11	43.19	99%
CO ₂ (tons/year)	46,961	38,322	21,819	13,180	22%
CH ₄ (tons/year)	0.89	1.438	0.41	0.964	52%
N ₂ O (tons/year)	0.09	0.353	0.04	0.306	78%
Total GHGs (CO ₂ e tons/year)	47,007	38,462	21,840	13,295	22%
Fuel Consumption (MMBtu/year)	803,436	573,250	373,287	143,102	15%
Equal to the annual GHG emissions from this many passenger vehicles:				2,516	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				1,646	

This CHP project will avoid yearly emissions of greenhouse gases by 13,295 tons of carbon dioxide equivalent.

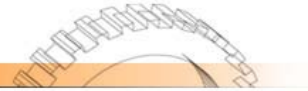
Equal to the annual greenhouse gas emissions from 2,516 passenger vehicles.



Equal to the annual greenhouse gas emissions from the generation of electricity used by 1,646 homes.



CHP Results



The results of this analysis have not been reviewed or endorsed by the EPA CHP Partnership.

Table 2

CHP Technology: Combustion Turbine	
Fuel: Natural Gas	
Unit Capacity:	7,343 kW
Number of Units:	1
Total CHP Capacity:	7,343 kW
Operation:	8,460 hours per year
Heat Rate:	11,668 Btu/kWh HHV
CHP Fuel Consumption:	724,882 MMBtu/year
Duct Burner Fuel Consumption:	78,554 MMBtu/year
Total Fuel Consumption:	803,436 MMBtu/year
Total CHP Generation:	62,127 MWh/year
Useful CHP Thermal Output:	276,233 MMBtu/year for thermal applications (non-cooling)
	57,101 MMBtu/year for electric applications (cooling and electric heating)
	333,333 MMBtu/year Total

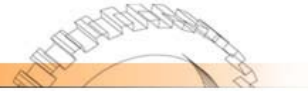
Table 3

Displaced On-Site Production for Thermal (non-cooling) Applications:	Existing Gas Boiler 0.10 lb/MMBtu NOx 0.00% sulfur content
Displaced Electric Service (cooling and electric heating):	817 tons of cooling capacity from CHP system
	CHP: Single-Effect Absorption Chiller
Replaces: User Defined	
	5.86 COP

Table 4

Displaced Electricity Profile: eGRID Fossil Fuel (2012 data)	
Egrid State: UP Upstate NY	
Distribution Losses: 9%	
Displaced Electricity Production:	62,127 MWh/year CHP generation
	1,999 MWh/year Displaced Electric Demand (cooling)
	- MWh/year Displaced Electric Demand (electric heating)
	6,474 MWh/year Transmission Losses
	70,599 MWh/year Total

CHP Results



The results of this analysis have not been reviewed or endorsed by the EPA CHP Partnership.

Table 5

Annual Analysis for CHP				
	CHP System: Combustion Turbine	CHP System: Duct Burners		Total Emissions from CHP System
NO _x (tons/year)	19.99	3.93		23.92
SO ₂ (tons/year)	0.21	0.02		0.24
CO ₂ (tons/year)	42,369	4,591		46,961
CH ₄ (tons/year)	1	0		1
N ₂ O (tons/year)	0	0		0
Total GHGs (CO ₂ e tons/year)	42,411	4,596		47,007
Fuel Consumption (MMBtu/year)	724,882	78,554		803,436

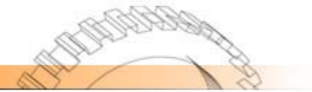
Table 6

Annual Analysis for Displaced Production for Thermal (non-cooling) Applications				
				Total Displaced Emissions from Thermal Production
NO _x (tons/year)				18.66
SO ₂ (tons/year)				0.11
CO ₂ (tons/year)				21,819
CH ₄ (tons/year)				0
N ₂ O (tons/year)				0
Total GHGs (CO ₂ e tons/year)				21,840
Fuel Consumption (MMBtu/year)				373,287

Table 7

Annual Analysis for Displaced Electricity Production					
	Displaced CHP Electricity Generation	Displaced Electricity for Cooling	Displaced Electricity for Heating	Transmission Losses	Total Displaced Emissions from Electricity Generation
NO _x (tons/year)	19.01	0.61	-	1.98	21.61
SO ₂ (tons/year)	38.12	1.23	-	3.97	43.32
CO ₂ (tons/year)	33,723	1,084.82	-	3,514.14	38,322
CH ₄ (tons/year)	1.266	0.04	-	0.132	1.438
N ₂ O (tons/year)	0.311	0.01	-	0.032	0.353
Total GHGs (CO ₂ e tons/year)	33,846	1,089	-	3,527	38,462
Fuel Consumption (MMBtu/year)	504,456	16,228	-	52,567	573,250

CHP Results



The results of this analysis have not been reviewed or endorsed by the EPA CHP Partnership.

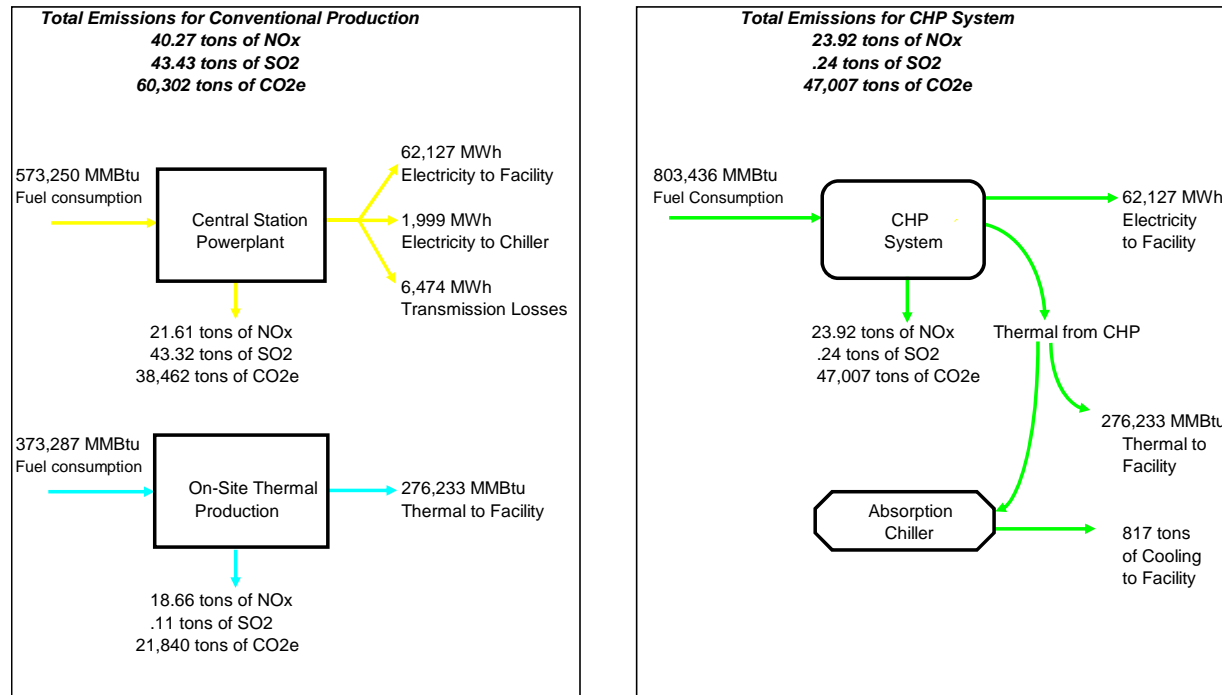


Table 8

Emission Rates			
	CHP System including Duct Burners	Combustion Turbine Alone	Displaced Electricity
NO _x (lb/MWh)	0.77	0.64	0.61
SO ₂ (lb/MWh)	0.01	0.01	1.23
CO ₂ (lb/MWh)	1,512	1,364	1,086

Table 9

Emission Rates	
	Displaced Thermal Production
NO _x (lb/MMBtu)	0.10
SO ₂ (lb/MMBtu)	0.00059
CO ₂ (lb/MMBtu)	116.90

APPENDIX K

PROPOSED CHP PLANT RENDERINGS

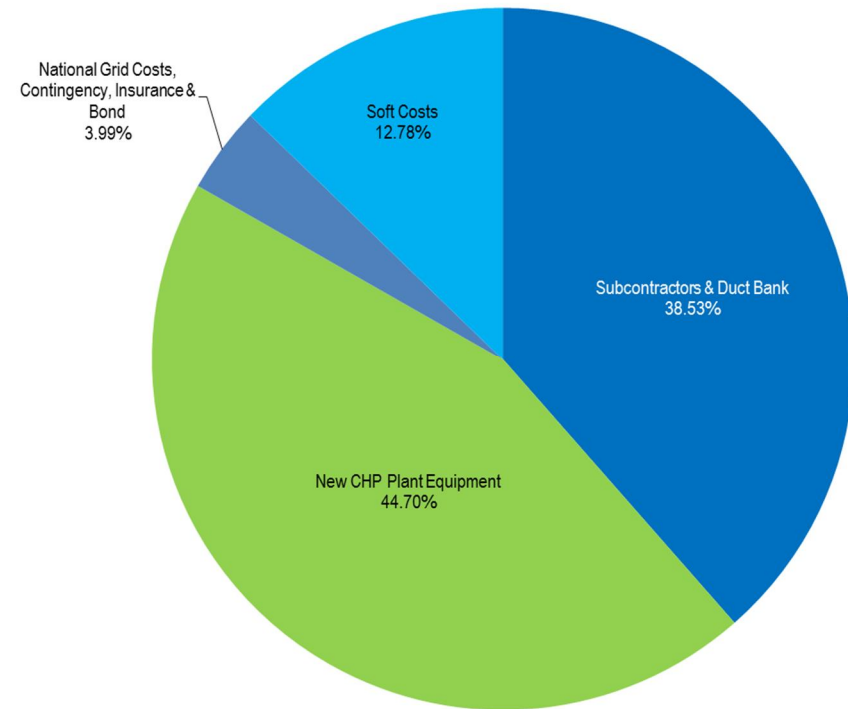


APPENDIX L

CAPITAL AND OPERATING COSTS

CAPITAL COST

DESCRIPTION	2016 COST
Subcontractors & Duct Bank	\$10,353,717
New CHP Plant Equipment	\$12,014,028
National Grid Costs, Contingency, Insurance & Bond	\$1,071,631
Design Engineering Fee	\$3,434,787
TOTAL	\$26,874,163



OPERATING COST

COST PER YEAR	DESCRIPTION
\$789,000	Turbine, HRSG, Gas Compressor, BSG, Chiller, Miscellaneous Maintenance all for the CHP Plant. Annual oil samples from each customer transformer, labor, and lab testing of oil. Infrared inspections, minor part replacements.

APPENDIX M

BURRSTONE ENERGY CENTER PSC WAIVER

STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

At a session of the Public Service
Commission held in the City of
Albany on August 22, 2007

COMMISSIONERS PRESENT:

Patricia L. Acampora, Chairwoman
Maureen F. Harris
Robert E. Curry, Jr.
Cheryl A. Buley

Case 07-E-0802 - Burrstone Energy Center LLC - Petition For a
Declaratory Ruling That the Owner and
Operator of a Proposed Cogeneration Facility
Will Not Be Subject to Commission
Jurisdiction.

DECLARATORY RULING ON
EXEMPTION FROM REGULATION

(Issued and Effective August 28, 2007)

BY THE COMMISSION:

BACKGROUND

In a Petition filed on July 9, 2007, Burrstone Energy Center LLC (Burrstone) requests issuance of a Declaratory Ruling finding that the 3.6 MW cogeneration facility it intends to construct in Oneida County will not be regulated under the Public Service Law (PSL). Burrstone reports that it will provide electric and steam service to Faxton-St. Luke's Health Care, Inc. (the Hospital), and electric service to Utica College (the College) and St. Luke's Home Residential Health Care Facility, Inc. (the Home). Burrstone believes its facility, including its appurtenant distribution lines, is a qualifying cogeneration facility (QF) under PSL §2(2-a) and §2(2-d).

No responses to the Petition were received within the 21-day period prescribed under the Rules of Procedure, 16 NYCRR §8.2(c). That period expired on July 30, 2007.

THE PETITION

Burrstone begins by describing its cogeneration facility as consisting of four natural gas-fueled engine generators with a total capacity of approximately 3.6 MW that will operate in parallel with the system of the local utility, National Grid (Grid). The thermal output from the engine generators will be consumed by the Hospital in the form of steam and hot water, enabling it, through the installation of absorption chillers, to meet its cooling needs as well as its heating needs. The thermal energy usage, Burrstone asserts, will satisfy the requirements of the Public Utility Regulatory Policies Act of 1978 (PURPA) and PSL §2(2-a), enabling it to obtain QF status under both federal and state law.

Besides distributing electricity to the Hospital, the College, and the Home, Burrstone intends to sell excess electricity to Grid. The Hospital, the College and the Home will remain Grid customers, purchasing from it any electricity they need in excess of the cogeneration facility's production.

Its generators, Burrstone relates, will be installed in a separate building constructed on the Hospital's campus. From the cogeneration building, separate electric distribution systems will lead to the College, the Hospital, and the Home. To reach the College, Burrstone will install approximately 3,800 feet of underground cable that will cross underneath Champlin Avenue, a public street separating the Hospital and College campuses, and extend into the College campus. Thermal energy will be delivered to the Hospital through an approximately 50-foot pipeline. Burrstone anticipates commencing construction of

the project soon, and is aiming to enter service by the first quarter of 2008.

The project, says Burrstone, will benefit the customers and will further important public policies. Burrstone emphasizes that the new cogeneration facility will replace older, less efficient facilities, including the Hospital's boilers that are more than 50 years old. Burrstone also notes that, because its cogeneration project will enable the customers to achieve significant energy savings and enhances service reliability, in conformance with public policies, it was able to obtain a grant of \$1.0 million from the New York State Energy Research and Development Authority.

Asserting that it qualifies for the exemptions from regulation afforded to QFs under the PSL, Burrstone contends that it is a cogeneration facility under PSL §2(2-a), because it is sized at less than 80 MW, it generates electricity, and it produces thermal energy that is useful for commercial purposes. Its electric and steam distribution lines, Burrstone continues, are "related facilities" falling within the scope of the QF exemptions.

Burrstone cites the Nassau District and Nissequogue Rulings for the proposition that cogeneration facilities similar to its configuration have been granted the QF exemptions from regulation.¹ It notes that its electric and steam distribution lines are shorter than the lines that, in those Rulings, were deemed related facilities under PSL §2(2-d) because located "at or near" the cogeneration facilities.

¹ Case 89-E-148, Nassau District Energy Corporation, Declaratory Ruling (issued September 27, 1989); Case 93-M-0564, Nissequogue Cogen Partners, L.P., Declaratory Ruling (issued November 19, 1993).

The only feature of its project that distinguishes it from the Nassau District and Nissequogue projects, Burrstone explains, is that those cogeneration facilities serve only one user owning property on both sides of a street. Its facility, Burrstone continues, will supply multiple users, with one user, the College, owning property separated from the others by a street. Burrstone asserts, however, that PSL §2(2-d) explicitly contemplates multiple users, in providing for inclusion within the definition of related facilities those needed to transmit electricity or steam to "users," in the plural. That its electric line to the College crosses a street, Burrstone continues, does not remove the line from the scope of the §2(2-d) definition of related facilities. In both the Nassau District and Nissequogue Rulings, Burrstone emphasizes, distribution lines that crossed streets were treated as related facilities.

As a result, Burrstone believes its cogeneration facility, including the electric distribution line to the College, falls within the ambit of the exemptions from regulation granted to QFs, under PSL §2(3), §2(4), §2(13) and §2(22). Therefore, Burrstone concludes it is not, respectively, a corporation, person, electric corporation, or steam corporation for the purposes of the PSL.

DISCUSSION AND CONCLUSION

Under PSL §2(2-a), a cogeneration facility is defined as an electric generating plant sized at up to 80 MW, together with any related facilities located at the same project site, which simultaneously or sequentially produces electricity and thermal energy useful for industrial or commercial purposes. The electric and steam cogeneration facility that Burrstone intends to construct resembles the facilities found to satisfy

the §2(2-a) statutory definition in the Nassau District and Nissequogue Rulings. As a result, its cogeneration facility falls within the ambit of the §2(2-a) criteria.

Under PSL §2(2-d), a cogeneration facility includes, besides the electric and steam cogeneration facility itself, "such transmission or distribution facilities as may be necessary to conduct electricity...or useful thermal energy to users located at or near a project site."² The lines distributing electricity and steam from Burrstone's cogeneration facility to users are similar to lines, including some that cross public streets, that were deemed related facilities in the Nassau District and Nissequogue Rulings, except that Burrstone's lines are shorter and less extensive in scope. Since it was decided in those Rulings that the distribution facilities were located at or near the cogeneration facilities, notwithstanding the street crossings, we find that Burrstone's distribution lines are located at or near its cogeneration facility even though one line crosses a street.

As Burrstone points out, the only distinction between its circumstances and those at issue in the Nassau District and Nissequogue Rulings is that, instead of serving one user owning property on two sides of a public street, it is furnishing electric service to multiple users, with one user owning property separated from the others by a street.³ PSL §2(2-d), however, specifically contemplates multiple users, by providing that electricity may be distributed to "users," in the plural, and does not require that users share property ownership rights.

² See Case 06-E-1203, Steel Winds Project LLC, Declaratory Ruling on Electric Corporation Jurisdiction (issued December 13, 2006).

³ The College qualifies as a user because it consumes the electricity delivered to it for useful purposes.

Therefore, the electric and steam distribution facilities that Burrstone describes, with an electric distribution line extending across a property line and a public street to serve one of a number of multiple users, are related facilities falling within the exemption from regulation granted to cogeneration facilities.

Since Burrstone's proposed project is a cogeneration facility under PSL §2(2-a), and its electric and steam distribution lines are related facilities that are part of the cogeneration project under PSL §2(2-d), it qualifies for the exemptions from regulation set forth at PSL §§2(3), 2(4), 2(13) and 2(22). Therefore, Burrstone is not, respectively, a corporation, person, electric corporation or steam corporation for the purposes of the PSL.⁴

The Commission finds and declares:

1. The electric and steam generation and distribution facilities Burrstone Energy Center LLC describes in its Petition filed in this proceeding constitute a cogeneration facility as defined in the Public Service Law, and, accordingly, it is exempt from the provisions of the Public Service Law (except for Article VII).

2. This proceeding is closed.

By the Commission,

(SIGNED)

JACLYN A. BRILLING
Secretary

⁴ Burrstone is reminded that, under PSL §2(4), cogeneration facilities remain subject to PSL Article VII, if they build electric or gas transmission lines sized above the thresholds triggering application of that Article.

APPENDIX N

BENEFIT COST ANALYSIS

Benefit-Cost Analysis Summary Report

Site 51 – City of Troy (RPI Samaritan)

PROJECT OVERVIEW

As part of NYSED's NY Prize community microgrid competition, the City of Troy has proposed development of a microgrid that would serve several public and commercial facilities in the community. The proposed microgrid would support the following facilities:

- Approximately 31 buildings on the campus of Rensselaer Polytechnic Institute (RPI), including several dormitories and research facilities;
- Samaritan Hospital, a 134-bed facility providing general medical and surgical services;
- The John F. Kennedy Towers, a federal affordable housing facility for senior citizens, with 135 units and approximately 150 residents; and
- Troy's Fire Station #5.

The primary objective of the microgrid would be to supply RPI, Samaritan, and other facilities with reliable power and resiliency during outages. The proposed system would rely predominantly on a large combined heat and power (CHP) unit with a nameplate capacity of 7.7 megawatts (MW). This unit would be fueled by natural gas and would be located at the 11th Street Boiler House, on the RPI campus. It would operate continuously, producing about 63,400 MWh annually under normal conditions, or about 84 percent of the annual power used by the participating facilities. Heat from the CHP unit would augment the existing heating system on RPI's campus.

For added production during major outages, the microgrid would include a set of 17 diesel generators distributed across the facilities. Ten would be located at various RPI buildings, five at Samaritan Hospital, and one each at JFK Towers and the fire station. Most of these generators already exist and are used as backup power. The generators range in capacity from 0.05 to 1.25 MW and together would supply approximately 187 MWh per day during an outage.

METHODOLOGY AND ASSUMPTIONS

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

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

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

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

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

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.²

¹ The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO₂ 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 SO₂, NO_x, and PM_{2.5}, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

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

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results suggest that if no major power outages occur over the microgrid's assumed 20-year operating life, the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to exceed approximately 3.1 days per year (Scenario 2). The discussion that follows provides additional detail on the findings for these two scenarios.

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: 3.1 DAYS/YEAR
Net Benefits - Present Value	-\$24,200,000	\$674,000
Benefit-Cost Ratio	0.8	1.0
Internal Rate of Return	-4.7%	8.1%

Scenario 1

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

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

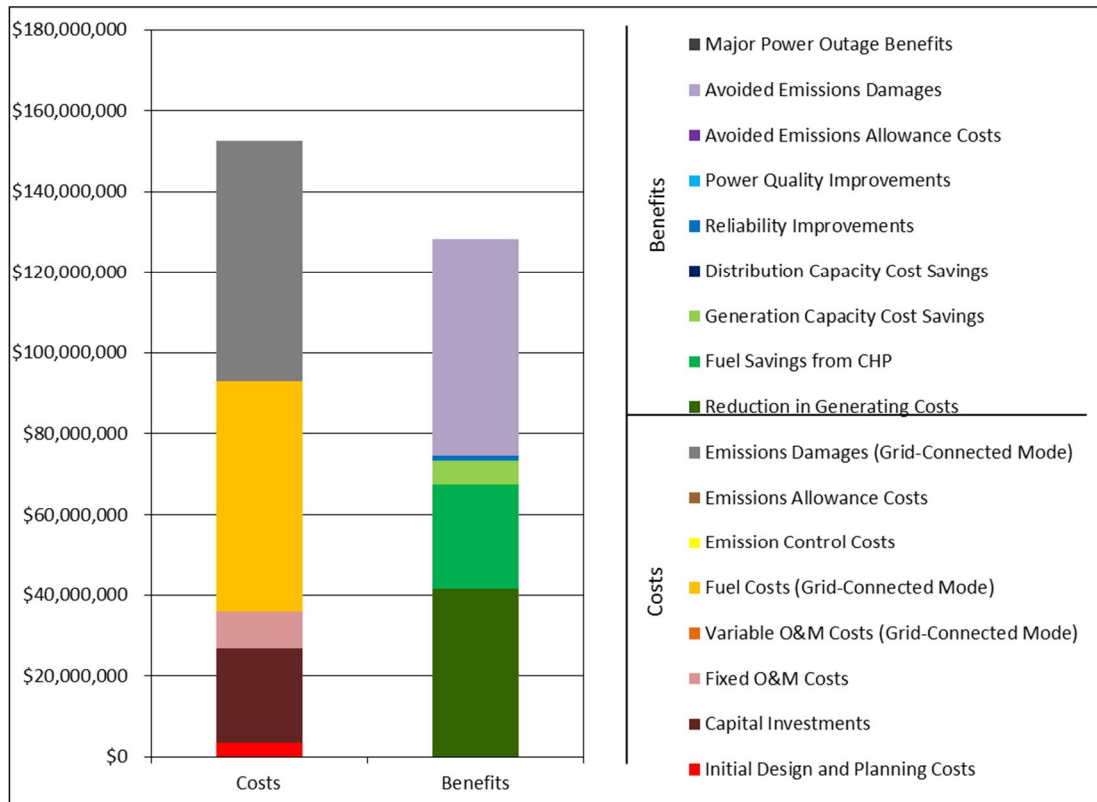


Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
Costs		
Initial Design and Planning	\$3,500,000	\$309,000
Capital Investments	\$23,400,000	\$1,760,000
Fixed O&M	\$8,940,000	\$789,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$57,200,000	\$5,050,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$59,600,000	\$3,890,000
Total Costs	\$153,000,000	
Benefits		
Reduction in Generating Costs	\$41,400,000	\$3,660,000
Fuel Savings from CHP	\$25,900,000	\$2,290,000
Generation Capacity Cost Savings	\$5,950,000	\$525,000
Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$1,310,000	\$115,000
Power Quality Improvements	\$0	\$0
Avoided Emissions Allowance Costs	\$21,500	\$1,900
Avoided Emissions Damages	\$53,700,000	\$3,510,000
Major Power Outage Benefits	\$0	\$0
Total Benefits	\$128,000,000	
Net Benefits	-\$24,200,000	
Benefit/Cost Ratio	0.8	
Internal Rate of Return	-4.7%	

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 \$3.5 million. The present value of the project's capital costs is estimated at approximately \$23.4 million. Significant investments include the turbine associated with the CHP power generation (about \$5.8 million); the system for generating steam heat supplied to RPI buildings; and various construction costs required to protect and consolidate cabling and modify the boiler facility where the CHP system will be located.

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 \$8.9 million, or about \$789,000 annually.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas for fueling the CHP unit. To characterize these costs, the BCA relies on estimates of fuel consumption

provided by the project team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.³ The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately \$57.2 million.

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's fuel-based generators are estimated at approximately \$3.9 million annually. These damages are primarily attributable to the emission of CO₂. Over a 20-year operating period, the present value of emissions damages is estimated at approximately \$59.6 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately \$41.4 million. Cost savings would also result from fuel savings due to the CHP system. The BCA estimates the present value of fuel savings over the 20-year operating period to be approximately \$25.9 million. These reductions in demand for electricity from bulk energy suppliers and heating fuel would also avoid emissions of CO₂, SO₂, NO_x, and particulate matter, yielding emissions allowance cost savings with a present value of approximately \$21,500 and avoided emissions damages with a present value of approximately \$53.7 million.⁴

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.⁵ The project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by 7.0 MW as a result of new demand response capabilities.⁶ Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately \$5.9 million over a 20-year operating period.

The project's consultants do not anticipate that the microgrid will enable utilities to avoid the cost of expanding or improving the local distribution network. However, the project appears to entail a substantial investment in new distribution infrastructure (e.g., cable and conduit for connecting JFK Towers and the fire station to the microgrid). These investments may yield benefits beyond what is accounted for in this analysis.

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

⁴ Following the New York Public Service Commission's (PSC) guidance for benefit cost analysis, the model values emissions of CO₂ 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 SO₂ and NO_x from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

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

⁶ The project team did not clarify whether RPI already participates in a demand response program. The analysis assumes that RPI does not, and therefore may overstate generation capacity cost savings.

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

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 \$115,000 per year, with a present value of \$1.3 million over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:⁷

- System Average Interruption Frequency Index (SAIFI) . 0.96 events per year.
- Customer Average Interruption Duration Index (CAIDI) . 116.4 minutes.⁸

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.⁹ It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

Summary

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

Scenario 2

Benefits in the Event of a Major Power Outage

The estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA

⁷ www.icecalculator.com.

⁸ SAIFI and CAIDI values were provided by the project team for National Grid.

⁹ <http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#1>.

methodology is designed to assess the impact of a total loss of power . including plausible assumptions about the failure of backup generation . on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.^{10,11}

The project team indicates that all four facilities served by the microgrid possess backup generators. Table 3 summarizes the estimated cost of operating these generators. Table 3 also indicates the loss in service capabilities that occurs while relying on these units, and the loss in service capabilities that would occur should these units fail. Several caveats warrant attention. First, the percent loss in service capability for RPI (80 percent) is an average for 31 individual buildings. These percentages vary greatly, from zero to 100 percent, depending on the type of building. Second, the project team did not provide estimates of fuel consumption for three of the generators. The analysis assumes 72 gallons of diesel per MWh produced, a figure consistent with fuel use reported for the other 15 generators. In all cases, the analysis assumes there is a 15 percent chance that the backup generator would fail.

Table 3. Costs and Level of Service Maintained by Backup Generators, Scenario 2

FACILITY	NUMBER OF GENERATORS	COST OF OPERATING BACKUP GENERATION		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE	
		ONE-TIME COSTS	ONGOING OPERATING COSTS (\$/DAY)	WITH BACKUP POWER	WITHOUT BACKUP POWER
RPI	14	\$14,000	\$25,380	80%	100%
Samaritan Hospital	2	\$0	\$1,380	50%	100%
John F. Kennedy Towers	1	\$0	\$265	0%	100%
Fire Station #5	1	\$1,000	\$93	0%	100%

Facilities also may incur costs for emergency measures necessitated by power outages. The analysis incorporates the following emergency costs specified by the project team:

- RPI anticipates that evacuating student dormitories would cost approximately \$10,000, and that housing the students at alternative facilities would cost \$76,000 per day. These costs would apply while operating backup power as well as during a complete loss of power.
- Samaritan Hospital was unable to provide specific information on the cost of evacuating and transporting patients, saying only that costs would run into the hundreds of thousands. To capture at least a portion of these costs, the analysis assumes one-time costs of \$100,000 during a complete loss of power.

In addition to these costs, the economic consequences of a major power outage depend on the value of the services the facilities of interest provide. For RPI and John F. Kennedy Towers, the analysis applies

¹⁰ The methodology used to estimate the value of lost services was developed by the Federal Emergency Management Agency (FEMA) for use in administering its Hazard Mitigation Grant Program. See: FEMA Benefit-Cost Analysis Re-Engineering (BCAR): Development of Standard Economic Values, Version 4.0. May 2011.

¹¹ As with the analysis of reliability benefits, the analysis of major power outage benefits assumes that development of a microgrid would insulate the facilities the project would serve from all outages. The distribution network within the microgrid is unlikely to be wholly invulnerable to service interruptions. All else equal, this will lead the BCA to overstate the benefits the project would provide.

the Department of Energy's ICE Calculator to estimate the cost of a loss of service. Consistent with the information provided by the project team, the analysis assumes that all facilities require a full 24 hours of service per day. For the remaining facilities . the fire station and Samaritan Hospital . the impact of an outage is analyzed using standard FEMA methodologies.

Based on the estimated value of service as well as the backup power capabilities and operational features of the facilities, the analysis estimates that in the absence of a microgrid, the average cost of an outage is approximately \$738,000 per day.

Summary

Figure 2 and Table 4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 3.1 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 3.1 Days/Year; 7 Percent Discount Rate)

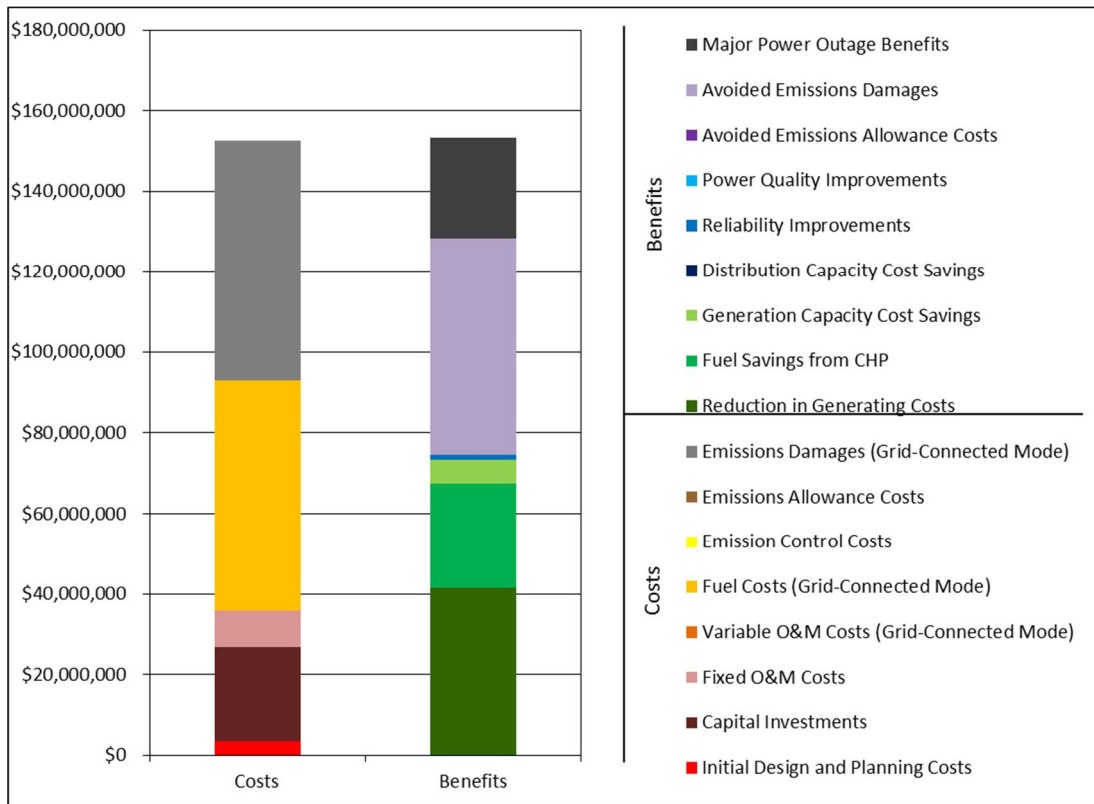


Table 4. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 3.1 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014\$)	ANNUALIZED VALUE (2014\$)
Costs		
Initial Design and Planning	\$3,500,000	\$309,000
Capital Investments	\$23,400,000	\$1,760,000
Fixed O&M	\$8,940,000	\$789,000
Variable O&M (Grid-Connected Mode)	\$0	\$0
Fuel (Grid-Connected Mode)	\$57,200,000	\$5,050,000
Emission Control	\$0	\$0
Emissions Allowances	\$0	\$0
Emissions Damages (Grid-Connected Mode)	\$59,600,000	\$3,890,000
Total Costs	\$153,000,000	
Benefits		
Reduction in Generating Costs	\$41,400,000	\$3,660,000
Fuel Savings from CHP	\$25,900,000	\$2,290,000
Generation Capacity Cost Savings	\$5,950,000	\$525,000
Distribution Capacity Cost Savings	\$0	\$0
Reliability Improvements	\$1,310,000	\$115,000
Power Quality Improvements	\$0	\$0
Avoided Emissions Allowance Costs	\$21,500	\$1,900
Avoided Emissions Damages	\$53,700,000	\$3,510,000
Major Power Outage Benefits	\$24,900,000	\$2,210,000
Total Benefits	\$153,000,000	
Net Benefits	\$674,000	
Benefit/Cost Ratio	1.0	
Internal Rate of Return	8.1%	

APPENDIX O

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REFERENCES

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