16- East Bronx (Bronx)

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East Bronx Healthcare Microgrid

NY Prize Phase One Feasibility Study Report

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Abbreviations

ANSI	American National Standards Institute, Inc.
AQDM	Air Quality Data Management
BCA	Benefit Cost Analysis
BOOM	Build-Own-Operate-Maintain
BSD	Black Start Diesel
BTU	British Thermal Unit
CAIDI	Customer Average Interruption Duration Index
CEQR	City Environmental Quality Review
CERN	European Organization for Nuclear Research
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
Cogen	Cogeneration
ConEd	Consolidated Edison, Inc.
CO_2e	Carbon dioxide equivalent
DER	Distributed Energy Resources
DOSA	Department of Substance Abuse
DR	Demand Response
EBHM	East Bronx Healthcare Microgrid
EDC	Electric Distribution Company
EES	Environmental Engineering Solutions, PC
EPA	Environmental Protection Agency
FC	Fire Code (New York City)
FDNY	Fire Department of New York
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse gas
ICE	Interruption Cost Estimator (Department of Energy)
IEc	Industrial Economics, Inc.
IRR	Internal Rate of Return
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
Mcf	One thousand cubic feet
MW	Megawatt
MWh	Megawatt hour
NOx	Nitrogen Oxides
NPV	Net Present Value
NYC	New York City
NYCDEP	New York City Department of Environmental Protection
NYCDOB	New York City Department of Buildings
NYISO	New York Independent System Operator

NYPSC	New York Public Service Commission
NYPSL	New York Public Service Law
NYSDEC	New York State Department of Environmental Conservation
NYSDEC/PBS	Petroleum Bulk Storage (NYSDEC)
NYSERDA	New York Energy Research and Development Authority
O&M	Operations and Maintenance
PM	Particulate matter
PSC	Public Service Commission
PSL	Public Service Law
PPA	Power Purchase Agreement
PON	Program Opportunity Notice (NYSERDA)
PURPA	Public Utility Regulatory Policies Act of 1978
PV	Photovoltaic
QF	Qualifying Facility
REV	Renewing the Energy Vision
RFP	Request for Proposal
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SCR	Selective Catalytic Reduction
SEP	State Energy Plan (New York)
SO_2	Sulfur dioxide
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TPF	Third Party Financing

Executive Summary

The objective of the enclosed study is to determine the feasibility of building and operating the East Bronx Healthcare Microgrid (EBHM) for the purpose of maintaining reliable thermal and electric operations for three large healthcare institutions and a medical college in the Bronx: Montefiore Medical Center's Jack D. Weiler Hospital (Weiler); the Albert Einstein College of Medicine (Einstein); Jacobi Medical Center, part of NYC Health + Hospital (Jacobi); and Calvary Hospital (Calvary). The study assesses the ability of the microgrid to power the off-taking institutions (off-takers) at times when weather events or other emergencies severely disrupt the capacity of the local distribution and transmission system to serve essential customer needs, and also the microgrid's ability to serve the off-takers continually, operating in parallel with the utility grid.

Our team, consisting of Gotham 360, van Zelm Engineers, and Environmental Engineering Solutions, approached this project in accordance with the scope of work outlined in the NY Prize Phase 1 Project Agreement. We began by issuing RFIs to the customers to define normal and emergency loads and identify distributed energy resources and demand response needs, as well as conducting site visits at each of the hospitals and the medical college. The outcomes of Phase 1 informed the design options that were considered under Task 2. Task 2 activity included the distributed energy resources sizing, quantity, and location; identification of electrical configuration; the evaluation of the impact of any renewable generation; system protection strategy, and specification of microgrid controls. We also prepared cost estimates, system drawings and specifications for the microgrid's distributed energy resources, electric distribution, load management and microgrid controls components. Our final deliverable also includes an assessment of potential financing options available to the microgrid's off-takers. Our findings are presented below, and categorized according to the project tasks outlined in the scope of work.

Task 1: Microgrid Capabilities

The East Bronx Healthcare Microgrid (EBHM) is designed to provide 100% of the electric load and provide for the thermal needs of four mission-critical customers in the East Bronx: Montefiore Medical Center's Jack D. Weiler Hospital, the Albert Einstein College of Medicine, Jacobi Medical Center, and Calvary Hospital. The combined facilities provide medical services to over 137,000 patients annually and conduct advanced medical research in cancer treatment, cardiovascular disease, aging, transplantation surgery and children's health. The hospitals are staffed by over 2,000 fulltime faculty, and housing for approximately 1,000 staff members is provided on site. The EBHM would provide for the energy resilience to operate these facilities at 100% capacity in island mode during grid outage, and also provide for their full energy load during grid-operating mode, with the ability to export excess generation into the utility grid.

The proposed design meets all of the required and preferred capabilities of the microgrid as outlined in Task 1. The microgrid serves multiple critical loads, with the ability to island and the provision of reserve fuel on site. The primary generation is through natural gas fueled CHP engines, with solar PV contributing the maximum amount renewable generation possible, given the space constraints of an urban environment. Ample space exists on site to house the CHP and controls equipment, and all facilities have indicated their support for the project.

Through the course of the feasibility study, several innovative technologies were considered, as outlined in Appendix I, and a design was arrived at that balances the drive for innovation with the necessity to provide secure reliable power to the participating medical institutions.

Task 2: Technical Configuration

The proposed design of the EBHM is to incorporate several distributed energy resources (DER) to power the microgrid as a single controllable entity. The physical configuration of equipment is dispersed to suit the geographical layout of the customers' campuses. Jacobi Medical Center and Montefiore-Einstein sit adjacent to one another, while Calvary Hospital is a stand-alone building on the opposite side of Eastchester Rd. from the other facilities. Space was identified in an abandoned steam plant owned by Jacobi and under a long-term lease to Einstein to site the majority of CHP engines and microgrid control technology. Due to Calvary's distance from the other facilities, a separate microturbine and solar array will be sited at Calvary, to most efficiently utilize the thermal commodity from the CHP generation. Five 4.6 MW CHP engines will be located in the abandoned steam plant and one 1 MW CHP microturbine will be located at Calvary Hospital. Solar PV will be distributed throughout the site. Two 2 MW diesel generators will be located at the abandoned steam plant as well, in order to provide black start capability.

In addition to the technology previously mentioned, the EBHM approached innovation in several ways. Technological innovation was considered through the use of medical waste to energy gasification technology, a wide array of battery storage, and several control systems, as outlined in Appendix I. Some of these technologies were deemed too experimental to be incorporated into a microgrid serving an active healthcare environment, and others will be revisited in later stages of the project (including expansion of the solar array and battery technology). The current design incorporates supervisory control and data acquisition (SCADA) control systems, two-way communication between microgrid customers and the utility through underground fiber optic cables, and compressed natural gas (CNG) to fuel the CHP engines. The microgrid would be able to support the combine 21 MW peak demand from its customers, with excess capacity to support the microgrid in the event of turbine failure, or to export to the utility grid during normal operations.

Task 3: Commercial and Financial Viability

Development interest has been expressed by several third party private development firms, as outlined in Appendix E. The model for this project is a Build-Own-Operate-Maintain (BOOM) third party finance structure that would leverage the demonstrated expertise of industry leaders in CHP development and large energy retrofits. Selection of the developer will take place over the summer and fall of 2016, and the selected partner will join the project team, should this project move forward to stages 2 and 3 of NY Prize.

The developer is expected to assume ownership of all microgrid assets, and enter into individual power purchase agreements (PPAs) with the customers. Each PPA will consist of three components: Energy charge per kWh, demand charge per kW per day, and minimum take or pay per kWh to ensure debt service for initial capital outlays by the developer. Initial estimates of capital costs for equipment are approximately $34.4 million, and revenue streams in excess of $13 million annually are anticipated to accrue to the microgrid owner. One innovative approach taken by this project is for control of distribution of microgrid-generated power to remain in the hands of the utility, and for the utility to install and maintain interconnections to the utility grid. This model is based on previous microgrid legislation in Connecticut (Public Act 12-148[1]). If the cost of installation and maintenance of interconnections is to be borne by the microgrid developer, the capital costs would be much higher than the existing estimate. Further discussions with the utility are expected as this project developed further, and it is recommended that state legislation be enacted to govern the interconnection standards of microgrids as an outcome of NY Prize.

Task 4: Benefit Cost Analysis

A third party Benefit Cost Analysis (BCA), conducted by Industrial Economics, Inc. (IEc) indicated very positive benefits arising from construction of the EBHM. The BCA identified $87.2 million in net benefits, a benefit-cost ratio of 1.4, and a 29% internal rate of return (IRR). The BCA is included in full in Section 4 of this report, and the questionnaires used as input to the BCA model are included as Appendix H. A sensitivity analysis conducted on the price assumptions of natural gas (the primary fuel for the microgrid) indicated that average prices 2.81 times higher than assumed would yield breakeven results from the BCA.

Non-monetized benefits include the preservation of medical research and the prevention of loss of life by maintaining 100% operating capacity at the EBHM customers during grid outage. Additional benefits arising from the project include:

- Reduced electrical and steam cost due to the efficiency of CHP generation and provision of a hedge to future spikes in commodity cost through the PPA structure
- A carbon footprint reduction due to greater efficiency
- Reduction of load on the current generating system
- Deferred investment in electrical infrastructure upgrades due to reduced distribution load on the local substation
- Job creation for construction and long-term operations, and
- The project's contribution to the goals of REV

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[1] https://www.cga.ct.gov/asp/cgabillstatus/cgabillstatus.asp?selBillType=Bill&bill_num=23&which_year=2012

Task 5: Final Written Documentation

This report and accompanying appendices include the findings of each task outlined in NY Prize Stage 1, and concludes with the following recommendations.

1. The Public Utility Regulatory Policies Act of 1978 (PURPA) and New York Public Service Law should be expanded to clarify the definition of Qualifying Facilities and the eligibility of microgrids for special rates and regulations
2. Tariff structures would need to be developed that are appropriate for community microgrids
3. The rules governing the interconnection and distribution of microgrid-generated power would need to be specified to fully take advantage of the economic potential of microgrids
4. Financial incentives beyond NY Prize would support the ongoing development of microgrids throughout New York State
5. The current evolving literature on microgrids will be helpful in specifying what types of business models, financing, and technological and regulatory configurations are most feasible

Key Findings

- Development of the East Bronx Healthcare microgrid will provide for 100% of the energy needs of its customers, both during normal grid-connected and islanded operation
- The microgrid will provide $87.2 million in net benefits (present value 2014$)
    - Benefits accrued to the microgrid's customers include the ability to ensure uninterrupted service to patients and the avoidance of lost revenue during grid outage, reduction in energy costs due to the efficiency of combined heat and power (CHP), and the furtherance of commitments to reduce their greenhouse gas emissions
    - Benefits to the utility include a reduction of load on the current generating system, deferred investment in electrical infrastructure upgrades, and the reduction of load during re-energization of the grid after a power outage
    - Benefits to the community include the ability of the hospitals to continue supporting community needs and the energy resilience of facilities of refuge during emergencies
- The microgrid will offset an estimated 77,241,207 lbs. of CO2e at the source of generation
- Ample interest has been expressed by third party developers to facilitate construction of the East Bronx Healthcare Microgrid – included as Appendix E
- The EBHM is technically and financially feasible, although further specification of the regulations and incentives for microgrid development in New York would support development of this and other microgrids throughout the state

1: Microgrid Capabilities

Background

The East Bronx Healthcare Microgrid (EBHM) is envisioned to provide 100% of the electric load and provide for the thermal needs of the mission-critical customers in both grid-connected and islanded mode. The combined customers provide medical services to over 137,000 patients annually and conduct advanced medical research in cancer treatment, cardiovascular disease, aging, transplantation surgery and children's health. The Einstein-Montefiore residency program is the second largest in the country. It includes a 639-bed teaching hospital as part of Jacobi Medical Center's North Bronx Hospital, and has more than 9,000 alumni among the top medical researchers and educators in the country. The proposed microgrid would also serve neighboring Calvary Hospital, the only fully accredited acute care specialty hospital exclusively providing palliative care for advanced cancer patients in the United States.

Located in the Morris Park neighborhood of the Bronx, the East Bronx Hospitals serve nearly 10% of the population of the Bronx annually. Many of these patients live below the poverty line with just under 50% of total patients meeting the New York State Medicaid eligibility requirements. By building this microgrid, there will be increased resiliency and reliability for healthcare for these low-income neighborhoods.

In this neighborhood of the Bronx, the local utility utilized overhead power lines to provide power to the Montefiore Weiler Division. During Hurricane Sandy, winds knocked out these power lines for 56 hours. On March 13, 2010 high winds and storms also knocked out these power lines for 15 hours. Montefiore is currently engaged in a FEMA study to bury the power lines entering the hospital, which would either take place prior to or concurrently with construction of the EBHM.

In addition to providing for the healthcare needs of the Bronx, the participating hospitals accept overflow from many of the hospitals in Manhattan and other parts of New York City during grid outages that necessitate patient evacuation. During Superstorm Sandy, Montefiore accepted neonatal patients and remained fully operational throughout the storm and recovery. Should an event occur that knocks out power to more areas of New York City, it is vital that these four hospitals be able to remain open for patient transfers from evacuated hospitals and to be able to accept new patients through their emergency rooms.

With these concerns at the forefront, the initial activities undertaken as part of the first project task outlined in the NY Prize Stage 1 feasibility study scope of work focused on information discovery with the aim to meet all required and suggested capabilities of the microgrid. These include the ability for the microgrid to operate both in grid-connected and island mode, automated switching between modes, maintenance of an uninterruptible fuel supply, and advancement of the goals of Renewing the Energy Vision (REV).

In the first phase of the feasibility study, site visits were conducted at all participating facilities to discover existing energy infrastructure, gap areas, site layouts, and design constraints and opportunities. Several informational meetings were held between Gotham 360 and providers of emerging technology solutions for energy generation, storage, and microgrid control systems. The NY Prize ConEd orientation meeting held on September 3, 2015 was attended by Gotham 360's project manager and the principal engineer from van Zelm Engineers, a subcontractor on the project. A subsequent face-to-face meeting was held with Consolidated Edison (ConEd) on October 16, 2015 to determine the technical constraints and abilities of the utility grid to facilitate a microgrid installation at the project site in the East Bronx.

Data collection and analysis was conducted by Gotham 360, van Zelm Engineers, and Environmental Engineering Solutions, PC (EES). Gotham 360 provided project management and preliminary financial and commercial analysis, van Zelm conducted the engineering assessments and microgrid configuration analysis, and EES provided permitting and regulatory services to the project. The team's qualifications are presented in section 3.3.5 and Appendix D.

Following information gathering, our team analyzed the engineering requirements of the site and developed a concept with the capabilities to meet the necessary technical requirements as outlined in Task 2. We engaged in preliminary financial analysis in order to prepare an RFP for a third party developer of the microgrid and provided the raw data needed for Industrial Economics Inc. (IEc). to conduct a Benefit Cost Analysis, as outlined in tasks 3 and 4. The following presents an overview of the institutions participating in the feasibility study and the required and suggested capabilities from task one that informed subsequent tasks in the feasibility study.

Microgrid Customers

Weiler Hospital (Montefiore Medical Center)

The Montefiore Jack D. Weiler Hospital is a 431-bed private hospital on the Albert Einstein College of Medicine campus. Medical care at Weiler Hospital is provided to approximately 15,000 patients each year by voluntary attending physicians affiliated with the Einstein Department of Medicine, and physicians of other Einstein acute care services.

Albert Einstein College of Medicine

Albert Einstein College of Medicine (Einstein) is a not-for-profit, private graduate medical school located in the Bronx in New York City. In addition to medical degrees, Einstein offers graduate biomedical degrees through the Sue Golding Graduate Division. Montefiore Health System acquired Einstein from Yeshiva University in 2015.

Einstein's main focal areas are medical education, basic research, and clinical investigation. During the 2015–2016 academic year, Einstein is home to more than 2,000 full-time faculty members, 731 M.D. students, 193 Ph.D. students attending the Sue Golding Graduate Division and 106 students in the combined M.D./Ph.D. program. In addition, there are 278 postdoctoral research fellows at the Belfer Institute for Advanced Biomedical Studies.

The medical school is known for its humanistic approach to its curriculum and training and for the diversity of its student body. The class of 2018 includes 183 students from 20 different U.S. states, 15% were born outside the U.S., and 9% identify themselves as belonging to groups considered underrepresented in medicine.

Einstein is also a major biomedical and clinical research facility. Faculty members received $157 million in awards from the National Institutes of Health in 2014, ranking 25th out of 138 medical schools receiving NIH funding. In addition, the NIH funds major research centers at Einstein in aging, intellectual development disorders, diabetes, cancer, clinical and translational research, liver disease, and AIDS.

Calvary Hospital

From its inception in 1899, Calvary Hospital has been faithfully devoted to providing palliative care to adult patients in the advanced stages of cancer, addressing the symptoms of the disease, not its cure. A voluntary, not-for-profit hospital, operated in connection with the Archdiocese of New York, Calvary continues to embody this tradition of caring through the services and programs offered and through the dedication and concern shown by its staff members.

Calvary strives primarily to expand its programs and services to meet the emerging physical, psychosocial, and spiritual needs of both patients and families through the provision of acute inpatient, outpatient, home care, and hospice, and services. In addition, through the Palliative Care Institute the Hospital will endeavor to transmit to other health care professionals, through research and education, the knowledge and competence, which it has developed in the care of the advanced cancer patient.

Through this twofold commitment, Calvary Hospital will deepen and strengthen the philosophy of compassionate care which has been the cornerstone of its program of service, and will offer to those in its expanded community and others, a tradition of successful experience in the care of the advanced cancer patient.

Calvary Hospital is the only fully accredited acute care specialty hospital exclusively providing palliative care for advanced cancer patients in the United States. With 200 beds in the Bronx and more than 950 employees, Calvary serves more than 5,500 patients annually. The Calvary programs include inpatient care, case management, outpatient care, hospice, home care and support programs for families and friends.

Jacobi Medical Center

Founded in 1955, Jacobi Medical Center is a municipal hospital, under the direction of the New York City Health + Hospitals, in Morris Park, Bronx, New York and is one of the largest Public Hospitals in the Bronx. Jacobi opened concurrent with the opening of the Albert Einstein College of Medicine. For the first time, a medical school and a municipal hospital center had entered into a formal affiliation agreement to be built and opened the same time.

Jacobi Medical Center provides state of art medical care, delivered with compassion, dignity, and respect. Many of their physicians are recognized leaders in important clinical research, thus assuring their patients of the latest advancements in treatment options. Jacobi is also a part of NYC Health +

Hospitals' North Bronx Healthcare Network, which includes North Central Bronx Hospital.

Jacobi is a 639 bed teaching hospital affiliated with the Albert Einstein College of Medicine, and offers numerous centers of excellence including its renowned trauma center, multi-person hyperbaric unit, burn center, surgical intensive care unit, stroke center and regional perinatal center.

Jacobi Medical Center has the only Snakebite Treatment Center in the entire tristate area, the only Level I pediatric trauma center in the Bronx, and one of the busiest trauma centers in New York State. Jacobi's Hyperbaric Medicine Program has treated approximately 3,000 victims of carbon monoxide poisoning, which is more than any other hospital in the Northeastern United States.

1.1 Minimum Required Capabilities

The East Bronx Healthcare Microgrid will serve 30 buildings located across 4 campuses: Montefiore Medical Center's Jack D. Weiler Hospital, Albert Einstein College of Medicine (acquired by Montefiore in 2015), Jacobi Medical Center, and Calvary Hospital. The site layout is presented in Figure 1. Weiler, Jacobi, and Calvary Hospital are all critical facilities, admitting and treating over 137,000 patients annually. Montefiore and Calvary are both private, non-profit hospitals, and Jacobi Medical Center is part of NYC Health + Hospitals. Einstein College is a premier medical research facility, with over 1,000 M.D. and Ph.D. students and 2,000 full-time faculty, with housing for over 1,000 individuals on site.

The primary generation will be recuperated natural gas turbines located at Jacobi and Calvary Hospitals. One MW of solar PV will also be distributed throughout the site, and incorporated through block loading of the turbine at Calvary Hospital. These generation sources will power the microgrid both in grid-connected and island operating modes, and will be able to transition seamlessly between modes in the event of an outage and reconnection to the grid following the outage. Four MW of diesel backup generation will be included to provide for black start capability in the event of grid failure, and sized to meet capacity of the microgrid in the event of loss of one of the primary gas turbines. The microgrid will be fueled by an uninterruptible natural gas supply from the utility and provide three days of reserve fuel in compressed natural gas (CNG) storage tanks on site.

All maintenance requirements will be stipulated in the contractual agreements between the eventual third-party owner-operator and the microgrid's customers. The system will maintain frequency and voltage while running in parallel with the grid and conform to ANSI c84-1 standards when islanded.

Two-way communication between the microgrid owner/operator and the utility is proposed through fiber optic cables run alongside the electrical distribution conduit to ensure seamless communication and control, to safeguard privacy, and to protect the system against cyber-disruption.

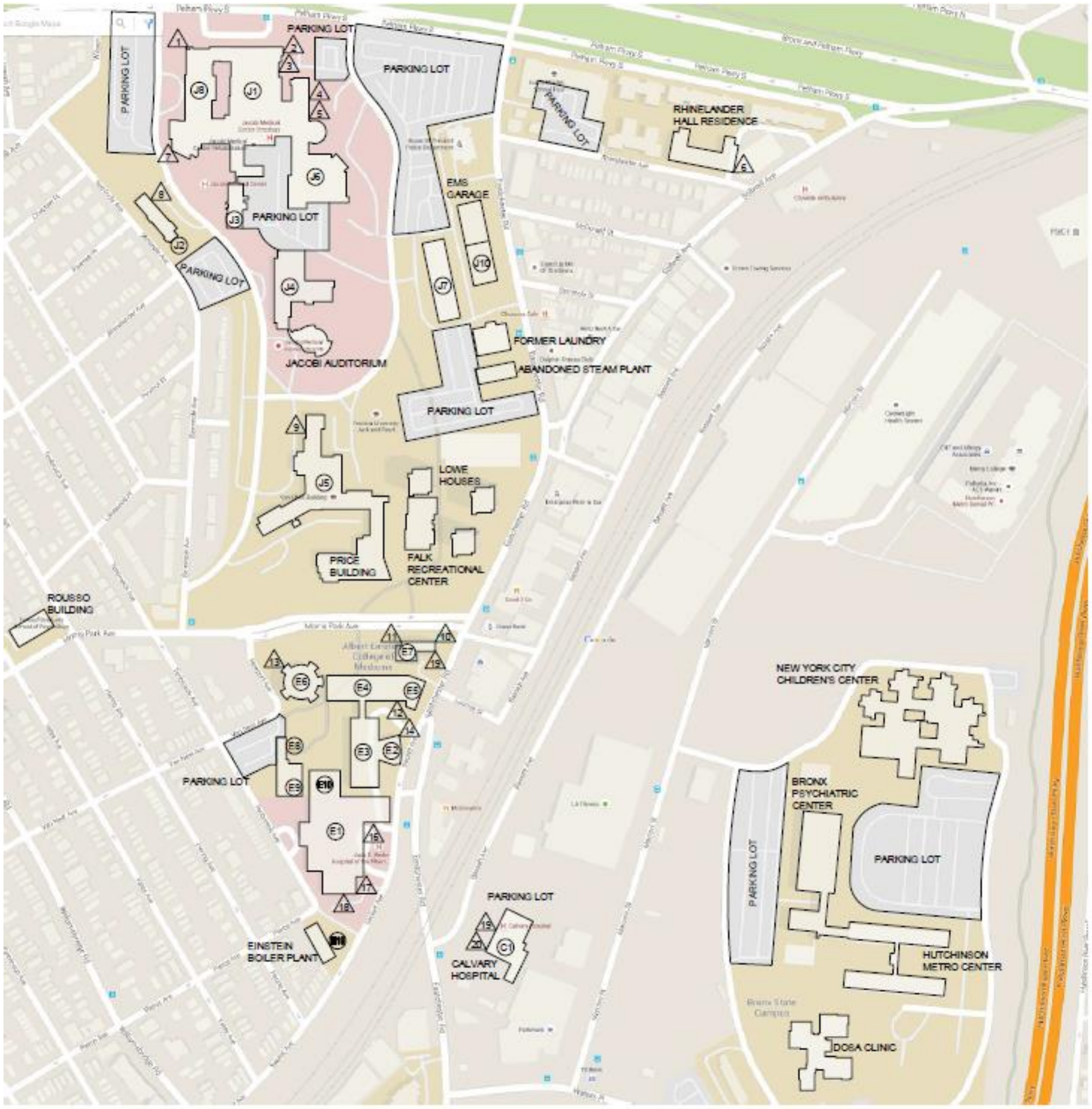

Figure 1: Microgrid Site Map

Jacobi Medical Center

J1 Medical Center
J2 Staff House
J3 Rose F. Kennedy Center
J4 Nurses Residence
J5 Van Etten Building
J6 MC Building 6
J7 Store House
J8 Ambulatory Care Bldg.
J10 Engineering & Maint. Bldg.

Montefiore Einstein-Weiler Hospital

E1 Weiler Hospital
E2 Robbins Auditorium
E3 Chanin Inst. For Cancer Research
E4 Forcheimer Medical Science Bldg.
Gottesman Library & Friedman Lounge
E5 Golding Building
E6 Ullmann Research Center
E7 Belfer Educational Center
E8 Harold & Muriel Block Bldg.
E9 Lubin Dining Hall, Singer Faculty Club
E10 Gruss Magnetic Resonance Research Ctr.
E19 Einstein Boiler Plant

Calvary Hospital

C1 Calvary Hospital

The microgrid generating equipment will be located in an abandoned steam plant owned by Jacobi Medical Center and under a 99-year lease to Albert Einstein College of Medicine. The site is fully sheltered to protect against inclement weather and is located on elevated ground to safeguard against flooding. All electric and steam distribution from the generating equipment to the customers' facilities will be located belowground to ensure physical resiliency of the microgrid to physical disruption.

1.2 Preferable Microgrid Capabilities

Several innovative technologies were considered during the course of the feasibility study and are outlined in Appendix I. These included technologies for power generation, storage, and microgrid control systems. A few of the more innovative options considered were a medical waste to energy gasification system, a liquefied air storage system, and a Linux-based controls system in use at the Large Hadron Collider at the European Organization for Nuclear Research (CERN). Ultimately, for the purposes of determining feasibility, the design proposed in this studied erred on the side of proven technologies.

The proposed design incorporates 1 MW of solar PV to serve part of the microgrid's load with renewable energy. The solar power will be incorporated into the microgrid through block loading of a micro turbine at Calvary Hospital, to serve the total load of the customers while accommodating the intermittent nature of solar generation, and eliminating the need to rely on battery technology, which would drive up costs. The inclusion of photovoltaic panels also presents the opportunity to build electric vehicle charging stations to power electric vehicles with 100% renewable power. Compressed natural gas storage onsite, used primarily to power the CHP engines, also presents the opportunity for the construction of CNG fueling stations, as has already been used to fuel CNG-powered ambulances at North Shore LIJ.[2]

We anticipate further refinements to the design if awarded NY Prize Stage 2 funding, including possible expansion of the solar capacity, revisiting battery storage depending on the total generation expected from solar PV, and final selection of a suitable controls system. The intent for the control and communication systems is to allow the EBHM to act as a smart-grid, integrated with building automation systems, demand response technologies, and the ability to provide information back to the microgrid customers for metrics tracking and reporting.

The microgrid design proposes that easements be granted for ConEd to install and operate the interconnections between the microgrid and the utility's underground network, and also to control the distribution of microgrid power, discussed further in sections 3.2.2 and 3.4.7. ConEd's engineering team has been open to this possibility in conversations to date regarding the high level concerns of technical interconnection, with the expectation that this discussion will progress as the development process moves forward.

In coordinating this process with the aims of REV, the EBHM would serve as a model for urban microgrid development serving multiple critical loads. The microgrid will not only serve the energy reliability and efficiency needs of its end users, but challenges, lessons learned, and emerging best practices will be

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[2] https://www.northwell.edu/about/news/first-its-kind-natural-gas-powered-ambulance-debuts-long-island

made public throughout the course of the NY Prize Competition. In keeping with these aims, the Benefit Cost Analysis conducted by Industrial Economics, Inc. (IEc) is included herein as a measure of benefits and costs to society arising from the EBHM. It is anticipated that further assessments of benefits and costs will take place as the full microgrid design proceeds, and a comprehensive financial evaluation is performed. A comprehensive financial analysis concurrent with an audit-grade design will take place if this project moves forward to Stage 2, at which point a third party developer will join the project team. One of the primary considerations in selection of a third party developer will be their ability to leverage private capital. Although further public funding is deemed critical for this project to progress, private investment is anticipated to provide the majority of funding for the final implementation.

Further development of the EBHM would have numerous tangible benefits, to the microgrid's customers, the contractors and vendors employed during construction, the utility in the form of grid stability, and to the wider community in the form of job creation, reduced greenhouse gas (GHG) emissions, and most importantly in the resilience to institutions that serve the healthcare needs of the community and would provide refuge during times of severe weather and other emergencies.

Synergies

Montefiore Weiler is currently exploring the prospect of replacing the overhead power lines with underground lines to mitigate against future outages. Separately, Calvary Hospital began exploring the feasibility of a cogeneration project before the NY Prize competition began. Both projects present possible synergies with development of a microgrid, which would reduce costs if implemented simultaneously, and improve the integration of the energy infrastructure served by the EBHM.

We anticipate other advantages to implementing a comprehensive energy solution across these facilities. In late 2015, Montefiore Medical Center acquired Albert Einstein College of Medicine, and is currently in the process of integrating energy management between the two institutions. Montefiore will begin incorporating the tracking of Einstein's greenhouse gas emissions (GHG) as part of the New York City Carbon Challenge and benchmarking the aggregate emissions under NYC Local Law 84.

The feasibility study also identified two currently abandoned buildings, a former steam plant and laundry facility owned by Jacobi Medical Center and leased to Montefiore Einstein, as the optimum location of a cogeneration (cogen) facility to serve the needs of Jacobi, Einstein, and Weiler Hospital. Due to Calvary Hospital's distance from the other campuses, a separate cogen facility and solar PV installation is proposed at Calvary, as outlined below within the scope of task 2.

There exists the further possibility to take advantage of Calvary's proximity to the neighboring Bronx Psychiatric Hospital, NYC Children's Center, and the DOSA Clinic to expand the PV installation on ample open space on the neighboring grounds that is unsuitable for building construction, but would likely be able to support a solar PV array. The possibilities for expansion of the solar capacity at the neighboring campuses extend beyond the scope defined in our NY Prize Phase One Agreement, and so have not been explored in detail. The possibility is presented here as a potential for further integration of the East Bronx Medical infrastructure into the EBHM at a later phase of this project. The possibility would also expand the opportunity to incorporate renewable clean power and adoption of emerging technology.

2: Technical Configuration

2.1 Microgrid Infrastructure and Operations

2.1.1 Campuses and Buildings Served by the Microgrid

The EBHM is proposed in order to provide electric power to three hospital campuses (Jacobi, Montefiore Einstein-Weiler and Calvary), as seen in the left-center of the Figure 1 map. Also shown, at the bottom right of the Figure 1 map, are the State of New York healthcare facilities of the Bronx Psychiatric Center, NYC Children's Center and the DOSA Clinic. The New York State campus facilities and the land area of their sites offer potential synergies, should their participation in the microgrid prove feasible.

Inasmuch as a microgrid is understood to be a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries, it can similarly support a thermal distribution system to provide heating and cooling essential to the operation of critical facilities. The proposed EBHM microgrid shall act as a single controllable entity with respect to the grid and will be able to function in both a connected and disconnected or "island" mode during cases of loss of grid emergency.

2.1.2 Distributed Energy Resources for Powering Microgrid

The distributed energy resources (DER) that shall provide power to the Microgrid are proposed as a combination of multiple units, affording maximum flexibility of operation as well as optimum matching of the DER capacity to the Microgrid electric demand.

The overall configuration of the three hospital campuses (Jacobi, Montefiore Einstein-Weiler and Calvary) finds that two of the three, Jacobi and Montefiore Einstein-Weiler, are abutting and represent the majority buildings that need to be served. Calvary is a stand-alone building apart from the larger campuses. All three campuses have their heating and cooling served by centralized systems. This makes it feasible to configure the EBHM to include thermal utilization of as a product of the distributed energy resources for their conventional generation electric supply. This will provide a dual benefit of substantial operating cost savings along with significant reductions in environmental emissions during its normally grid paralleled mode of operation. The U.S. Environmental Protection Agency (EPA) has recognized cogeneration as the most effective way to minimize the environmental impact of power plants. The EPA currently advocates this position through their Combined Heat and Power Partners Program.

The distributed energy resources of the proposed EBHM microgrid will predominately use cogeneration engine-generators which will enable it to recover the waste heat produced during the generation of electricity, thus saving energy and improving the system's efficiency during normal operations, but also providing essential thermal energy during a loss of grid emergency. On account of the significant distance separating the Calvary Hospital campus from it is preferred that a smaller modular gas turbine cogeneration system provide the cogenerated thermal for that campus, and it has been paired with an equal size Solar Photovoltaic array.

The pairing of a solar photovoltaic array with a modular gas turbine CHP system, in a microgrid configuration, affords a novel manner to optimize the electric supply to Calvary Hospital. The proposed 1 MW gas turbine system is configured with modularity to allow block load steps at 20, 40, 60, 80 and 100 percent electric output, inclusive of variability at each load step. Normal operation in grid parallel mode, to smoothly provide the hospital power regardless of intermittency of the solar resource, will allow data logging of power production by each source. This will facilitate optimization of the solar component of the supply resources for the microgrid, the capability of the solar resource to extend operation using onsite stored fuel, and potential benefit of adding battery storage to the system. All of which would enhance performance in a loss of grid emergency.

On account of the combined medical care and mission critical medical research conducted within the EBHM campuses, the DER asset mix has been diversified, i.e., fewer larger machines could have been configured, however, a forced outage would have compromised capacity. Instead machine sizes were limited to 20% of microgrid peak load. Additionally, to provide a dual benefit of redundant emergency capacity as well as capability to black start the microgrid in the event of loss of grid emergency that impacted the campus into needing to black start the microgrid, black start Diesel (BSD) machines have been included, at sizes that would allow the microgrid to support the EBHM in the event of a forced outage of one of the primary DER assets. The selected machines are the largest Diesels that can be black started using self-contained battery banks. Table 1 below, provides a tabulation of these resources.

Unit Number	Distributed Energy Resource Type	Facility / Location	Available Capacity (MW)
CHP 1	Gas Turbine CHP	Jacobi MC / Former Laundry & Steam Plant	4.6
CHP 2	Gas Turbine CHP	Jacobi MC / Former Laundry & Steam Plant	4.6
CHP 3	Gas Turbine CHP	Jacobi MC / Former Laundry & Steam Plant	4.6
CHP 4	Gas Turbine CHP	Jacobi MC / Former Laundry & Steam Plant	4.6
CHP 5	Gas Turbine CHP	Jacobi MC / Former Laundry & Steam Plant	4.6
CHP 6	Gas Turbine CHP	Calvary Hospital / Parking Lot	1.0
SPV 1	Solar PV Array	Calvary Hospital / Parking Lot	1.0
BSD 1	Diesel Generator Set	Jacobi MC / Former Laundry & Steam Plant	2.0
BSD 2	Diesel Generator Set	Jacobi MC / Former Laundry & Steam Plant	2.0

Table 1: Distributed Energy Resource Locations

The equipment layout for the distributed energy resources is contained in Appendix A.

As part of the prime mover selection it was decided to select recuperated gas turbines for both the Jacobi and Calvary sited units. This technology reduces the turbine emissions sufficiently such that post combustion catalysts are not required. In the event of a loss of grid condition, these DER assets have the flexibility of operating with or without thermal load. Non-recuperated generating assets would require significant ancillary equipment for heat rejection in the absence of thermal load. Even though the proposed gas turbine DER assets will normally operate as CHP resources, in a loss of grid emergency, they can be immediately started and operated as 'electric only' capacity. Upon achieving stabilized operations, they will also provide thermal energy, which is also essential to hospital operations.

The utilization of the recuperated gas turbine equipment, at the larger size units, i.e., CHP 1 to 5 sited at Jacobi, limits their fuel option to gaseous fuel only. In order to provide a 72 hour on site fuel supply, a compressed natural gas storage system has been included. It includes a gas compressor system such that in normal operations, recharging of the stored fuel would be accomplished by taking fuel from the ConEd gas service. In the event of an extreme emergency causing an outage of the ConEd gas system for in excess of 72 hours, compressed natural gas can be delivered to the site by truck delivery. This technology is mature and there are currently central plants, including gas turbine prime movers, that are receiving their entire fuel supply by truck transported compressed natural gas. In one case the transport distance is 100 miles, and the commercial competitiveness of using natural gas is the motivation for this choice of fuel supply.

The Calvary unit, CHP 6, though also using recuperated gas turbine technology, does have the capability to utilize number 2 fuel oil as an alternate. Calvary is converting the alternate fuel supply of their central plant to use only number 2 fuel oil, so the 72-hour supply for that site will be provided by the existing fuel storage assets.

2.1.3 Microgrid Electrical Infrastructure

From meetings and subsequent discussions with the local electric distribution utility, The Consolidated Edison Company of New York (ConEd), proposed initial circuiting and switching requirements for the Microgrid electrical distribution system have been developed. On account of the required capacity of 20 Mega Watts (MW) of power to service the EBHM complex, ConEd has concurred that this Microgrid could only be practical to implement at the primary voltage level, described internally by ConEd operations as High Tension. The ConEd area network distribution serving the EBHM buildings is at the 15 kilo Volt (kV) class, operating at 13,200 Volts.

In order to coordinate with this requirement, the major generating assets and Microgrid distribution system is proposed as 15 kV class equipment. ConEd is cooperating with the creation of the microgrid within their area distribution network by the placement of separating switches, as are required to create the isolated electric distribution essential for a microgrid of this scale. With one exception, the EBHM campus buildings receive their power services from underground ConEd feeder cables. Typically an underground transformer vault receives its incoming power from redundant ConEd 13.2 kV feeders, using multiple transformers to step down and provide building services at 208, 240, or 480 as appropriate to a particular building.

The intent is for ConEd to provide control of the microgrid via supervisory control and data acquisition (SCADA) automation, such that the transition from grid power to microgrid islanded operation will be fully automated, and take effect immediately upon a loss of grid incident. It is proposed that all communications to the separating switches as well as the microgrid power distribution monitoring and control utilize fiber optic communication that will be routed in the same trenchways as the electrical distribution work. This would provide capability for complete isolation and grid independent operation to include isolation from ConEd's existing grid SCADA, hardening the EBHM from any cyber threat (potentially why a loss of grid incident might have occurred). The electrical one-line diagram for the proposed microgrid configuration is contained in Appendix A.

2.2 Load Characterization

The electrical and thermal loads for the EBHM are summarized as follows:

Peak Load:	21,006 kW
Average Load:	14,001 kW
Annual Energy Use:	122,654,951 kWh
Monthly kWh:	Varies as shown in the charts and graphs below per site.
Weekly kWh:	Varies as shown in the charts and graphs below per site.

Since the Microgrid is being sized to meet most of the load and ensure operations as normal in both islanded and normal operating conditions, the peak loads are identical in both cases. Please refer to the previously attached one-line diagram in Appendix A and to the tables and graphs below for a detailed breakdown of electrical loads. The totalized electric demand per campus is provided by the demand profile curve below.

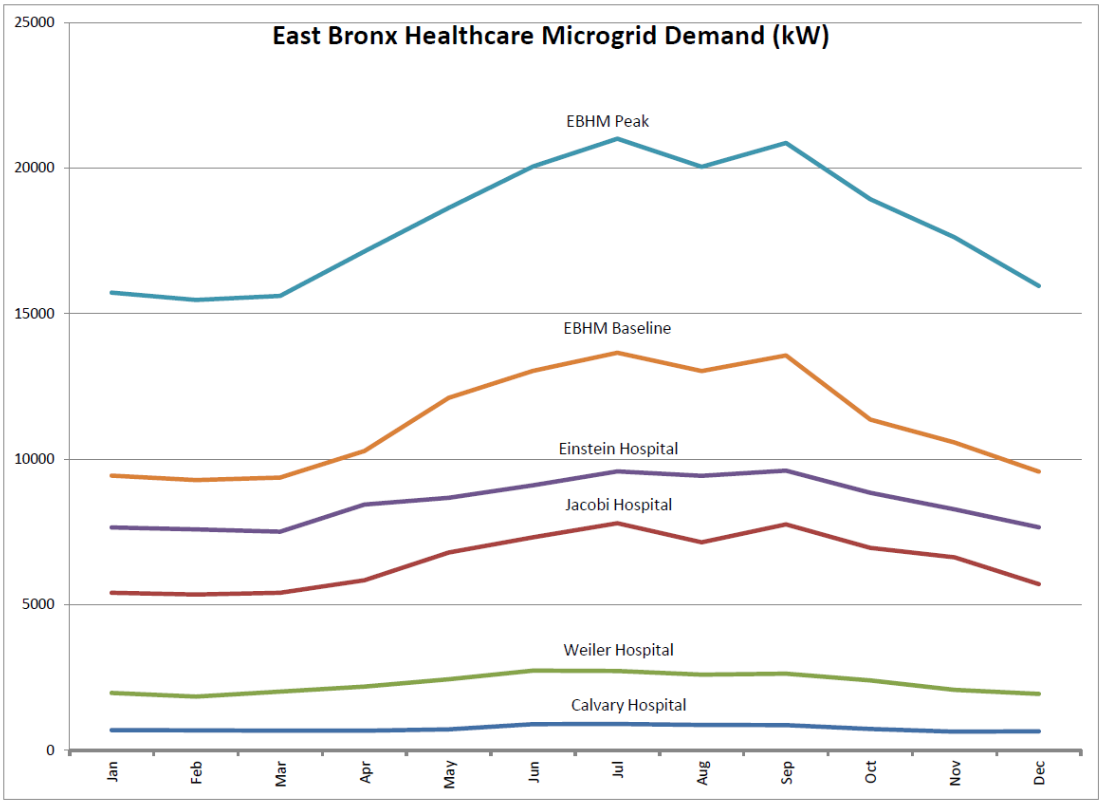

Figure 2: Annual Demand Profile

Month	Calvary (kW)	Jacobi (kW)	Einstein (kW)	Weiler (kW)	Total (kW)
Jan	694	5,411	7,650	1,967	15,722
Feb	689	5,350	7,585	1,845	15,469
Mar	672	5,411	7,508	2,017	15,608
Apr	674	5,840	8,438	2,187	17,139
May	720	6,791	8,675	2,442	18,628
Jun	895	7,314	9,105	2,738	20,052
Jul	905	7,801	9,578	2,721	21,005
Aug	872	7,142	9,427	2,601	20,042
Sep	864	7,760	9,604	2,633	20,861
Oct	731	6,954	8,845	2,398	18,928
Nov	639	6,630	8,276	2,074	17,619
Dec	650	5,706	7,657	1,940	15,953

Table 2: Monthly Electrical Power Demand

Month	Calvary (therms)	Weiler (therms)	Jacobi (therms)	Einstein (therms)	Total (therms/hr.)
Jan	17,732	83,717	159,888	1,152,530	1,900
Feb	27,162	87,479	211,809	842,300	1,739
Mar	22,940	92,401	274,492	608,400	1,341
Apr	15,904	55,113	152,916	462,320	953
May	16,981	69,316	153,170	583,260	1,105
Jun	30,500	78,549	176,239	623,260	1,261
Jul	42,783	82,158	176,002	730,120	1,386
Aug	38,635	83,920	172,647	696,420	1,333
Sep	28,362	76,480	146,332	691,250	1,309
Oct	16,478	31,535	151,925	499,368	939
Nov	17,190	49,201	210,406	489,661	1,064
Dec	11,714	81,704	266,343	600,148	1,290

Table 3: Monthly Thermal Demand (as natural gas fuel input)

The hourly demand load profile curve is shown below for both the electrical and the thermal loads.

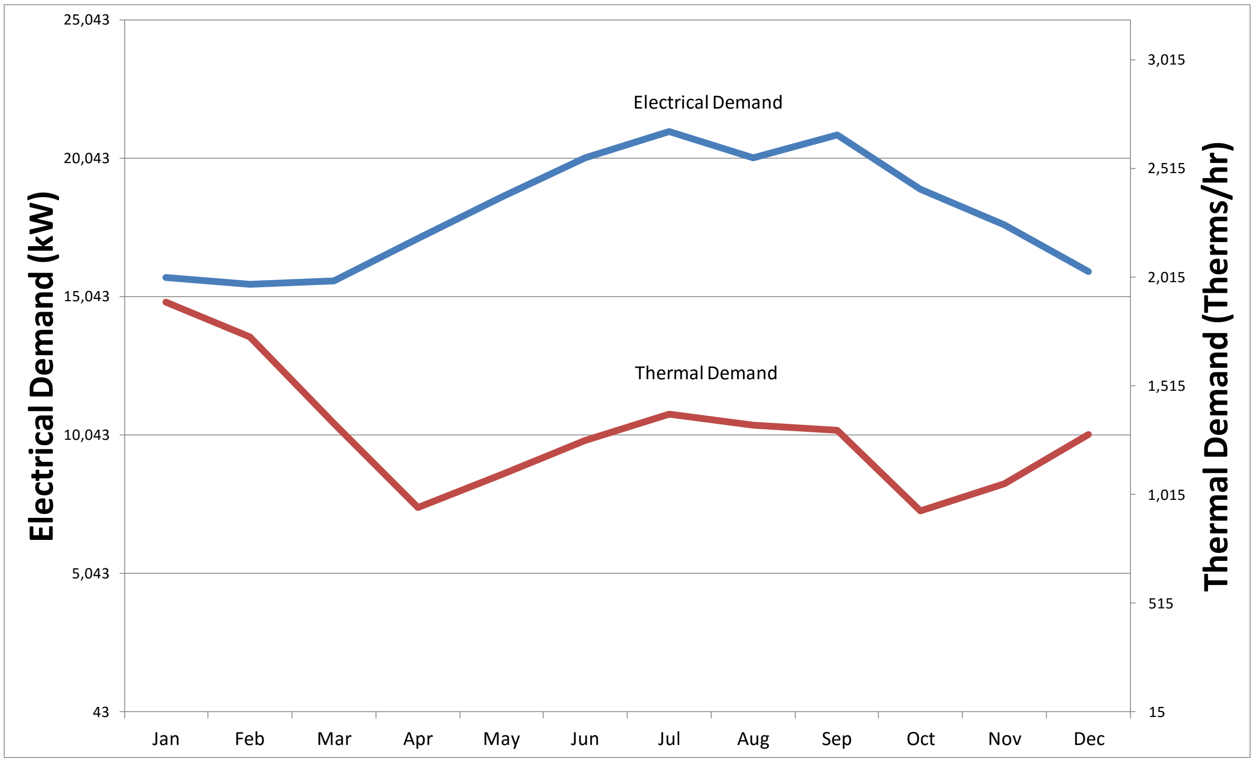

Figure 3: Load Profile Curves

Regarding redundancy level of the Microgrid, the proposed design allows for one of the 4.6 MW primary generating resources to be taken offline (either for maintenance or due to equipment failure). The Diesel generators, in addition to providing system black start capability, offer redundant capacity to offset an outage, scheduled or forced of the primary gas turbine generating assets. The solar PV system will be used to offset as much electrical load as it can when operational as well.

2.3 Distributed Energy Resources Characterization

The following tabulation summarizes the size and type of fuel for each of the DER's.

Unit Number	Available Capacity (MW)	Fuel Input Rate (Btu/kWh)	Normal Energy Source	Emergency Energy Source
CHP 1	4.6	8,865	Pipeline Natural Gas	Stored or Truck Delivered Compressed Natural Gas
CHP 2	4.6	8,865	Pipeline Natural Gas	Stored or Truck Delivered Compressed Natural Gas
CHP 3	4.6	8,865	Pipeline Natural Gas	Stored or Truck Delivered Compressed Natural Gas
CHP 4	4.6	8,865	Pipeline Natural Gas	Stored or Truck Delivered Compressed Natural Gas
CHP 5	4.6	8,865	Pipeline Natural Gas	Stored or Truck Delivered Compressed Natural Gas
CHP 6	1.0	10,300	Pipeline Natural Gas	Number 2 Fuel Oil
SPV 1	1.0	N/A	Sunlight	Sunlight
BSD 1	2.0	9,600	Diesel Oil	Diesel Oil
BSD 2	2.0	9,600	Diesel Oil	Diesel Oil

Table 4: Size and Fuel Type for DERs

The tables in the previous sections of this report and one-line diagrams in Appendix A provide a summary of the distributed energy resources that will constitute the East Bronx Health Care Microgrid. The proposed resources are all new equipment. New switchgear and control systems will also be installed to enable the microgrid to operate as designed.

The proposed microgrid equipment is currently sized to meet and track peak electrical demand during both normal and emergency operations. The gas-fired turbines will provide 24 MW of gross output power, with the solar PV system providing 1 MW for a total capacity of 25 MW. The waste heat from the engines will also be able to meet the thermal demand from the hospitals at all times. Currently, the peak electrical demand from the microgrid is just above 21 MW. Thus, one of the large engines could be taken offline for maintenance without potentially affecting operability.

The gas fired DERs will be located in a building capable of withstanding typical forces of nature and thus protect the generating resources. The solar PV panels will be ballasted and secured according to code requirements and thus will be able to meet forces of nature.

The proposed microgrid will primarily utilize natural gas for operation in both normal and islanded modes. The proposed microgrid design calls for 3 days of fuel storage via storing compressed natural gas (CNG) in tanks on the microgrid site.

The proposed microgrid will be black start capable. In order to provide black start capability two 2 MW diesel backup generators are proposed at central DER power plant at the Jacobi campus. The microgrid will be able to follow loads by operating the generating equipment as required and making generating resources offline during periods of low loads. The design calls for multiple generating resources of varying sizes, which allows for a high level of flexibility in terms of taking equipment offline to meet required loads. The proposed microgrid equipment has been utilized on several previous projects and can maintain the quality of power; i.e. high power factor, maintain the voltage, maintain frequency in both normal operation and islanded modes. Additionally, the proposed equipment will meet the utility's interconnection standards to enable the microgrid to operate in grid-connected mode.

2.4 Electrical and Thermal Infrastructure Characterization

The preferred location for the conventional generation equipment is to repurpose the abandoned Jacobi buildings that formerly housed the central steam plant and laundry. This location is ideally proximate to the largest concentration of buildings, affording lowest capital cost to distribute and utilize waste heat from the generating assets of a cogeneration system. These buildings have already withstood elements of nature for several years. The microgrid will be designed to exceed local codes for weather events.

The proposed configuration is for the microgrid power to be sent into the ConEd distribution system and in turn redistributed by ConEd to the microgrid loads. In the event of a loss of grid, ConEd will automatically operate separating switches to isolate and "island" the microgrid from the rest of their system, allowing the microgrid to operate grid-independent for as long as required. Upon restoration of grid power ConEd will revert the system back to grid connected normal operation. The distributed energy resources, electrical switchgear, storage tanks, interconnections, control system and ancillary work will all be served by new equipment.

As shown in the electrical one line diagram contained in the appendices, the microgrid will have 11 interconnections with the utility. ConEd will have to add high tension system separating switches and some coordination of control sequences to control and direct the microgrids output.

Maintaining a microgrid system at maximum reliability is best accomplished by having a system, which is in continuous operation. For on-site electric generation using heat engines, economics dictate that the generation cannot be operated as Separate Heat and Power (SHP), as is the case for utility electric and separate heating boilers, but instead must be integrated into the host facility such that the waste heat from the electric generation cycle can be reclaimed and put to beneficial use.

The concurrent production and utilization of electricity and thermal energy is known as Combined Heat and Power (CHP) or Cogeneration. All electricity generated in systems using fossil fuels produce thermal energy as a by-product. This energy is typically rejected to the atmosphere as a waste product. Which in combination with electric transmission system energy losses, results in power delivered to end users at fuel to power conversion efficiencies in the range of 25% to 50%. By generating electricity at a location where the thermal by-product can be used effectively (such as campus facilities that have centralized thermal distribution) the conversion of fuel to useful energy (electric plus thermal) can be as high as 90% utilization, as illustrated by Figure 4 and Figure 5.

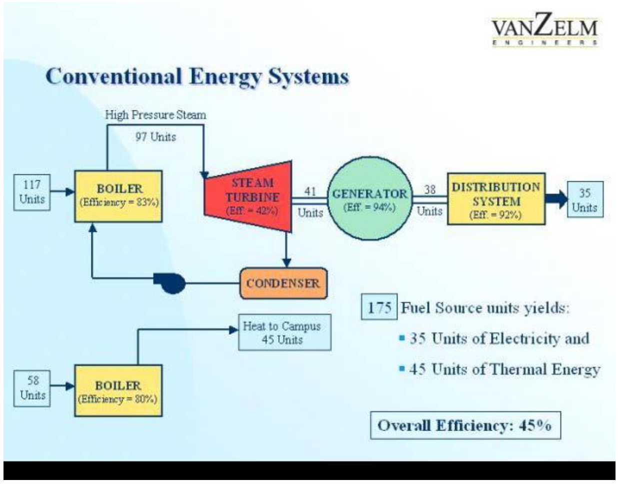

Figure 4: Separate Heat & Power System

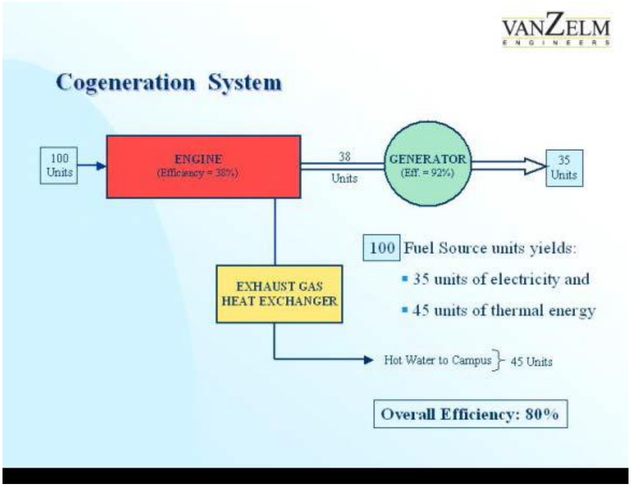

Figure 5: Combined Heat & Power System

2.5: Microgrid and Building Controls Characterization

The proposed East Bronx Healthcare Microgrid (EBHM) shall act as a single controllable entity with respect to the grid and will be able to function in both a connected and disconnected or "island" mode during cases of loss of grid emergency. The proposed configuration is for the microgrid power to be sent into the ConEd distribution system and in turn redistributed by ConEd to the microgrid loads. In the event of a loss of grid, ConEd will automatically operate separating switches to isolate and "island" the microgrid from the rest of their system, allowing the microgrid to operate grid-independent for as long as required. Upon restoration of grid power ConEd will revert the system back to grid connected normal operation. The microgrid will have black start capabilities in the event of a power failure. The operational sequence calls for running the solar panels and microturbines located at Calvary Hospital and the five 4.6 MW engines as determined by incidental load requirements. The black start diesel generators will be used to provide start up power to the microgrid in case of a grid power failure.

It is not anticipated that the microgrid will participate in any demand response or load shedding programs, but as an additional measure of resiliency, in the detailed design phase, the potential for establishing a hierarchy of non-critical building loads that could be shed to accommodate forced outages or to extend operating time on onsite fuel storage will be examined.

As part of integrating cogeneration into the microgrid, conventional power generation will in continuous operation for in excess of 8,000 hours per year. The microgrid will base load the proposed generating equipment to satisfy the electrical demands, while utilizing the resulting thermal by product for winter space heating, summer cooling using absorption chillers, and year round production of domestic hot water.

Recent storms, such as Tropical Storm Sandy, clearly emphasize the need for distributed generation of electrical power and thermal energy at critical facilities such as hospitals, utility distribution centers etc. In case of a loss of grid incident, whether on account of a weather event or otherwise, a microgrid can be “islanded” (i.e. cut off from the de-energized grid) and the hospitals could continue operating as usual. Figure 6 below shows the extent of the 2012 Storm Sandy blackout in Manhattan.

Figure 6: Storm Sandy Manhattan Blackout

In the absence of a distributed energy generation microgrid, the facilities would have had to significantly reduce their power consumption by switching over to back up generators, which would have significantly impeded operations. As critical and long-term care facilities, it is imperative that they are able to operate continuously even in the event of a blackout. A microgrid will ensure this.

2.6 Information Technology (IT)/Telecommunications Infrastructure Characterization

As part of powering the East Bronx Healthcare Microgrid, the preliminary intent for load management will be accomplished using a variant on the smart grid technology, in that the microgrid isolation and islanding, and dispatch of the generation will be controlled by ConEd distribution SCADA, coordinated with control of the building loads by building automation systems. The two will be firewall isolated, yet will provide coordinated load management, such that the ability to maximize the generating assets will be accomplished, i.e., if a significant solar PV component becomes feasible, it’s variability need to be accommodated by control of conventional generation assets and building load management. Additionally, the energization of large loads will be managed to effectively accommodate the block loading capability of the generating assets.

It is proposed that the Microgrid control system shall employ SCADA technology, contained entirely within the microgrid. This will utilize fiber optic communication and is intended to exclude internet connection to any of the control system.

3: Commercial and Financial Feasibility

3.1 Commercial Viability – Customers

3.1.1: Number of individuals impacted by outage

The participating hospitals' primary service area is the Bronx, NY, with a population of 1,438,149, as of 2014. With a combined 1,270 beds, the hospitals provide emergency, long-term, and hospice care to the surrounding community, serving as the primary medical infrastructure of the East Bronx. Serving over 137,000 patients annually, the hospitals serve 9.5% of the Bronx population.

Albert Einstein College of Medicine has over 1,300 students enrolled in M.D, Ph.D., and post-doc programs, has over 2,000 fulltime faculty, and provides staff housing to over 1,000 individuals on site. Several thousand patients, staff and faculty would be directly effected in the event of an outage, with wider impacts felt throughout the community.

3.1.2: Direct and paid services generated by microgrid operation

The EBHM is not anticipated to provide ancillary services to the grid, such as frequency regulation and spinning reserve. However, the sale of electricity into the grid is envisioned in a net metering arrangement, such as SC9 - Rate V.[3]

3.1.3: Microgrid customers

The customers of the EBHM are Montefiore Medical Center's Jack D. Weiler Hospital, Jacobi Medical Center, Calvary Hospital, and Albert Einstein College of Medicine. Weiler Hospital and Jacobi Hospital are privately owned not-for-profit hospitals, and Jacobi Medical Center is part of New York City's public Health + Hospitals Corporation. Montefiore Medical Center acquired Albert Einstein College of Medicine in 2015, which now operates under the Montefiore umbrella.

3.1.4: Microgrid stakeholders

There are multiple stakeholders in the project and each receives different benefits. Clear definable benefits for the identified customers of the EBHM are:

- Reduced electrical and steam cost due to more efficient generation.
- Able to be operational during a grid disturbance/outage, which will enable service to their community.
- Provision of a hedge to future spikes in commodity cost over the life of the EBHM.

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[3] http://www.coned.com/documents/2013-rate-filings/Electric/Exhibits/159-ExhibitERP-1.pdf

- The potential for green electric vehicle charging

The surrounding community also receives benefits from the development of the EBHM.

- During a grid outage the hospital facilities can remain operational to support the community needs and act as a place of refuge.
- Immediate carbon footprint benefit and a greater benefit after the retiring of the Indian Point nuclear generating station.

Likewise, the utility will benefit from the installation of the EBHM. These benefits are predominately related to the grid stability and operation.

- Reduction of load on the current generating system, and the purchase of natural gas to power the generating equipment.
- Deferred investment in electrical infrastructure upgrades due to reduced distribution load on the local substation
- Capital cost for interconnection of new facilities and immediate upgrade capital for system bracing if required.
- Reduction of load during re-energization of grid after outage.

Suppliers and partners will benefit from the initial business created by design and construction, and financial returns from ongoing operation through a PPA.

New York State (and New York City) will benefit in many ways by the development of the EBHM.

- The project’s contribution to the goals of REV
- The project’s contribution to the goals of OneNYC.
- State Tax generation from wages and purchases
- Job creation for the initial installation and future full time operations

This EBHM will provide reliable, affordable power at numerous adjoining critical facilities, allowing operation of the healthcare infrastructure during grid outages, and improving the energy efficiency of the off-takers, reducing their contribution to the state’s greenhouse gas emissions.

3.1.5: Relationship between the microgrid owner and the purchaser of the power

The microgrid owner is envisioned to be a third party entity selected through a competitive bidding process over the summer and fall of 2016. This third party owner would assume ownership of all generating assets and enter into PPAs with the individual customers, Montefiore’s Weiler Hospital, Einstein, Jacobi, and Calvary. Once a developer is selected, the specific arrangements between the owner and the customers will be outlined in Power Purchase Agreements (PPAs) between the microgrid owner and the individual customers. Items for inclusion in the PPAs are outlined in section 3.1.7; however, the details of the PPAs will be established in contractual negotiations between the parties.

3.1.6: Purchase of electricity during normal operation and islanded operation

All participating institutions will purchase power during both grid-connected and island mode. The design of the microgrid is to have the microgrid act as the primary supplier for the customers, operating in parallel with the utility grid in a net metering arrangement, discussed further in Under this arrangement the customers purchase power from the microgrid owner through their respective PPAs, while the microgrid owner enters into a PPA with the utility to sell power back into the grid.

3.1.7: Planned contractual agreements with critical load purchasers

The contractual arrangements will be established as individual PPAs between a third party microgrid owner-operator, financier, and the off-takers. The financier will be selected through a competitive bid process in the summer of 2016, and will undertake the outlining of contractual agreements with the off-takers thereafter. The PPAs will addresses the following areas:

- Interconnection and metering agreements
- Delivery arrangements
- Obligations to sell and purchase energy for the owner and customers respectively
- Price agreements and payment terms
- Operations and Maintenance arrangements
- Legal terms of the agreement

All customers of the EBHM will be critical load purchasers.

3.1.8: Customer registration

The customers (Montefiore, Einstein, Jacobi, and Calvary) have already been identified and are committed to the project, having provided letters of support at the outset of Y Prize (included as Appendix F). The actual registration of customers as off-takes of the EBHM will take place through the PPA contractual negotiations between customers and the third party microgrid owner.

3.1.9: Commodities provided by the microgrid

The EBHM will provide electricity and steam to its customers through combined heat and power generation. Steam generation at the Einstein Steam Plant will supply the thermal needs of Jacobi and Einstein, as indicated in Appendix A. Due to its distance from the Steam Plant, Calvary Hospital will be supplied with steam through a separate 1 MW cogen unit located at the hospital. The electric and thermal commodities will be the only two energy commodities provided by the EBHM.

3.2 Commercial Viability - Value Proposition

3.2.1: Benefits and costs to the community

The community will realize the benefit of ongoing operation of the hospitals during a grid outage. This serve's the community's need to have ongoing medical treatment for those already admitted to the hospitals during the event of an outage, and also the need to serve the community in the event of natural or man-made disasters. Ongoing operation of the hospitals will allow each of them to serve as facilitates of refuge, accepting patients from the surrounding neighborhoods as well as accepting overflow from Manhattan, as occurred at Weiler Hospital during Hurricane Sandy.

Ongoing operation also supports the preservation of medical research at Einstein College of Medicine in the event of grid outage, the loss of which is estimated to be over $700,000 million in direct losses, aside from the immeasurable loss of potential medical discoveries.

An additional benefit to the community is reduction in carbon footprint, an estimated 77,241,207 lbs. CO2e at the source, based on the generating mix in the region. Additional benefits include job creation for construction of the EBHM as well as for full time operations once completed.

The community is not anticipated to incur any costs arising from the EBHM aside from incidental traffic delays during construction.

3.2.2: Benefits and costs to the utility

Benefits to the utility are predominately related to the grid stability and operation. The utility would see a reduction of load on the current generating system, as well as a reduction of load during re-energization of the grid after an outage. The utility would also benefit from the purchase of natural gas from the utility to power the generating equipment. Deferred investment in electrical infrastructure upgrades due to reduced distribution load on the local substation would be an additional benefit.

The microgrid design proposes to distribute power over utility-owned lines, presenting upfront costs to the utility, but befits in the long term resulting from tariffs and grid stability. Upfront costs to the utility include capital cost for interconnection of new facilities and immediate upgrade capital for system bracing if required. This arrangement was arrived at based on the model of the state of Connecticut, which provided for utility-controlled interconnection of microgrids to the utility grid.[4]

3.2.3: Proposed business model and SWOT Analysis

The proposed business model is to establish a Third Party Financing (TPF) vehicle with a qualified Build, Own, Operate and Maintain (BOOM) entity. This entity will be selected through a competitive Request for Proposal (RFP) to take place during the summer of 2016. Initial expressions of interest from third party developers are included as Appendix E. This list of participating bidders is being routed for approval and includes industry experts who will provide the necessary knowledge and experience to fully develop, design, build, own operate and maintain the EBHM.

In addition, the selected BOOM will manage the EBHM facility and bring private financing to this installation. The BOOM is also expected to provide a complete range of services, from design consultation, finance and installation to operation, maintenance and monitoring. Most importantly, the selected BOOM will guarantee the EBHM off-takers with continuous thermal and electrical outputs sufficient to meet their needs for the duration of the contract.

The contracts that will be negotiated between the BOOM and the EBHM off-takers are expected to be a lengthy process that will take into account the particular circumstances and requirements of each site (for example a College of Medicine vs. an inpatient hospital or a private institution's investment policy vs. a City hospital). The contract duration is expected to exceed five years in order for the BOOM to achieve their desired return on investment.

A SWOT Analysis for the BOOM model is presented in Figure 7, and expanded upon below.

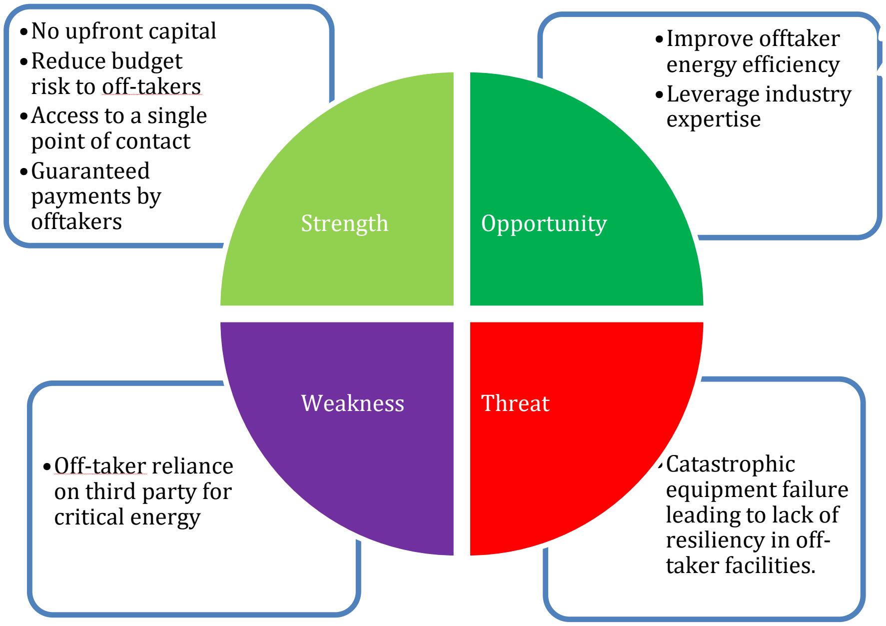

Figure 7: SWOT Analysis

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[4] https://www.cga.ct.gov/asp/cgabillstatus/cgabillstatus.asp?selBillType=Bill&bill_num=23&which_year=2012

The strengths of this model include:

- No initial capital requirement - the total cost of the project will be financed through the BOOM Agreement
- Reduced budget risk to the customers through take-or-pay contractual arrangements that specify a pre-arranged purchase amount from the customers, mitigating against possible future spikes in commodity costs.
- Each EBHM off-taker will have access to a single point of contact who has the required technical and financial expertise
- Each EBHM off-taker will pay the BOOM for guaranteed services (the energy delivered)

A potential weakness of this model is the reliance of the customers on a third party to serve critical loads. This weakness will be mitigated through a rigorous selection process for the microgrid owner, as well as the ability of the microgrid to operate in parallel with the utility grid. This arrangement establishes resiliency by allowing the microgrid and the utility grid to both act as backup in the event of loss of power from either grid.

Opportunities arising from the BOOM model include the ability to improve the efficiency of energy used by the off-takers through serving multiple loads from the microgrid. The BOOM model allows the microgrid developer/owner to size equipment appropriately to the loads being served, and to enter into separate PPAs with each off-taker. The model also opens the opportunity to leverage industry expertise from developers who have demonstrated expertise in large CHP development projects. A wider opportunity of the project is to serve as a model for community microgrid development as this technology is deployed elsewhere in New York and in other states as well.

The primary threat of this model is catastrophic simultaneous equipment failure, leaving the microgrid owner unable to fulfill its contractual obligations. This scenario is very unlikely to occur. However, such an eventuality will be addressed in the PPAs between the owner and off-takers.

Gotham Energy 360 LLC is expected to remain involved in the EBHM project as a facilitator to the EBHM development and to represent the off-takers in the selection of the BOOM and the negotiation of the contract.

3.2.4: Unique technological and site-specific characteristics

This project will promote innovative integration of various technology, including solar photovoltaics, alternative vehicle fueling stations, and smart communication technology, as discussed in section 3.2.10.

Beyond the technology, the site of the EBHM is unique in the NY Prize competition, consisting of three critical healthcare facilities, and a college of medicine conducting ongoing medical research. These healthcare facilities are located in the Bronx, serving a vulnerable community, with 31.5% living below the poverty line as of 2014, and just under 50% qualifying for the state eligibility requirements for

Medicaid. These hospitals, however, are located on elevated ground, mitigating the risk from flooding to the microgrid's infrastructure.

This project is also unique, given the institutional expertise of Montefiore Medical Center in the development and operation of CHP. Montefiore's Moses campus was the first implementation of CHP in New York City, with a nearly 5 MW installation in 1993. The plant was expanded to just over 9 MW in 2001, which allowed the hospital to remain fully operational during the Blackout of 2003, and Hurricane Sandy in 2001. This previous experience provided Montefiore with the insight to the value of on-site energy production to support the resiliency of their facilities, and secured their early commitment to pursue the development of a microgrid at Weiler Hospital.

3.2.5: Replicability and scalability

The proposed design utilizes 5 natural gas turbines, a solar PV array, and existing backup generation to integrate loads across numerous facilities and customers. The modular nature of the design allows this particular microgrid to be scaled up if additional customers are added in the future, and provides a model that can be replicated in other locations, including distribution switching and design elements around a campus offset power scheme. The latter allows for the placement of generation where the space is available and not particularly at the load as is what is done for conventional CHP projects.

The BOOM model has been demonstrated in previous CHP projects and is scalable to the development of a microgrid incorporating CHP and solar. Expressed interest by third party developers highlights the applicability of the BOOM model to development of the EBHM.

3.2.6: Project purpose and resiliency

The purpose of this project is to ensure the highest quality power and continuous service for the three participating hospitals and research being conducted at Einstein College of Medicine. The facilities are located in a 2018 ConEd targeted zone for CHP development, identified as an area where the reliability of power can be enhanced by the deployment of on-site generation. Resiliency is particularly critical for the customers of the EBHM, which must maintain reliable power to serve their patients as well to serve the community as facilities of refuge during emergencies.

The microgrid will be designed to withstand extreme weather events, such as high winds and will be sited on elevated land to safeguard against flooding. All power lines utilized by the microgrid will be underground to support resiliency to weather, as well as other disruptive phenomena such as, damage by animals, falling tree branches, traffic accidents, and intentional damage resulting from vandalism or terrorism. Communication between the utility and the customers is proposed via underground fiber optic cable installed in the same trench ways as the electrical conduit, safeguarding the IT infrastructure against cyber-attack. The microgrid will be designed with the capacity to island for a minimum of seven days in the event of grid failure.

3.2.7: Project value proposition

The value of the microgrid is the provision of reliable power to ensure energy resiliency and ongoing operation of the facilities in the event of grid failure. This supports not only the primary customers, but also the surrounding community the utility, the project partners, New York City and New York State.

The customers receive the ongoing benefit of a reduced electrical and steam cost due to more efficient generation, and a hedge to future spikes in commodity cost over the life of the microgrid. Additionally, the facilities will be able to be operational during a grid disturbance, which will safeguard against lost revenue from interrupted service to patients, and enable wider benefits through ongoing medical service and shelter to the community.

Additional benefits to the community, the city, and the state, are a carbon footprint benefit now and a greater benefit after the retiring of the Indian Point nuclear generating station. One megawatt of solar contributes to the Renewable Portfolio Standard, and the efficiency of the microgrid overall will produce a 77,241,207 lb. CO2e reduction at the source of emissions, as calculated by the current mix of generation.

More immediate value will be the creation of jobs for construction, revenue to project partners, including the developer and project subcontractors to be determined in the next stage of the process.

Over all, the EBHM will provide value to a wide array of project stakeholders, both in the short-term in the form of jobs and economic activity development resulting from planning and construction, and in the long-term through reduction in greenhouse gas emissions and improved energy resiliency to support the critical facilities.

3.2.8: Revenue streams, savings, and costs to the off-takers

One potential revenue stream is through demand response (DR) payments, depending on the eligibility of microgrid customers to enrollment in DR programs, however the reduction of load on the utility grid through islanding of the microgrid would likely not qualify for DR. The business model for the EBHM is for third party financing, and for the financier to recoup initial outlays through a depreciation benefit and electric and thermal commodity sales to the off-takers.

Due to these considerations, revenue streams are not anticipated to accrue to the microgrid off-takers. Their primary benefit will be the provision of reliable power from the microgrid. Likewise, the customers are not anticipated to bear any costs of development. Savings from CHP efficiency could benefit the facilities, but at this time, this benefit as well as the premium power and redundancy provided by the microgrid will not be monetized. This is a new benefit to the off-takers, which will be delivered while maintaining budget neutrality and providing a hedge to potential electricity spikes in the market. A monetization of revenue streams to the microgrid owner is provided in section 3.5.1 and a comprehensive financial analysis will be undertaken as part of Stage 2.

3.2.9: Promotion of state policy objectives

The EBHM supports both REV and the Renewable Portfolio Standard. The incorporation of solar PV furthers the Renewable Portfolio Standard by contributing 1 MW of power to the EBHM. The project supports REV through improving the energy efficiency of the customer's facilities, new investment in energy infrastructure, smart-grid technology through SCADA technology and automatic islanding, and supporting alternative energy in transportation through the installation of electric vehicle charging stations and compressed natural gas fueling stations.

3.2.10: Promote new technology

This project will provide and promote new technology in many ways. The EBHM aims to incorporate on-site CNG storage as backup fuel for the natural gas turbines, which may also be used to fuel natural gas powered vehicles. This provides a unique way of creating storage for fuel interruption while maintaining a very clean emissions profile. Traditionally, turbine installations would seek a dual fuel installation, which would switch to Ultra low sulfur fuel oil. Burning fuel oil in turbines usually reduces the service interval thus creating more downtime. By staying with natural gas as our singular fuel, complexity, system availability and emissions will benefit.

Another new application of technology brings district operations tasks to the end user. SCADA switching will allow for uninterrupted power in the event of grid-outage. The EBHM will transition to island mode and the switching will allow the use of the street feeders to support the off-takers. Upon re-energizing of the grid, the switches will return to their normal state

3.3 Commercial Viability - Project Team

3.3.1: Securing community support

Full support has already been obtained from the microgrid's customers. In addition, the utility has been cooperative and engaged throughout the feasibility study. The New York City Mayor's Office of Sustainability is closely following the project and has offered to provide support as needed. The project is not designed to serve any residential or commercial loads.

3.3.2: Roles of the team members

Development of this project will be conducted by a third party developer to be selected through a competitive RFP over the summer of 2016. Gotham 360 is the project manager, acting on behalf of the applicants: Montefiore Medical Center, Jacobi Medical Center, Albert Einstein College of Medicine, and Calvary Hospital. These applicants will be the customers of the microgrid.

The RFP for the third party developer will seek a BOOM entity, as outlined in section 3.2.3, that can secure financing for the EBHM, provide design consultation during NY Prize Phase 2, build the microgrid during NY Prize Stage 3, and own, operate, and maintain the microgrid thereafter. These services could be provided by one entity or by several. The most appropriate arrangement will be determined through the developer selection process. Subcontractors will be identified as appropriate based on the arrangement arrived at with the developer.

Van Zelm Engineers and Environmental EES are partners on this project and will continue to provide design, engineering, and permitting for the EBHM. The utility has been forthcoming and enthusiastic about this project to date, and has indicated ongoing support during NY Prize Stage 2.

3.3.3: Public-private partnerships

The EBHM will serve two private institutions, Montefiore-Einstein, and Calvary Hospital, and one public Hospital, Jacobi Medical Center. Each of these entities will enter into individual PPAs with the microgrid owner. Financing will be secured through capital markets, as well as any potential funding from future stages of NY Prize. Due to these arrangements, public-private cooperation will be crucial to the success of this project, although contractual arrangements will be established on an individual basis with each facility.

3.3.4: Financial strength of the applicants

The primary applicant is Montefiore Medical Center. As of December 31, 2014, Montefiore had $3.47 billion in operating revenue, and $3.35 billion in operating expenses, an excess of revenue of over expenses of $126,472,000. Total assets were $3.39 billion and total liabilities were $2.49 billion, for a total of $905,711,000 in total net assets. Montefiore acquired Albert Einstein College of Medicine in 2015, which receives over $157 million in funding from the National Institutes of Health (NIH). Montefiore has yet to release financial information since the acquisition, however this information will be made available once released.

Jacobi Medical Center is part of the NYC Health Plus Hospitals Corporation, which as of June 30, 2015 had $6,035,959 in total assets and $10,979,213 in total liabilities, for a total deficit position of -$5,186,192.

As of December 31, 2015 Calvary Hospital had a total of $110,426,400 in revenue and $120,285,900 in expenses for a total of -$9,859,000 in net income. Calvary reported a $6,439,150 decrease in net assets from December 31, 2014 to December 31, 2015.

Financial statements are included as Appendix G. The financial standing of the owner will be provided once a development partner is selected.

3.3.5: Team member qualifications

The team members on this project are Gotham 360, LLC, van Zelm Engineers, Environmental Engineering Solutions, RC (EES), and Couch White, LLP. The team's qualifications are attached as Appendix D.

3.3.6: Selection of suppliers and contractors

Suppliers and contractors will be determined following selection of a development partner through a competitive RFP. The selection of a project developer will consider the proposer's ability to provide financing, construction, and O&M for the microgrid. Any services not performed by the developer will be sought through project subcontractors to be selected from a competitive bidding process.

3.3.7: Selection of financiers

Financiers and investors will be determined in the next phase of the project. An RFP will be issued to qualified firms and define the instrument that we believe will offer the most significant value to the EBHM off-takers. We have held preliminary talks with many firms, including GI Energy, Veolia, and Ameresco. An RFP will be issued over the summer of 2016 to identify the project developer, and communicated to NYSERDA as a development partner is selected.

A primary consideration in the selection of a developer will be their ability to demonstrate previous success leveraging capital markets and securing financing for large CHP installations. The microgrid will be entirely developed by the third party entity without upfront capital requirements from the microgrid's customers.

3.3.8: Legal and regulatory team members

Environmental Engineering Solutions PC is one of the original partners on the project and is providing regulatory and permitting services. Couch White, LLP is the legal advisor on the team. Their qualifications are included in section 3.3.5 and in Appendix D.

3.4 Commercial Viability - Creating and Delivering Value

3.4.1: Benefits and challenges of selected technology

Recuperated natural gas turbines were selected as the prime movers due to their efficiency, emissions, and modularity. Post combustion catalysts are not required due to the sufficiently low emissions from the turbines. They are also able to operate with and without thermal load if necessary, avoiding the necessity to install ancillary equipment for heat rejection in the absence of thermal load. This allows the turbines to operate to serve only the electric load if required in a grid outage event. During normal operation the turbines will operate as CHP engines, providing both electric and thermal commodities.

The 1 MW micro turbine at Calvary allows a modular configuration to operate in 20-increment block load steps, with variability at each step, to provide the appropriate amount of power to balance the intermittent production of solar power, provided by a 1 MW solar PV installation. The solar installation will make use of otherwise unused space above parking lots and on rooftops, contributing renewable power to the EBHM.

Due to the mission critical facilities to be served by the EBHM, the energy generation mix has been diversified. Fewer larger machines could have been configured, however, a forced outage would have compromised capacity. Instead machine sizes were limited to 20% of microgrid peak load. Additionally, to provide a dual benefit of redundant emergency capacity as well as capability to black start the microgrid in the event of loss of grid emergency that impacted the campus into needing to black start the microgrid, black start Diesel (BSD) machines have been included, at sizes that would allow the microgrid to support the EBHM in the event of a forced outage of one of the primary energy generation assets. The selected machines are the largest diesels that can be black started using self-contained battery banks. Table 1 in section 2.1.2 provides a tabulation of these resources.

The primary challenge to diversifying the asset mix is increased cost; however, this design is proposed due to its benefit to the resiliency of the customers.

3.4.2: Existing assets

All facilities currently provide for their backup emergency generation, which will remain in place as a layer of redundancy to support life safety and critical systems. Jacobi and Montefiore also currently provide their own steam. A full engineering design will determine the most optimal way to incorporate existing steam generation assets with new CHP equipment. All existing energy assets will be purchased by the third party microgrid owner to coordinate the production of both the electric and thermal commodities on site. The selection process for the third party owner will take place over the summer and fall of 2016. The current design will be adjusted as necessary to conform to the development requirements of the owner.

The hospitals also currently own unused space that will house the microgrid's equipment. CHP units will be located at a former steam plant and laundry facility owned by Jacobi and leased to Einstein, and in the basement of Calvary Hospital. Solar PV panels will be distributed on rooftops and above parking lots throughout the site.

3.4.3: Balance of generation and load

The proposed design utilizes 6 natural gas turbines, a solar PV array, and existing backup generation to integrate loads across numerous facilities and customers. The modularity of the micro turbine at Calvary Hospital allows for the smooth integration of solar. The sizing of each of the CHP engines at Jacobi (limited to 20% of peak load) and their ability to operate as 'electric only' provide the ability to tailor the system so that generation balances the load requirements of the customers.

3.4.4: Required permits

Permits from NYSDEC (including Part 222 Distributed Generation), NYCDEP, NYCDOB, FDNY and NYSDEC/PBS will be required at a minimum. Any new combustion source projects in NYC require all of the above permits. EPA rules (Subpart KKKK, IIII, ZZZZ, JJJJ) will be included in NYSDEC analysis/permit.

3.4.5: Proposed approach for developing, constructing and operating the project

A third party developer will be selected through a competitive bid over the summer of 2016. The developer will be a qualified Build, Own, Operate and Maintain (BOOM) entity, as outlined in section 3.2.3. The conventional financing is a split of debt and equity. In this method, an equity partner would buy down debt for the project for the depreciation benefit that the project generates. Depending on the structure of the project and the amount of benefit, sometimes the third party operator can perform this role as their parent can value the advanced depreciation benefit of the project.

In this vehicle, the third party operator and the constructor mitigate risk of operations and construction respectively. The project/program management team ensures project schedule is met so as to control the interest during construction and to meet commercial availability of the system to its off-takers.

In this model, the project management firm (Gotham 360) is involved until commercial availability. After that milestone, the off-takers, operations and maintenance entity, microgrid owner, and the financier are the only participants remaining. This arrangement is illustrated in Figure 8.

While we believe this is the best financial vehicle for the project we are not foregoing other options, which will be proposed by the potential RFP respondents. By allowing for alternates by the firms this will open the possibility to utilize other creative development and financing options.

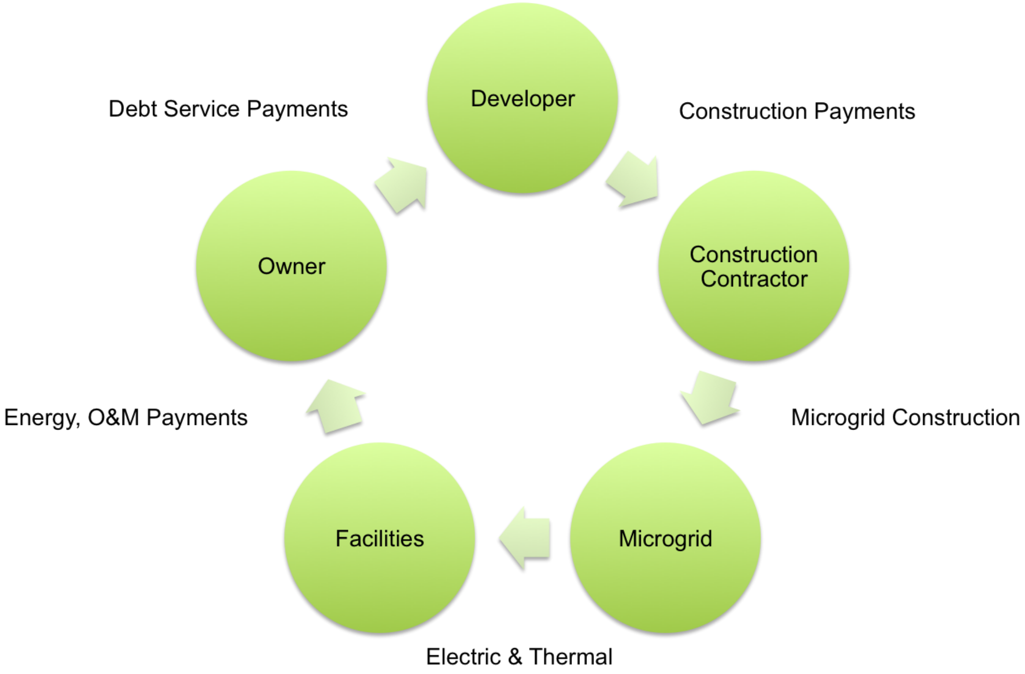

Figure 8: BOOM Model

3.4.6: Benefits and costs to the community

The community may incur minimal costs due to incidental travel delays during construction, but no significant costs to the community are anticipated.

Benefits will accrue to the community as a result from having fully functional medical facilities to provide ongoing care and emergency treatment during grid outage. Fully operational hospitals will also serve as facilities of refuge when needed, providing shelter to the community during natural or manmade disasters.

The location of the EBHM in a 2018 ConEd targeted zone will also support the reliability of power in the East Bronx, contributing 25MW of generation to the grid. These benefits will be passed to the community in the form of reliable power and in the ability of the utility to defer further upgrades.

3.4.7: Requirements from the utility

The design of the EBHM is for the utility to own and maintain the power lines used to distribute microgrid power, as discussed in section 3.2.2. ConEd has indicated an openness to this proposal in discussions with utility engineers, which would require the facilities to grant easements to the utility for the installation of new conduit and for line maintenance or repairs when needed. Further discussions would be required to fully outline the contractual arrangements between the microgrid owner and the utility. Regulatory specifications would also be required as an outcome of NY Prize to facilitate this arrangement. Discussions with the utility are anticipated to occur as part of Stage 2, audit-grade design. Guidance will be sought from the PSC, NYSERDA, and the utility as to the appropriate scope of innovation, given the ongoing nature of regulatory reforms through REV and timeframe of NY Prize Stage 2 design in the regulatory reform process.

3.4.8: Demonstration of selected technology

Given the critical nature of the facilities, the choice of all equipment prioritized proven applications of CHP and solar technologies. Five 4.6 MW Solar Mercury 50 natural gas turbines and one dual-fuel 1 MW Capstone Microturbine were selected as the primary generating technologies. Case studies of these technologies' application are included as Appendix J.

3.4.9: Operational scheme

The operational scheme follows from the BOOM development model. In this arrangement, the microgrid owner is responsible for the technical operation, and provides power to the customers through PPA contractual arrangements. Separate PPAs are established with each customer, which govern the financial transactions between owner and customers. This is proposed to take the form of take-or-pay agreements, in which each customer is guaranteed to purchase a minimum amount of power to safeguard the revenue streams for the owner. The customers, in turn, benefit from reduced costs due to the efficiency of CHP.

The microgrid owner is responsible for O&M (whether they provide this service internally or subcontract to a third party entity). The owner is also the entity that enters into an arrangement with the utility, governing the operation of the microgrid in parallel with the utility grid, and entering into a net metering arrangement through a long-term PPA with the utility.

The operational details will be fully outlined in Stage 2, once a development partner has been brought on board.

3.4.10: Metering and charging of microgrid customers

The individual microgrid customers will be charged via a PPA for all electricity and thermal benefits. This PPA will be indexed on fuel price. Even though Zone J has traditionally held a large correlation between natural gas and electrical pricing, the index will handle both the increases in fuel cost or the potential divergence of the commodities in the future.

The PPA will have three main parts;

- Energy charge per kWh
- Demand charge per kW per day
- Minimum take or pay kWh

The third component insures debt service for the microgrid is achieved.

3.4.11: Replication business/commercialization plans

Since each project is unique, exact replicability of this project would not be advised. However, aspects of the model are appropriate for replication, including distribution switching and design elements around a campus offset power scheme. The latter allows for the placement of generation where the space is available and not particularly at the load as is what is done for conventional CHP projects.

The BOOM model has been demonstrated in previous CHP projects and is scalable to the development of a microgrid incorporating CHP and solar. Expressed interest by third party developers highlights the applicability of the BOOM model to development of the EBHM.

3.4.12: Barriers to market entry

Since the contract vehicle will be a PPA, there are not any significant financial barriers to entry.

There are contractual and permitting requirements that will need to be addressed in detail. There will be metering requirements necessary to facilitate billing. For the participant facilities that will house generation assets, there must be comprehensive contractual arrangements established with the microgrid owner/operator. These negotiations will take place once a development partner has been selected. Additionally, air emissions from the new generation facility can add to the resistance to entry. However, permitting is anticipated to be relatively straightforward given the low-emissions profile of the proposed generation assets.

3.4.13: Overcoming barriers

The current project team, with the addition of a development partner will bring extensive experience to the development of this project, including addressing the barriers outlined in section 3.4.12. For an overview of the team's experience see Appendix D. For an outline of the anticipated PPA structure, see section 3.1.7. For the outlining of emissions and permitting requirements see sections 3.4.4 and 3.6.5.

3.5 Financial Viability

3.5.1: Categories and magnitudes of revenue streams

The microgrid will see revenue streams from their off-takers in the form of payments for delivered energy. Since the project will be supplying electrical power and thermal energy, both streams will be monetized. Based on the current usage profiles and the market cost of natural gas, the cost to produce thermal energy through conventional boilers would be approximately $6.3MM.

Month	Load	SYSTEM LOSS FACTOR	Adjusted Load for system losses	COMMODITY & BASIS AT THE NY CITYGATE	Supply subtotal	GRT ON COMMODITY	Supply Total
JAN	176733.4	2.063%	180,379.38	$ 4.97280	$ 896,991	2.4066%	$ 918,577.58
FEB	146093.8	2.063%	149,107.66	$ 3.83930	$ 572,469	2.4066%	$ 586,246.09
MAR	124779.1	2.063%	127,353.32	$ 3.32880	$ 423,934	2.4066%	$ 434,136.12
APR	85781.63	2.063%	87,551.30	$ 3.55880	$ 311,578	2.4066%	$ 319,075.99
MAY	102840.9	2.063%	104,962.48	$ 3.04890	$ 320,020	2.4066%	$ 327,721.72
JUN	113568.5	2.063%	115,911.42	$ 2.68690	$ 311,442	2.4066%	$ 318,937.56
JUL	128882.9	2.063%	131,541.73	$ 2.47790	$ 325,947	2.4066%	$ 333,791.50
AUG	123952.8	2.063%	126,509.90	$ 2.40650	$ 304,446	2.4066%	$ 311,772.86
OCT	117803	2.063%	120,233.28	$ 2.82460	$ 339,611	2.4066%	$ 347,783.99
NOV	87413.25	2.063%	89,216.59	$ 3.09990	$ 276,562	2.4066%	$ 283,218.25
DEC	95807.25	2.063%	97,783.75	$ 3.48740	$ 341,011	2.4066%	$ 349,217.83
SEPT	119988.6	2.063%	122,463.99	$ 2.36570	$ 289,713	2.4066%	$ 296,685.30
							$ 4,827,164.78

Table 5: Revenue Stream Supply Component

FIRST 3 MMBTU	DELIVERY FIRST 50,000 MMBTU	DELIVERY NEXT 50,000 MMBTU	subtotal	GRT ON DELIVERY	Delivery total
$ 10.000	$ 0.800	$ 0.700	$ 144,314	2.6026%	$ 189,398
$ 10.000	$ 0.800	$ 0.700	$ 119,296	2.6026%	$ 156,563
$ 10.000	$ 0.800	$ 0.700	$ 101,893	2.6026%	$ 133,721
$ 10.000	$ 0.800	$ 0.700	$ 70,051	2.6026%	$ 91,929
$ 10.000	$ 0.800	$ 0.700	$ 83,980	2.6026%	$ 110,211
$ 10.000	$ 0.800	$ 0.700	$ 92,739	2.6026%	$ 121,707
$ 10.000	$ 0.800	$ 0.700	$ 105,243	2.6026%	$ 138,119
$ 10.000	$ 0.800	$ 0.700	$ 101,218	2.6026%	$ 132,835
$ 10.000	$ 0.800	$ 0.700	$ 96,197	2.6026%	$ 123,693
$ 10.000	$ 0.800	$ 0.700	$ 71,383	2.6026%	$ 93,677
$ 10.000	$ 0.800	$ 0.700	$ 78,237	2.6026%	$ 102,673
$ 10.000	$ 0.800	$ 0.700	$ 97,981	2.6026%	$ 125,988
					$ 1,520,515

Table 6: Revenue Stream Delivery Component

This assumes that the boilers are on an interruptible rate, which would require a backup liquid fuel requirement. This revenue would go to the microgrid to provide the same thermal that would have been supplied from their own boiler plants. This revenue will be based on a minimum take or pay contract with the off-takers to ensure the debt service and operations cost for the microgrid are realized. Additionally, the microgrid will be supplying electrical power to its off-takers. The current projection of electrical cost to the off-takers assuming SC9 Rate II is approximately $13.8 MM and is shown below:

Month	Demand Cost
January	$ 174,200
February	$ 171,397
March	$ 172,937
April	$ 189,900
May	$ 206,398
June	$ 369,637
July	$ 383,960
August	$ 369,486
September	$ 381,796
October	$ 209,722
November	$ 195,219
December	$ 176,759

$ 3,001,410	Demand
$ 978,350.58	Energy Delivery Charge
$ 1,236.48	Meter
$ 3,980,997	
$ 26,602	EST Reactive Power Demand charge
$ 9,783,506	Commodity
$ 13,791,105	

Table 7: Revenue Streams to Microgrid Owner

These costs would now become revenue streams to the microgrid facility. The premium power and redundancy provided by the microgrid will not be monetized. This is a new benefit to the off-takers, which will be delivered while maintaining budget neutrality and providing a hedge to potential electricity spikes in the market.

3.5.2: Incentives

Solar and CHP incentives would contribute significantly to the development of this project.

Currently, under the Clean Energy Fund, up to $2.5 million in incentives per project are available toward the development of CHP systems. NYSERDA has revised the CHP Program, eliminating PON 2701, and incorporating all incentives in PON 2568[5]. The revisions provide a catalogue incentive for projects up to 1 MW and custom incentives for larger projects, not to exceed 3 MW after December 31, 2016.

With 24 MW of CHP generation, the EBHM would benefit from an extension for large projects to apply to the CHP Program. In the likely eventuality that this option is not available, the option to apply 3 MW of larger projects to the incentive, or the application of the incentive to the Calvary Hospital CHP installation, designed to provide 1 MW of generation, would support the development of the EBHM. The expansion of PON 2568 to apply to systems fueled by compressed natural gas further supports the design of the EBHM.

If found to be eligible for the incentive, the EBHM would also benefit from the 10% bonus available to facilities of refuge, as well as to projects located in the designated 2018 Targeted Zone in the East Bronx, which encompasses the EBHM. The solar PV component of the EBHM would also be eligible for NY Sun's Commercial/Industrial Block 1 in ConEd territory. At $0.63/W, the 1 MW solar installation at the EBHM would be eligible for $630,000 in incentives.

3.5.3: Categories and magnitudes of capital and operating costs

Capital costs will be incurred for the CHP engines, diesel black start generator, fuel tanks, and switchgear. The installed cost per item is presented in table 8. The total installed cost of capital components is estimated to be $34,350,000. This estimate assumes ConEd will retain ownership of the microgrid transmission infrastructure and will bear the costs of interconnection.

There will be fixed and variable components to the O&M costs, presented in Tables 9 and 10, respectively. Fixed costs for labor, replacement parts not under warranty, downtime costs, and equipment rental costs were estimated at $367,965 per year, for a total of $4,171,102 in present value costs (expressed in 2014 dollars), as calculated by IEc in the Benefit Cost Analysis, which assumed a 7% discount rate.

Variable O&M costs were estimated at $184 annually, for a total of $2,086 in present value 2014 dollars over 20 years. These costs (for external mechanical assistance, and design and emissions consultants) are expressed in $/MWh in Table 10.

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[5] http://www.nyserda.ny.gov/PON2568

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
Cogeneration Plant Unit 1	$4,800,000	30	Gas powered Solar Mercury 4.6 MW Cogen Engine
Cogeneration Plant Unit 2	$4,800,000	30	Gas powered Solar Mercury 4.6 MW Cogen Engine
Cogeneration Plant Unit 3	$4,800,000	30	Gas powered Solar Mercury 4.6 MW Cogen Engine
Cogeneration Plant Unit 4	$4,800,000	30	Gas powered Solar Mercury 4.6 MW Cogen Engine
Cogeneration Plant Unit 5	$4,800,000	30	Gas powered Solar Mercury 4.6 MW Cogen Engine
Cogeneration Plant Unit 6	$1,100,000	30	Dual Fuel (Gas/Diesel) 1 MW Capstone Microturbine
Diesel Black Start Generator	$3,200,000	30	4 MW Caterpillar Diesel Backup generator
Diesel Fuel Tanks	$350,000	60	Fuel tanks to store Diesel
Switchgear for interconnection	$4,500,000	50	Electrical switchgear
Utility switchgear	$1,200,000	50	Electrical switchgear
TOTAL	**34,350,000**		

Table 8: Installed Cost of Capital Components

Fixed O&M Costs	What cost components are included in this figure?
$367,965 ($/year)	Labor, parts not covered by warranty, downtime costs, equipment rental costs
$4,171,102 (Present Value over 20 years in 2014 dollars)	

Table 9: Fixed Operation and Maintenance Costs

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
External mechanical help	$/MWh	0.001
External Design Consultants (including emissions consultant)	$/MWh	0.0005
Interest on borrowed capital	Other - please specify	Interest on capital borrowed for investment will affect the monthly or annual interest payments.

Table 10: Variable Operation and Maintenance Costs

3.5.4: Profitability of the business model

The take-or-pay arrangements as outlined in the PPAs between the microgrid owner and the off-takers ensure a minimum purchase by the off-takers, securing a profitable revenue stream for the microgrid owner.

3.5.5: Financing structure

The intent for this project is to develop an RFP for a finance partner. It is envisioned that the finance partner will use a conventional construction loan with draws during the construction period. That loan will be converted to a combination of equity investment and debt service at the conclusion of construction. The details of financing will be arranged once a financial partner has been selected.

3.6 Legal Viability

3.6.1: Proposed project ownership and ownership stakes

The microgrid owner will be a third party entity selected through a competitive bid, as outlined by the BOOM model, in section 3.2.3. The customers will not own the assets, and will enter into contractual arrangements to be determined once a developer has been selected, however the PPAs will outline the stake the customers have in the development of the EBHM as long-term customers of the microgrid.

3.6.2: Relationship of the applicant to the project owner

The owner is anticipated to be the same entity as the project developer, and will be selected through a competitive bid over the summer of 2016. Developers who have expressed interest to date are included in Appendix E.

3.6.3: Ownership of the site

The site of the majority of microgrid generation equipment is owned by Jacobi Medical Center and leased to Albert Einstein College of Medicine under a 99-year lease. Calvary Hospital owns their facility, which will house a 1 MW cogen engine and a portion of the solar PV assets. These site will be made available to house the microgrid equipment, to be owned by a third party, and outlined under contractual arrangements between the customers and the owner, following the selection of the microgrid developer/owner.

3.6.4: Protecting privacy rights of the microgrid's customers

Individual PPAs will be established between the microgrid owner and each of the customers to safeguard the privacy of each customer. Communications infrastructure will also be located underground to protect against cyber intrusion.

3.6.5: Potential regulatory hurdles and implications

City Environmental Quality Review

A City Environmental Quality Review (CEQR) will be required. Assuming that there will be air impact only, at a minimum an air quality dispersion modeling (AQDM) for stack height assessment, greenhouse gas impact and associated negative/restrictive declaration will be required. Furthermore, if there is land use impact, storm water impact, zoning, wastewater impact, etc., these may have to be addressed as well.

The plan to address these is as follows:

- Obtain emissions guarantees for each combustion source for NOx, PM10 and PM2.5
- Identify maximum hours of operation, limitation that the plant can take and perform modeling to determine stack height.

- We anticipate there will be NO ADVERSE IMPACT due to the new project. To meet this objective, NOx control systems (such as SCR) may be required to minimize the impact, depending on results of the AQDM.

Similarly, other areas of CEQR must be addressed, if impacted. However, at this time, we do not anticipate other areas of CEQR will be affected.

New York City Fire Department Regulations

The storage and use of compressed natural gas is subject to NYC Fire Department Certificates of Fitness as outlined by Fire Codes (FC) and Rules (R): FC2201.7, FC3001.4.1, FC3001.4.2, FC3501.4.2 and R3507-01(e). Certificates of Fitness will be sought during the comprehensive engineering design phase.

4: Benefit Cost Analysis

Project Overview

Industrial Economics Inc. (IEc) was retained by NYSERDA to conduct the following Benefit Cost Analysis (BCA) for each of the NY Prize Stage 1 feasibility studies.

The proposed EBHM project would be powered by six new combined heat and power (CHP) plants, with a combined nameplate capacity of 24 MW, as well as a 4 MW diesel black start generator. Five of the CHP plants and the black start generator would be located in the Jacobi Abandoned Steam Plant, and one CHP plant (with a 1 MW capacity) would be located in the Calvary Hospital parking lot. The specific facilities that the proposed microgrid would serve are summarized in Table 11. The system as designed would have sufficient generating capacity to meet 100 percent of average demand for electricity from the supported facilities during normal operations, as well as 100 percent of supported facilities' demand during a major outage. The system would have the capability of providing black start support to the grid.

To assist with completion of the project's NY Prize Stage 1 feasibility study, IEc conducted a screening-level analysis of the project's potential costs and benefits. The following describes the estimations that informed IEc's analysis, the methodology used in their analysis, results of the BCA, a sensitivity analysis conducted by Gotham 360 on the estimation of natural gas fuel prices over a 30 year estimated lifespan, and a note on benefits that were not able to be monetized for inclusion in the BCA.

Outline of Estimations

Outlined below are the data and assumptions relied on to provide IEC with the initial input requested for the BCA. The microgrid and facilities questionnaires issued by IEc and completed for each facility are included in Appendix H.

The distance to the nearest hospital was found to be 3.2 miles (St. Barnabas). Although each of the three EBHM hospitals neighbor each other, it was assumed that grid failure affecting any one of the three hospitals would affect them all.

The cost of hospital evacuations was estimated based on the average cost of an ambulance ride + (average cost per mile * 3.2 miles) * the number of beds per each hospital. The cost of ambulance service was taken from the City of New York Schedule of Charges for Fire Department Ambulance Transport services.[6]

Lost revenue for each hospital was calculated as 100% loss of revenue with 100% loss of power + 70% of daily revenue in fixed costs, which was found to be the minimum financial exposure to hospitals of loss

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[6] http://rules.cityofnewyork.us/content/section-4900-02-schedule-charges-fire-department-ambulance-transport-service

of power, by a 2010 White Paper issued by Schneider Electric.[7]

Lost revenue while operating on backup power was adjusted proportionally to reflect the provision of service while operating on backup power, provided by each hospital, included in the facilities questionnaires in Appendix H.

Cost of evacuating residents from Einstein was estimated based on a bus quote from CharterEverything.com, and salary information from glassdoor.com for the overtime pay rate of 5 NYPD officers for 2 hours to facilitate the evacuation.[8]

The population of the Bronx was determined to be the primary service area of all hospitals, which was 1,438,149, as of 2014.[9]

A 17% increase in EMS service time resulting from weather-related delays was obtained from a Wall St. Journal report published on March 24, 2015.[10] This estimate was used for all hospitals.

Jacobi Medical Center shelters in place, and so estimates for tables 2 and 4 were not provided on the Jacobi Facilities Questionnaire.

In all cases, conservative estimates were used where data was scarce, or where there were conflicting estimates, in order for the BCA to reflect the minimum possible benefit resulting from microgrid.

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.

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[7] Lawrence, B., Hancock, M., Stieva, G. (2010). *How unreliable power affects the business value of a hospital: An in-depth look at the causes and effects of power outages in hospitals across North America, and recommendations to ensure power reliability*. Schneider Electric.

[8] Obtained from Glassdoor.com

[9] http://www.census.gov/quickfacts/table/SEX255214/36005

[10] http://www.wsj.com/articles/ems-response-times-worry-new-york-officials-1427244465

Facility Name	Facility Description
Jacobi Medical Center	Large specialty hospital
Jacobi Staff House	Hospital staff housing
Jacobi - Rose F. Kennedy Center	Hospital center
Jacobi Nurses Residence	Hospital staff housing
Jacobi Van Etten Building	Hospital health care facility
Jacobi New Building	Hospital residence building
Jacobi Store House	Hospital ancillary equipment storage
Jacobi Ambulatory Care Building	Hospital health care building
Jacobi Engineering and Maintenance Building	Hospital engineering and maintenance facility
Montefiore Weiler Hospital	Hospital health care building
Einstein Robbins Auditorium	Auditorium
Einstein Chanin Inst. For Cancer Research	Hospital research building
Einstein Forcheimer Medical Science Bldg. Gottesman Library & Friedman Lounge	Hospital health care building
Einstein Golding Building	Hospital health care building
Einstein Ullmann Research Center	Hospital research building
Einstein Belfer Educational Center	Hospital research building
Einstein Harold & Muriel Block Bldg.	Hospital research building
Einstein Lubin Dining Hall, Singer Faculty Club	Hospital dining facility
Einstein Gruss Magnetic Resonance Research Ctr.	Hospital research building
Einstein Boiler Plant	Hospital boiler plant
Calvary Hospital	Hospital health care building

Table 11. Facilities Served by Proposed Microgrid

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.[11] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of

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[11] The seven percent discount rate is consistent with the U.S. Office of Management and Budget's current estimate of the opportunity cost of capital for private investments. One exception to the use of this rate is the calculation of environmental damages. Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model relies on temporal projections of the social cost of carbon (SCC), which were developed by the U.S. Environmental Protection Agency (EPA) using a three percent discount rate, to value CO_2 emissions. As the PSC notes, "The SCC is distinguishable from other measures because it operates over a very long time frame, justifying use of a low discount rate specific to its long term effects." The model also uses EPA's temporal projections of social damage values for SO_2, NOx, and PM2.5, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

the 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.[12]

Results

Table 12 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that even if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's benefits would exceed its costs by roughly 40 percent.

Since the Scenario 1 results suggest a benefit-cost ratio greater than one, this report does not provide a detailed analysis of the impact of major power outages under Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio.

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[12] 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.

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2
Net Benefits - Present Value	$87,200,000	Not Evaluated
Benefit-Cost Ratio	1.4	Not Evaluated
Internal Rate of Return	29%	Not Evaluated

Table 12. BCA Results (Assuming 7 Percent Discount Rate)

Scenario 1

Figure 9 and Table 13 present the detailed results of the Scenario 1 analysis.

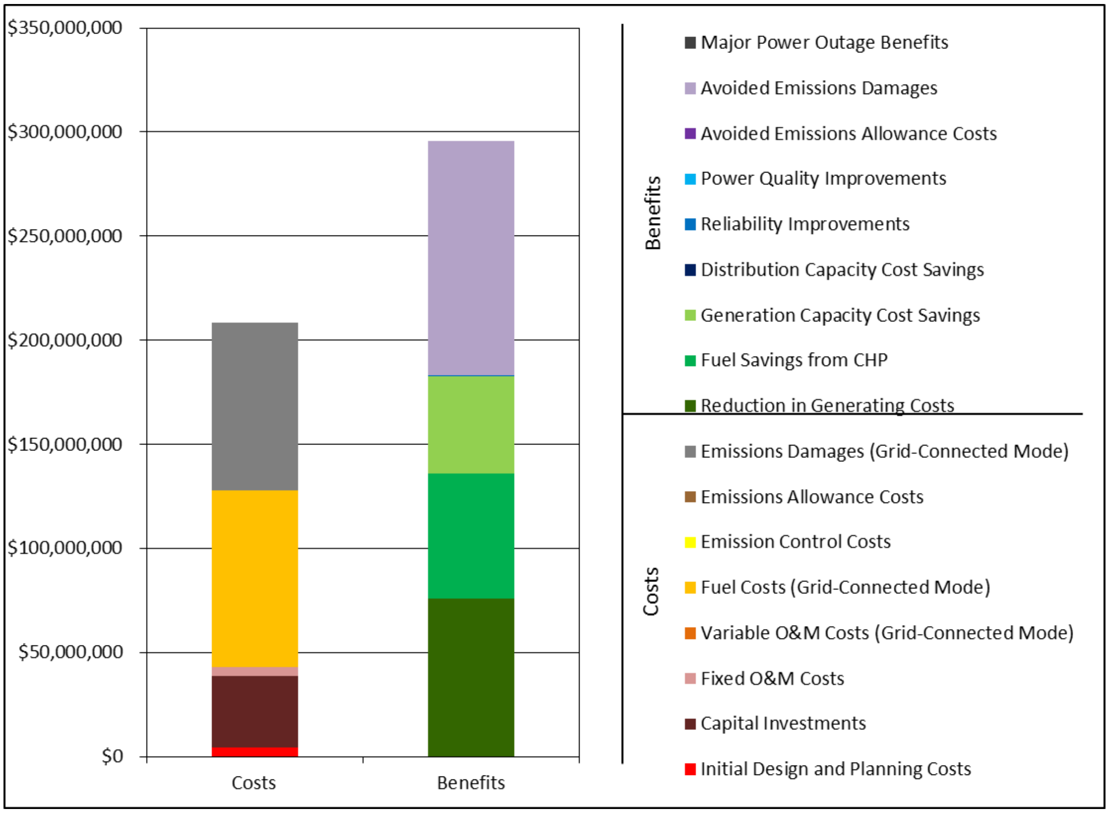

Figure 9. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$4,500,000	$397,000
Capital Investments	$34,400,000	$2,540,000
Fixed O&M	$4,170,000	$368,000
Variable O&M (Grid-Connected Mode)	$2,090	$184
Fuel (Grid-Connected Mode)	$84,900,000	$7,490,000
Emission Control	$0	$0
Emissions Allowances	$16,200	$1,430
Emissions Damages (Grid-Connected Mode)	$80,400,000	$5,250,000
Total Costs	**$208,000,000**	
Benefits		
Reduction in Generating Costs	$75,800,000	$6,680,000
Fuel Savings from CHP	$60,200,000	$5,310,000
Generation Capacity Cost Savings	$46,600,000	$4,110,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$566,000	$50,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$41,600	$3,670
Avoided Emissions Damages	$112,000,000	$7,330,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$296,000,000**	
Net Benefits	**$87,200,000**	
Benefit/Cost Ratio	**1.4**	
Internal Rate of Return	**29.0%**	

Table 13. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

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 $4.5 million, which includes the costs of project design, obtaining building and development permits, securing financing, marketing the project, and negotiating contracts. The present value of the project's capital costs is estimated at approximately $34.4 million, including costs associated with the six CHP plants and the black start generator, diesel fuel tanks, and electrical switchgear.

Fixed operations and maintenance (O&M) costs for the entire system, which include labor, replacement of parts not covered by warranty, downtime costs, and equipment rental costs, would be approximately $368,000 per year. The present value of these O&M costs over a 20-year operating period is approximately $4.2 million.

Variable Costs

The model's analysis of variable costs considers the costs of fuel required to run the microgrid's distributed energy resources, as well as variable O&M costs and the social costs of environmental damages associated with pollutant emissions from the microgrid's DERs. The largest variable cost associated with the proposed project is the cost of natural gas to operate the system's CHP plants. To characterize these costs, the analysis 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. The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $84.9 million.

The model also considers the project team's best estimate of the microgrid's variable O&M costs (i.e., O&M costs that vary with the amount of energy produced). The project team estimates that variable O&M measures, including external mechanical help and external design consultants, would cost about $0.0015 per MWh. Over a 20-year operating period, the present value of these costs is about $2,090.

The analysis of variable costs also considers costs associated with pollutant emissions from the microgrid's DERs, based on the operating scenario and emissions rates provided by the project team and the understanding that the microgrid's generators would be subject to emissions allowance requirements. Based on the emissions rates associated with the CHP plants and the black start generator, the analysis estimates that emissions from the microgrid's DERs would require the purchase of allowances with a present value of about $16,200 and damages with a present value of about $80.4 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 $75.8 million. Substantial cost savings would also result from fuel savings due to the combined heat and power systems, which are expected to reduce energy use for heat by about 778,000 MMBtu per year. The analysis estimates the present value of fuel savings over the 20-year operating period to be approximately $60.2 million. These reductions in demand for electricity from bulk energy suppliers and for heating fuel would also avoid emissions of CO2, SO2, NOx, and particulate matter, yielding avoided emissions allowance costs with a present value of about $41,600 and avoided emissions damages with a present value of approximately $112 million.[13]

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.[14] Based on the application of appropriate availability factors for each DER, the project team estimates the impact of the microgrid on generating capacity requirements to be approximately 28 MW per year. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $46.6 million over a 20-year operating period.

The project team has indicated that the proposed microgrid would be designed to provide black start support 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 market for black start support is highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing this service.

Reliability Benefits

An additional benefit of the proposed 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 $50,000 per year, with a present value of $566,000 over a 20-year operating period. This estimate is calculated using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[15]

- System Average Interruption Frequency Index (SAIFI) – 0.11 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 181.2 minutes.[16]

The estimate takes into account the number of 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

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[13] 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 NOx 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.

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

[15] www.icecalculator.com.

[16] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Consolidated Edison.

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.[17] 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 1.4; i.e., the estimate of project benefits exceeds costs by about 40 percent. Accordingly, the analysis does not consider the potential for the microgrid to mitigate the impact of major power outages in Scenario 2. Consideration of such benefits would further increase the net benefits of the project's development.

Sensitivity Analysis

Add A sensitivity analysis is included here to assess the effect of natural gas prices on the net benefits of the EBHM.

The BCA uses the 2013 New York State Energy Plan projections for natural gas prices, and adjusts the projections by applying a price multiplier of 0.62 to each year of the model to reflect the average commercial price of natural gas in October 2015. The sensitivity analysis examines three alternative projections made by adjusting the multiplier to reflect the possibility of higher natural gas prices. The first alternative applies a multiplier of 1, to reflect the projections of the 2013 NY State Energy Plan and the second applies a multiplier of 2 to reflect prices twice as high as those projected in the State Energy Plan. The results of the sensitivity analysis are presented in Table 14. The scenarios are compared across net benefits, benefit/cost ratio, internal rate of return (IRR), and average cost of natural gas per thousand cubic feet ($/Mcf). All dollar values in the table and following discussion are presented in 2014 dollars.

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

Scenario (Price Multiplier)	BCA Results (0.62)	State Energy Plan Projections (1)	Double State Energy Plan Projections (2)	Break Even Scenario (2.81)
Net Benefits	$87.2 million	$72 million	$32 million	$0
Benefit/Cost Ratio	1.4	1.28	1.08	1
IRR	29%	24.35%	13.27%	4.45%
Average $/Mcf natural gas, 2016-2035	$6.79	$10.95	$21.91	$30.78

Table 14: Sensitivity Analysis of BCA Results by Adjusting the Natural Gas Price Multiplier (2014$)

The sensitivity analysis indicates that in a scenario where natural gas prices were twice as high as the 2013 State Energy Plan projections, the EBHM would still yield net benefits. A multiplier of 2.81 would be needed to cause the project to break even. Under this break-even scenario, the average price of natural gas over the 20-year operating period of the microgrid would be $30.78/Mcf. For comparison, natural gas prices peaked at $9.74/Mcf in 2008[18].

Preservation of Human Life and Medical Research

Also noted in the delivery of the questionnaires to IEc, but not included in the BCA itself are the value of research at Einstein and the value of preserving human life, both of which may be jeopardized in the catastrophic event of prolonged grid failure and loss of existing backup generation.

The loss of research was estimated to be a minimum of $700 million due to the impact of lost biological material alone. This estimate was arrived at from an extrapolation of Einstein's approximate average annual research budget and the 2-3-year timeframe to breed genetic strains for medical testing. This estimate was also compared to the estimated loss of research at NYU resulting from Hurricane Sandy, which was reported to be closer to $1.4 billion. These estimates reflect only the direct loss to ongoing research, and do not include damages to facilities or infrastructure. The estimates also do not account for the potentially much greater loss to society resulting from lost or prolonged discoveries in medical treatments and cures. Similarly, although it is common practice to assign a statistical value to human life for the purpose of economic analysis (the EPA value is $9.1 million per life[19]), we took the value of human life to be incalculable, and therefore the benefit to protecting human life arising from the EBHM to be invaluable.

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[18] U.S. Energy Information Administration [IEA], 2016: Henry Hub Natural Gas Spot Price: http://www.eia.gov/dnav/ng/hist/rngwhhdA.htm

19 http://www.nytimes.com/2011/02/17/business/economy/17regulation.html?_r=0

5: Summary and Conclusions

The East Bronx Healthcare Microgrid presents ample opportunity to enhance the energy infrastructure of the participating facilities, whiles advancing the goals of REV and OneNYC, and providing wider benefits to the utility and the surrounding community.

This feasibility study has proposed generating assets that would provide for 100% secure power both in grid-connected and island mode, to ensure against the loss of power at critical healthcare facilities and to preserve invaluable medical research in the event of grid outage. The selection of equipment also aims to support the Renewable Portfolio Standard through inclusion of solar PV and advancement of the implementation of emerging technology for energy resilience. Solar PV would incorporate 1 MW of renewable generation at a minimum and has the potential to contribute a much greater amount if inclusion of the Bronx Psychiatric property proves to be feasible.

Initial expressions of interest from potential development partners have indicated substantial interest in developing this project. Issuing an RFP will be the next step in selecting a development partner, financier, owner, and subcontractors, all of which will bring valuable expertise and insight to development of the EBHM.

Recommendations

Regulatory Framework

Federal Energy Regulatory Commission (FERC) changes to the definition of a Qualifying Facility (QF) under the Public Utility Regulatory Policies Act of 1978 (PURPA) would specify the extent to which microgrids of different configuration could be considered QFs. The design of the EBHM relies heavily on CHP generation, which are QF's under the Code of Federal Regulations (CFR) §292.203(b)[20].

Similar specifications to New York Public Service Law §2-a, §2-b, and/or §2-d would address the applicability of microgrids, such as the EBHM, that produce power through a combination of CHP and renewable generation, and the extent of the definition of *related facilities* necessary for their construction and operation[21].

Utility Interconnection and Distribution

The State of Connecticut was the first state to legislate Microgrid power systems, as a reaction to multiple severe weather events causing lengthy widespread power outages. It was enacted as Connecticut Public Act 12-148[22]. The intent of the act was to assure maintaining power to critical facilities, defined as:

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[20] http://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp

[21] http://codes.findlaw.com/ny/public-service-law/pbs-sect-2.html

[22] https://www.cga.ct.gov/asp/cgabillstatus/cgabillstatus.asp?selBillType=Bill&bill_num=23&which_year=2012

<u>Critical Facility:</u> Any hospital, police station, fire station, water treatment plant, sewage treatment plant, public shelter or correctional facility, any commercial area of a municipality, a municipal center, as identified by the chief elected official of any municipality, or any other facility or area identified by the Department of Energy and Environmental Protection as critical.

The act also used the Department of Energy definition of a Microgrid, the same definition used by NYSERDA to inform NY Prize:

<u>Microgrid:</u> Means a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and that connects and disconnects from such grid to enable it to operate in both grid-connected or Island Mode.

The act provides block grants of state funding and an application methodology structured such that these funds would be provided to allow the electrical interconnection work be carried out by the Electric Distribution Company (EDC). As part of the application requirements, projects would only be able to apply if they:

- *Include a minimum of 2 or more critical facilities*
- *Are not served by a common electrical service entrance, and*
- *Are located in proximity to each other*

The current design of the EBHM meets these requirements and proposes that the interconnection and distribution of microgrid power be provided by the utility. This would allow the utility to manage voltage and frequency regulation, and force the microgrid into island mode if necessary. Financing would have to be determined at a later stage, but providing for utility installation of interconnection work would greatly ease the financial burden on the developer of the microgrid.

Tariff Structure

In order for microgrids receive the same treatment as campuses, there would need to be modifications in the current Con Edison electrical tariff SC9 Rate V. Currently, this rate includes a contract demand charge for each meter nominated for inclusion. Contract demand is defined as the maximum electrical load that will need to be supplied in case of CHP failure. These meters must be owned by the same entity (parent organization). The entities also need to be in close proximity.

In order to extoll all the benefits of the generation to the microgrid participants, the tariff would have to qualify the entirety of the microgrid as a campus. This will allow for over generation at one location to “offset” grid purchases at another. It will also allow for adoption of the distribution switching benefit when there is a grid disturbance.

Additionally, the new distribution switching will require some regulation or at the very least an operating agreement between Con Edison and the microgrid defining how and when these switches will be activated and maintained. Con Edison already has specifications for the interconnection and maintenance of generation, as well as the same for switchgear operations. It is envisioned that the site specific specifications for the switchgear and its operations will be modified to include these switches. If this is the case, the notification process, operations process, and maintenance process would be identified and agreed to by both Con Edison and the microgrid owner.

Evolving Incentive Structure

Several Incentives currently exist that would support development of this project. However, the incentive landscape is currently under revision and will likely be informed through the outcomes of NY Prize.

NYSERDA's revisions to the CHP Program, PON 2568, have eliminated the eligibility of large projects (over 3 MW) for the incentive.[23] The EBHM, or portions of the EBHM may still be eligible if modularly configured, although this possibility can't be guaranteed for this project.

NY Sun's Commercial/Industrial Block 1 incentive would support the solar component of the EBHM, and would provide a greater benefit to the project if expansion of the solar component on neighboring property at the Bronx Psychiatric Hospital, NYC Children's Center, and the DOSA Clinic proves feasible.

Although not currently indicated by NYSERDA or ConEd, an incentive specific to the development of microgrids would additionally prove beneficial to the EBHM, as well as the construction of microgrids throughout the state.

Demand Response

Demand response (DR) payments would provide an additional revenue stream to the microgrid, if ultimately applicable to microgrids. Any additional capacity (for example, through the redundancy currently designed into the EBHM to support resiliency for critical facilities) would be able to add generation during a DR event. The curtailment of non-critical operations would also still likely be applicable for enrollment in DR programs. However, the caveat with DR as applicable to microgrids is that a reduction on the utility grid's load, if achieved through islanding the microgrid, also removes generation, which is likely not to be supported through DR programs. Further specification is suggested for DR programs, both through the NYISO and through the utility companies, as they would apply to facilities served by microgrids.

Funding Microgrid Development

As microgrid development is still in the exploratory stages within New York State, future funding opportunities remain uncertain. NY Prize Stages 2 and 3 offer initial funding for microgrid projects currently under consideration, but are also intended to further the body of research to inform financial incentives and regulations moving forward. If the outcomes of NY Prize in the aggregate suggest that microgrid development would be beneficial to the energy resiliency of the state, more long-term financial incentives are suggested to further this development.

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[23] http://www.nyserda.ny.gov/PON2568

Substantial private sector interest has been shown for development of the EBHM, and will be further specified through the competitive RFP selection process currently underway. However, the evolving regulatory landscape and uncertainty surrounding the widespread feasibility of microgrids is likely to cause hesitation on the part of investors. It is the recommendation of the EBHM project team that if microgrids are deemed beneficial to the resiliency of New York, that steps be taken to clarify the issues raised in this and other NY Prize Stage 1 Feasibility Studies, including but not limited to:

6. The definition of Qualifying Facilities to be eligible for special rates and regulations
7. The specification of tariff structures appropriate for multi-customer (community) microgrids
8. The rules governing the interconnection and distribution of microgrid-generated power
9. The availability of financial incentives and savings programs for microgrid development and operations
10. The level of commitment from the PSC and the Joint Utilities of NY to support microgrid development beyond the conclusion of NY Prize